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K to 12 BASIC EDUCATION CURRICULUM

CONCEPTUAL FRAMEWORK

Science education aims to develop scientific literacy among learners that will prepare them to be informed and participative citizens who are able to make judgments and decisions regarding applications of scientific knowledge that may have social, health, or environmental impacts.

The science curriculum recognizes the place of science and technology in everyday human affairs. It integrates science and technology in the social, economic, personal and ethical aspects of life. The science curriculum promotes a strong link between science and technology, including indigenous technology, thus preserving our country's cultural heritage.

The K to 12 science curriculum will provide learners with a repertoire of competencies important in the world of work and in a knowledge-based society. It envisions the development of scientifically, technologically, and environmentally literate and productive members of society who are critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision makers, and effective communicators. This curriculum is designed around the three domains of learning science: understanding and applying scientific knowledge in local setting as well as global context whenever possible, performing scientific processes and skills, and developing and demonstrating scientific attitudes and values. The acquisition of these domains is facilitated using the following approaches: multi/interdisciplinary approach, science-technology-society approach, contextual learning, problem/issue-based learning, and inquiry-based approach. The approaches are based on sound educational pedagogy namely, constructivism, social cognition learning model, learning style theory, and brain-based learning.

Science content and science processes are intertwined in the K to 12 Curriculum. Without the content, learners will have difficulty utilizing science process skills since these processes are best learned in context. Organizing the curriculum around situations and problems that challenge and arouse learners’ curiosity motivates them to learn and appreciate science as relevant and useful. Rather than relying solely on textbooks, varied hands-on, minds-on, and hearts-on activities will be used to develop learners’ interest and let them become active learners.

As a whole, the K to 12 science curriculum is learner-centered and inquiry-based, emphasizing the use of evidence in constructing explanations. Concepts and skills in Life Sciences, Physics, Chemistry, and Earth Sciences are presented with increasing levels of complexity from one grade level to another in spiral progression, thus paving the way to a deeper understanding of core concepts. The integration across science topics and other disciplines will lead to a meaningful understanding of concepts and its application to real-life situations.
K to 12 BASIC EDUCATION CURRICULUM

Scientific, Technological and Environmental Literacy

The Conceptual Framework of Science Education
K to 12 BASIC EDUCATION CURRICULUM

CORE LEARNING AREA STANDARD: (SCIENCE FOR THE ENTIRE K TO 12)

The learners demonstrate understanding of basic science concepts and application of science-inquiry skills. They exhibit scientific attitudes and values to solve problems critically, innovate beneficial products, protect the environment and conserve resources, enhance the integrity and wellness of people, make informed decisions, and engage in discussions of relevant issues that involve science, technology, and environment.

KEY STAGE STANDARDS: (STANDARDS FOR SCIENCE LEARNING AREAS FOR K-3, 4-6, 7-10 AND 11-2)

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<tr>
<th>Grade</th>
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<tr>
<td>K–3</td>
<td>At the end of Grade 3, the learners should have acquired healthful habits and have developed curiosity about self and their environment using basic process skills of observing, communicating, comparing, classifying, measuring, inferring and predicting. This curiosity will help learners value science as an important tool in helping them continue to explore their natural and physical environment. This should also include developing scientific knowledge or concepts.</td>
</tr>
<tr>
<td>4–6</td>
<td>At the end of Grade 6, the learners should have developed the essential skills of scientific inquiry—designing simple investigations, using appropriate procedure, materials and tools to gather evidence, observing patterns, determining relationships, drawing conclusions based on evidence, and communicating ideas in varied ways to make meaning of the observations and/or changes that occur in the environment. The content and skills learned will be applied to maintain good health, ensure the protection and improvement of the environment, and practice safety measures.</td>
</tr>
<tr>
<td>7–10</td>
<td>At the end of Grade 10, the learners should have developed scientific, technological, and environmental literacy and can make that would lead to rational choices on issues confronting them. Having been exposed to scientific investigations related to real life, they should recognize that the central feature of an investigation is that if one variable is changed (while controlling all others), the effect of the change on another variable can be measured. The context of the investigation can be problems at the local or national level to allow them to communicate with learners in other parts of the Philippines or even from other countries using appropriate technology. The learners should demonstrate an understanding of science concepts and apply science inquiry skills in addressing real-world problems through scientific investigations.</td>
</tr>
<tr>
<td>11-12</td>
<td>At the end of Grade 12, the learners should have gained skills in obtaining scientific and technological information from varied sources about global issues that have impact on the country. They should have acquired scientific attitudes that will allow them to innovate and/or create products useful to the community or country. They should be able to process information to get relevant data for a problem at hand. In addition, learners should have made plans related to their interests and expertise, with consideration for the needs of their community and the country— to pursue either employment, entrepreneurship, or higher education.</td>
</tr>
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### Grade-Level Standards

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<td>Kindergarten</td>
<td>The learners will demonstrate an emerging understanding of the parts of their body and the general functions that they perform. They will describe similarities and differences given two objects, to tell the shape, color, texture, taste, and size of things around them, to describe similarities and differences given two objects, to tell the shape, color, texture, taste, and size of things around them, and to describe similarities and differences given two objects. Learners will use their senses to explore and describe the functions of their senses, to describe similarities and differences given two objects, to tell the shape, color, texture, taste, and size of things around them, and to describe similarities and differences given two objects. Learners will use their senses to explore and describe the functions of their senses, to describe similarities and differences given two objects, to tell the shape, color, texture, taste, and size of things around them, and to describe similarities and differences given two objects. Learners will use their senses to explore and describe the functions of their senses, to describe similarities and differences given two objects, to tell the shape, color, texture, taste, and size of things around them, and to describe similarities and differences given two objects.</td>
<td>At the end of Grade 1, learners will use their senses to locate and describe the external parts of their body; to identify, external parts of animals and plants; to tell the shape, color, texture, taste, and size of things around them; to describe similarities and differences given two objects; to tell the shape, color, texture, taste, and size of things around them; and to describe similarities and differences given two objects. At the end of Grade 2, learners will use their senses to explore and describe the functions of their senses; to describe similarities and differences given two objects; to tell the shape, color, texture, taste, and size of things around them; and to describe similarities and differences given two objects. At the end of Grade 3, learners can describe the functions of the different parts of the body in order to practice ways to maintain good health; they can classify plants and animals according to where they live and observe interactions among living things and their environment. At the end of Grade 4, learners can investigate changes in some observable properties of materials when mixed with other materials or when force is applied on them. They can identify materials that do not decay and use this knowledge to help minimize waste at home, school, and in the community.</td>
<td>At the end of Grade 2, learners will use their senses to explore and describe the functions of their senses; to describe similarities and differences given two objects; to tell the shape, color, texture, taste, and size of things around them; and to describe similarities and differences given two objects. At the end of Grade 3, learners can describe the functions of the different parts of the body in order to practice ways to maintain good health; they can classify plants and animals according to where they live and observe interactions among living things and their environment. At the end of Grade 4, learners can investigate changes in some observable properties of materials when mixed with other materials or when force is applied on them. They can identify materials that do not decay and use this knowledge to help minimize waste at home, school, and in the community.</td>
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</tr>
</tbody>
</table>
### Grade 5

At the end of Grade 5, learners can decide whether materials are safe and useful by investigating about some of their properties. They can infer that new materials may form when there are changes in properties due to certain conditions.

Learners have developed healthful and hygienic practices related to the reproductive system after describing changes that accompany puberty. They can compare different modes of reproduction among plant and animal groups and conduct an investigation on pollination. They have become aware of the importance of estuaries and intertidal zones and help in their preservation.

Learners can describe the movement of objects in terms of distance and time travelled. Learners recognize that different materials react differently with heat, light, and sound. They can relate these abilities of materials to their specific uses.

Learners can describe the changes that earth materials undergo. They can make emergency plans with their families in preparation for typhoons. They can observe patterns in the natural events by observing the appearance of the Moon.

### Grade 6

At the end of Grade 6, learners recognize that when mixed together, materials may not form new ones thus these materials may be recovered using different separation techniques. They can prepare useful mixtures such as food, drinks and herbal medicines.

Learners understand how the different organ systems of the human body work together. They can classify plants based on reproductive structures, and animals based on the presence or lack of backbone. They can design and conduct an investigation on plant propagation. They can describe larger ecosystems such as rainforests, coral reefs, and mangrove swamps.

Learners can infer that friction and gravity affect how people and objects move. They have found out that heat, light, sound, electricity, and motion studied earlier are forms of energy and these undergo transformation.

Learners can describe what happens during earthquakes and volcanic eruptions and demonstrate what to do when they occur. They can infer that the weather follows a pattern in the course of a year. They have learned about the solar system, with emphasis on the motions of the Earth as prerequisite to the study of seasons in another grade level.
## K to 12 BASIC EDUCATION CURRICULUM

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<td><strong>Grade 7</strong></td>
<td>At the end of Grade 7, learners can distinguish mixtures from substances through semi-guided investigations. They realize the importance of air testing when conducting investigations. After studying how organ systems work together in plants and animals in the lower grade levels, learners can use a microscope when observing very small organisms and structures. They recognize that living things are organized into different levels: Cells, tissues, organs, organ systems, and organisms. These organisms comprise populations and communities, which interact with non-living things in ecosystems. Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations. They can describe how various forms of energy travel through different mediums. Learners describe what makes up the Philippines as a whole and the resources found in the archipelago. They can explain the occurrence of breezes, monsoons, and ITCZ, and how these weather systems affect people. They can explain why seasons change and demonstrate how eclipses occur.</td>
</tr>
<tr>
<td><strong>Grade 8</strong></td>
<td>At the end of Grade 8, learners can describe the factors that affect the motion of an object based on the Laws of Motion. They can differentiate the concept of work as used in science and in layman’s language. They know the factors that affect the transfer of energy, such as temperature difference, and the type (solid, liquid, or gas) of the medium. Learners can explain how active faults generate earthquakes and how tropical cyclones originate from warm ocean waters. They recognize other members of the solar system. Learners can explain the behaviour of matter in terms of the particles it is made of. They recognize that ingredients in food and medical products are made up of these particles and are absorbed by the body in the form of ions. Learners recognize reproduction as a process of cell division resulting in growth of organisms. They have delved deeper into the process of digestion as studied in the lower grades, giving emphasis on proper nutrition for overall wellness. They can participate in activities that protect and conserve economically important species used for food.</td>
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<tr>
<td><strong>Grade 9</strong></td>
<td>At the end of Grade 9, learners have gained a deeper understanding of the digestive, respiratory, and circulatory systems to promote overall health. They have become familiar with some technologies that introduce desired traits in economically important plants and animals. Learners can explain how new materials are formed when atoms are rearranged. They recognize that a wide variety of useful compounds may arise from such rearrangements. Learners can identify volcanoes and distinguish between active and inactive ones. They can explain how energy from volcanoes may be tapped for human use. They are familiar with climatic phenomena that occur on a global scale. They can explain why certain constellations can be seen only at certain times of the year. Learners can predict the outcomes of interactions among objects in real life applying the laws of conservation of energy and momentum.</td>
</tr>
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At the end of Grade 10, learners realize that volcanoes and earthquakes occur in the same places in the world and that these are related to plate boundaries. They can demonstrate ways to ensure safety and reduce damage during earthquakes, tsunamis, and volcanic eruptions. Learners can explain the factors affecting the balance and stability of an object to help them practice appropriate positions and movements to achieve efficiency and safety such as in sports and dancing. They can analyze situations in which energy is harnessed for human use whereby heat is released, affecting the physical and biological components of the environment. Learners will have completed the study of the entire organism with their deeper study of the excretory and reproductive systems. They can explain in greater detail how genetic information is passed from parents to offspring, and how diversity of species increases the probability of adaptation and survival in changing environments. Learners can explain the importance of controlling the conditions under which a chemical reaction occurs. They recognize that cells and tissues of the human body are made up of water, a few kinds of ions, and biomolecules. These biomolecules may also be found in the food they eat.

### SEQUENCE OF DOMAIN/STRANDS PER QUARTER

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<td>Matter</td>
<td>Matter</td>
<td>Matter</td>
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<td>Living Things and Their Environment</td>
<td>Earth &amp; Space</td>
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<td>2nd Quarter</td>
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<td>Living Things and Their Environment</td>
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<tr>
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<td>Living Things and Their Environment</td>
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## MATTER

### PROPERTIES OF MATTER

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<tr>
<td>When learners observe different objects and materials, they become aware of their different characteristics such as shape, weight, definiteness of volume and ease of flow. Using characteristics, objects and materials can be grouped into solids, liquids or gases.</td>
<td>Aside from being grouped into solids, liquids, or gases, materials may also be grouped according to their ability to absorb water, ability to float or sink, and whether they decay or not.</td>
<td>After learning how to read and interpret product labels, learners can critically decide whether these materials are harmful or not. They can also describe ways in which they can use their knowledge of solids and liquids in making useful materials and products.</td>
<td>In Grade 4, the learners have observed the changes when mixing a solid in a liquid or a liquid in another liquid. From these investigations, learners can now describe the appearance of mixtures as uniform or non-uniform and classify them as homogeneous or heterogeneous mixtures.</td>
</tr>
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### CHANGES THAT MATTER UNDERGO

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<td>Changes in some characteristics of solid materials can be observed when these are bent, hammered, pressed, and cut. After investigating the changes in some observable characteristics of materials due to temperature in Grade 3, learners can now inquire about changes observed when a solid is mixed with a liquid or when a liquid is mixed with another liquid. Learners learn that some changes in the characteristics of a product such as food or medicine may affect its quality. One way of finding out is by reading and interpreting product labels. This information helps them decide when these products become harmful.</td>
<td>In Grade 4, learners investigated changes in materials that take place at certain conditions, such as applying force, mixing materials, and changing the temperature. In Grade 5, they investigate changes that take place under the following conditions: presence or lack of oxygen (in air), and applying heat. They learn that some of these conditions can result in a new product. Knowing these conditions enable them to apply the &quot;5R method&quot; (recycling, reducing, reusing, recovering and repairing) at home and in school.</td>
<td>Based on the characteristics of the components of a heterogeneous mixture, learners investigate ways of separating these components from the mixture. They will infer that the characteristics of each of the components remain the same even when the component is part of the mixture.</td>
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## K to 12 BASIC EDUCATION CURRICULUM

### PROPERTIES AND STRUCTURE OF MATTER

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<tr>
<td><strong>In Grade 6, learners learned how to distinguish homogenous from heterogeneous mixtures. In Grade 7, learners investigate properties of solutions that are homogeneous mixtures. They learn how to express concentrations of solutions qualitatively and quantitatively. They distinguish mixtures from substances based on a set of properties. Learners begin to do guided and semi-guided investigations, making sure that the experiment they are conducting is a fair test.</strong></td>
<td><strong>Using models, learners learn that matter is made up of particles, the smallest of which is the atom. These particles are too small to be seen through a microscope. The properties of materials that they have observed in earlier grades can now be explained by the type of particles involved and the attraction between these particles.</strong></td>
<td><strong>Using their understanding of atomic structure learned in Grade 8, learners describe how atoms can form units called molecules. They also learn about ions. Further, they explain how atoms form bonds (ionic and covalent) with other atoms by the transfer or sharing of electrons. They also learn that the forces holding metals together are caused by the attraction between flowing electrons and the positively charged metal ions. Learners explain how covalent bonding in carbon forms a wide variety of carbon compounds. Recognizing that matter consists of an extremely large number of very small particles; counting these particles is not practical. So, learners are introduced to the unit—mole.</strong></td>
<td><strong>Learners investigate how gases behave in different conditions based on their knowledge of the motion of and distances between gas particles. Learners then confirm whether their explanations are consistent with the Kinetic Molecular Theory. They also learn the relationships between volume, temperature, and pressure using established gas laws. In Grade 9, learners learned that the bonding characteristics of carbon result in the formation of large variety of compounds. In Grade 10, they learn more about these compounds that include biomolecules such as carbohydrates, lipids, proteins, and nucleic acids. Further, they will recognize that the structure of these compounds comprises repeating units that are made up of a limited number of elements such as carbon, hydrogen, oxygen, and nitrogen.</strong></td>
</tr>
</tbody>
</table>

### CHANGES THAT MATTER UNDERGO

<table>
<thead>
<tr>
<th>Grade 7</th>
<th>Grade 8</th>
<th>Grade 9</th>
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<tbody>
<tr>
<td><strong>Learners recognize that materials combine in various ways and through different processes, contributing to the wide variety of materials. Given this diversity, they recognize the importance of a classification system. They become familiar with elements and compounds, metals and non-metals, and acids and bases. Further, learners demonstrate that homogeneous mixtures can be separated using various techniques.</strong></td>
<td><strong>Learners learn that particles are always in motion. They can now explain that the changes from solid to liquid, solid to gas, liquid to solid, and liquid to gas, involve changes in the motion of and relative distances between the particles, as well as the attraction between them. They also recognize that the same particles are involved when these changes occur. In effect, no new substances are formed.</strong></td>
<td><strong>Learners explain how new compounds are formed in terms of the rearrangement of particles. They also recognize that a wide variety of useful compounds may arise from such rearrangements.</strong></td>
<td><strong>In Grade 9, learners described how particles rearrange to form new substances. In Grade 10, they learn that the rearrangement of particles happen when substances undergo chemical reaction. They further explain that when this rearrangement happens, the total number of atoms and total mass of newly formed substances remain the same. This is the Law of Conservation of Mass. Applying this law, learners learn to balance chemical equations and solve simple mole-mole, mole-mass, and mass-mass problems.</strong></td>
</tr>
</tbody>
</table>
## LIVING THINGS AND THEIR ENVIRONMENT

### Grade 3

In Grade 3, learners observe and describe the different parts of living things focusing on the sense organs of humans and the more familiar external parts of animals and plants. They also explore and describe characteristics of living things that distinguish them from non-living things.

### Grade 4

In Grade 4, the learners are introduced to the major organs of the human body. They also learn about some parts that help plants and animals survive in places where they live.

### Grade 5

After learning in Grade 4 how the major organs of the human body work together, the learners now focus on the organs of the reproductive systems of humans, animals, and plants.

### Grade 6

In Grade 6, learners describe the interactions among parts of the major organs of the human body. They also learn how vertebrates and invertebrates differ and how non-flowering plants reproduce.

### HEREDITY: INHERITANCE AND VARIATION

Learners learn that living things reproduce and certain traits are passed on to their offspring's.

Learners learn that humans, animals, and plants go through life cycles. Some inherited traits may be affected by the environment at certain stages in their life cycles.

Learners learn how flowering plants and some non-flowering plants reproduce. They are also introduced to the sexual and asexual modes of reproduction.

Learners learn how non-flowering plants (spore-bearing and cone-bearing plants, ferns, and mosses) reproduce.

### BIODIVERSITY AND EVOLUTION

Different kinds of living things are found in different places.

Learners investigate that animals and plants live in specific habitats.

Learners learn that reproductive structures serve as one of the bases for classifying living things.

They learn that plants and animals share common characteristics which serve as bases for their classification.

### ECOSYSTEMS

Learners learn that living things depend on their environment for food, air, and water to survive.

Learners learn that there are beneficial and harmful interactions that occur among living things and their environment as they obtain their basic needs.

Learners are introduced to the interactions among components of larger habitats such as estuaries and intertidal zones, as well as the conditions that enable certain organisms to live.

Learners are introduced to the interactions among components of habitats such as tropical rainforests, coral reefs, and mangrove swamps.
### K to 12 BASIC EDUCATION CURRICULUM

#### GRADE 7

**Parts and Function: Animal and Plants**

- In Grade 7, learners are introduced to the levels of organization in the human body and other organisms. They learn that organisms consist of cells, most of which are grouped into organ systems that perform specialized functions.

- In Grade 8, learners gain knowledge of how the body breaks down food into forms that can be absorbed through the digestive system and transported to cells.
  
  Learners learn that gases are exchanged through the respiratory system. This provides the oxygen needed by cells to release the energy stored in food.
  
  They also learn that dissolved wastes are removed through the urinary system while solid wastes are eliminated through the excretory system.

**Heredity: Inheritance and Variation**

- After learning how flowering and non-flowering plants reproduce, Grade 7 learners are taught that asexual reproduction results in genetically identical offspring whereas sexual reproduction gives rise to variation.

- Learners study the process of cell division by mitosis and meiosis. They understand that meiosis is an early step in sexual reproduction that leads to variation.

**Biodiversity and Evolution**

- Learners learn that the cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.

- Learners learn that species refers to a group of organisms that can mate with one another to produce fertile offspring. They learn that biodiversity is the collective variety of species living in an ecosystem. This serves as an introduction to the topic on hierarchical taxonomic system.

- Learners learn that most species that have once existed are now extinct. Species become extinct when they fail to adapt to changes in the environment.

**Ecosystems**

- Learners learn that interactions occur among the different levels of organization in ecosystems.

#### GRADE 8

**Parts and Function: Animal and Plants**

- Learners study the coordinated functions of the digestive, respiratory, and circulatory systems.

- They also learn that nutrients enter the bloodstream and combine with oxygen taken in through the respiratory system. Together, they are transported to the cells where oxygen is used to release the stored energy.

**Heredity: Inheritance and Variation**

- Learners study the structure of genes and chromosomes, and the functions they perform in the transmission of traits from parents to offspring.

**Biodiversity and Evolution**

- Learners are introduced to the structure of the DNA molecule and its function.

- They also learn that changes that take place in sex cells are inherited while changes in body cells are not passed on.

**Ecosystems**

- Learners investigate the impact of human activities and other organisms on ecosystems.

#### GRADE 9

**Parts and Function: Animal and Plants**

- Learners study the coordinated functions of the digestive, respiratory, and circulatory systems.

**Heredity: Inheritance and Variation**

- Learners study the structure of genes and chromosomes, and the functions they perform in the transmission of traits from parents to offspring.

**Biodiversity and Evolution**

- Learners revisit the mechanisms involved in the inheritance of traits and the changes that result from these mechanisms. Learners explain how natural selection has produced a succession of diverse new species. Variation increases the chance of living things to survive in a changing environment.

**Ecosystems**

- Learners investigate the impact of human activities and other organisms on ecosystems.

#### GRADE 10

**Parts and Function: Animal and Plants**

- Learners learn that organisms have feedback mechanisms that are coordinated by the nervous and endocrine systems. These mechanisms help the organisms maintain homeostasis to reproduce and survive.

**Heredity: Inheritance and Variation**

- Learners are introduced to the structure of the DNA molecule and its function.

**Biodiversity and Evolution**

- Learners revisit the mechanisms involved in the inheritance of traits and the changes that result from these mechanisms. Learners explain how natural selection has produced a succession of diverse new species. Variation increases the chance of living things to survive in a changing environment.

**Ecosystems**

- Learners investigate the impact of human activities and other organisms on ecosystems.
### FORCE, MOTION AND ENERGY

<table>
<thead>
<tr>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
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<tbody>
<tr>
<td><strong>FORCE AND MOTION</strong>&lt;br&gt; Learners observe and explore and investigate how things around them move and can be moved. They also identify things in their environment that can cause changes in the movement of objects.</td>
<td>Learners now learn that if force is applied on an object, its motion, size, or shape can be changed. They will further understand that these changes depend on the amount of force applied on it (qualitative). They also learn that magnets can exert force on some objects and may cause changes in their movements.</td>
<td>This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.</td>
<td>Aside from the identified causes of motion in Grade 3, such as people, animals, wind, and water, learners also learn about gravity and friction as other causes or factors that affect the movement of objects.</td>
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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Organisms of the same kind interact with each other to form populations; populations interact with other populations to form communities.</td>
<td>stored energy is used by cells during cellular respiration. These two processes are related to each other.</td>
<td>They learn how biodiversity influences the stability of ecosystems.</td>
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### ENERGY

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<thead>
<tr>
<th>Grade 3</th>
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<tbody>
<tr>
<td>Learners observe and identify different sources of light, heat, sound, and electricity in their environment and their uses in everyday life.</td>
<td>Learners learn that light, heat, and sound travel from the source. They perform simple activities that demonstrate how they travel using various objects.&lt;br&gt;&lt;br&gt;Note: Electricity is not included in Grade 4 because the concept of 'flow of charges' is difficult to understand at this grade level.</td>
<td>This time, learners explore how different objects interact with light, heat, sound, and electricity (e.g., identifying poor and good conductors of electricity using simple circuits). They learn about the relationship between electricity and magnetism by constructing an electromagnet. They also learn about the effects of light, heat, sound, and electricity on people.</td>
<td>At this grade level, learners are introduced to the concept of energy. They learn that energy exists in different forms, such as light, heat, sound and electricity, and it can be transformed from one form to another. They demonstrate how energy is transferred using simple machines.</td>
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<tr>
<td>Grade 7</td>
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<tr>
<td>FORCE AND MOTION</td>
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<tr>
<td>From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.</td>
<td>This time, learners study the concept of force and its relationship to motion. They use Newton’s Laws of Motion to explain why objects move (or do not move) the way they do (as described in Grade 7). They also realize that if force is applied on a body, work can be done and may cause a change in the energy of the body.</td>
<td>To deepen their understanding of motion, learners use the Law of Conservation of Momentum to further explain the motion of objects. From motion in one dimension in the previous grades, they learn at this level about motion in two dimensions using projectile motion as an example.</td>
<td>From learning the basics of forces in Grade 8, learners extend their understanding of forces by describing how balanced and unbalanced forces, either by solids or liquids, affect the movement, balance, and stability of objects.</td>
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</tbody>
</table>

ENERGY

This time learners recognize that different forms of energy travel in different ways—light and sound travel through waves, heat travels through moving or vibrating particles, and electrical energy travels through moving charges. In Grade 5, they learned about the different modes of heat transfer. This time, they explain these modes in terms of the movement of particles. Learners realize that transferred energy may cause changes in the properties of the object. They relate the observable changes in temperature, amount of current, and speed of sound to the changes in energy of the particles. Learners explain how conservation of mechanical energy is applied in some structures, such as roller coasters, and in natural environments like waterfalls. They further describe the transformation of energy that takes place in hydroelectric power plants. Learners also learn about the relationship between heat and work, and apply this concept to explain how geothermal power plants operate. After they have learned how electricity is generated in power plants, learners further develop their understanding of transmission of electricity from power stations to homes. Learners acquire more knowledge about the properties of light as applied in optical instruments. Learners also use the concept of moving charges and magnetic fields in explaining the principle behind generators and motors.
# Earth and Space

## Geology

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<tr>
<td>Learners will describe what makes up their environment, beginning with the landforms and bodies of water found in their community.</td>
<td>After familiarizing themselves with the general landscape, learners will investigate two components of the physical environment in more detail: soil and water. They will classify soils in their community using simple criteria. They will identify the different sources of water in their community. They will infer the importance of water in daily activities and describe ways of using water wisely.</td>
<td>In this grade level, learners will learn that our surroundings do not stay the same forever. For example, rocks undergo weathering and soil is carried away by erosion. Learners will infer that the surface of the Earth changes with the passage of time.</td>
<td>Learners will learn that aside from weathering and erosion, there are other processes that may alter the surface of the Earth: earthquakes and volcanic eruptions. Only the effects of earthquakes and volcanic eruptions are taken up in this grade level, not their causes (which will be tackled in Grades 8 and 9). Learners will also gather and report data on earthquakes and volcanic eruptions in their community or region.</td>
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</table>

## Meteorology

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<tr>
<th>Grade 4</th>
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</thead>
<tbody>
<tr>
<td>Learners will describe the different types of local weather.</td>
<td>After making simple descriptions about the weather in the previous grade, learners will now measure the components of weather using simple instruments. They will also identify trends in a simple weather chart.</td>
<td>Learners will learn that the weather does not stay the same the whole year round. Weather disturbances such as typhoons may occur. Learners will describe the effects of typhoons on the community and the changes in the weather before, during, and after a typhoon.</td>
</tr>
<tr>
<td>Learners will learn that the weather does not stay the same the whole year round. Weather disturbances such as typhoons may occur. Learners will describe the effects of typhoons on the community and the changes in the weather before, during, and after a typhoon.</td>
<td>After learning how to measure the different components of weather in Grades 4 and 5, learners will now collect weather data within the span of the school year. Learners will interpret the data and identify the weather patterns in their community.</td>
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## Astronomy

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<tr>
<th>Grade 4</th>
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<tbody>
<tr>
<td>Learners will describe the natural objects that they see in the sky.</td>
<td>After describing the natural objects that are seen in the sky, learners will now focus on the main source of heat and light on Earth: the Sun, its role in plant growth and development, and its effect on the activities of humans and other animals.</td>
<td>After learning about the Sun, learners will now familiarize themselves with the Moon and the stars. They will describe the changes in the appearance of the Moon and discover that the changes are cyclical, and that the cycle is related to the length of a month. Learners will identify star patterns that can be seen during certain times of the year.</td>
</tr>
<tr>
<td>After learning about the Sun, learners will now familiarize themselves with the Moon and the stars. They will describe the changes in the appearance of the Moon and discover that the changes are cyclical, and that the cycle is related to the length of a month. Learners will identify star patterns that can be seen during certain times of the year.</td>
<td>In Grade 6, learners will turn their attention to Earth as another natural object in space (in addition to the Sun, Moon, and stars). Learners will learn about the motions of the Earth: rotation and revolution. Learners will also compare the different members that make up the Solar System and construct models to help them visualize their relative sizes and distances.</td>
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</table>
### GEOLOGY

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<tr>
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<tbody>
<tr>
<td>Learners will explore and locate places using a coordinate system. They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate).</td>
<td>As a result of being located along the Ring of Fire, the Philippines is prone to earthquakes. Using models, learners will explain how quakes are generated by faults. They will try to identify faults in the community and differentiate active faults from inactive ones.</td>
<td>Being located along the Ring of Fire, the Philippines is home to many volcanoes. Using models, learners will explain what happens when volcanoes erupt. They will describe the different types of volcanoes and differentiate active volcanoes from inactive ones.</td>
<td>Using maps, learners will discover that volcanoes, earthquake epicenters, and mountain ranges are not randomly scattered in different places but are located in the same areas. This will lead to an appreciation of plate tectonics—a theory that binds many geologic processes such as volcanism and earthquakes.</td>
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### METEOROLOGY

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<tr>
<td>Learners will explain the occurrence of atmospheric phenomena (breezes, monsoons, and ITCZ) that are commonly experienced in the country as a result of the Philippines' location with respect to the equator, and surrounding bodies of water and landmasses.</td>
<td>Being located beside the Pacific Ocean, the Philippines is prone to typhoons. In Grade 5, the effects of typhoons were tackled. Here, learners will explain how typhoons develop, how typhoons are affected by landforms and bodies of water, and why typhoons follow certain paths as they move within the Philippine Area of Responsibility.</td>
<td>In this grade level, learners will distinguish between weather and climate. They will explain how different factors affect the climate of an area. They will also be introduced to climatic phenomena that occur over a wide area (e.g., El Niño and global warming).</td>
<td>Note: The theory of plate tectonics is the sole topic in Earth and Space in Grade 10. This is because the theory binds many of the topics in previous grade levels, and more time is needed to explore connections and deepen learners' understanding.</td>
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### ASTRONOMY

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<tr>
<td>Learners will explain the occurrence of the seasons and eclipses as a result of the motions of the Earth and the Moon. Using models, learners will explain that because the Earth revolves around the Sun, the seasons change, and because the Moon revolves around the Earth, eclipses sometimes occur.</td>
<td>Learners will complete their survey of the Solar System by describing the characteristics of asteroids, comets, and other members of the Solar System.</td>
<td>Learners will now leave the Solar System and learn about the stars beyond. They will infer the characteristics of stars based on the characteristics of the Sun. Using models, learners will show that constellations move in the course of a night because of Earth's rotation, while different constellations are observed in the course of a year because of the Earth's revolution.</td>
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</table>
## Grade 10 – Earth and Space
### FIRST QUARTER/FIRST GRADING PERIOD

<table>
<thead>
<tr>
<th>CONTENT</th>
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<th>PERFORMANCE STANDARDS</th>
<th>LEARNING COMPETENCY</th>
<th>CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Plate Tectonics</strong></td>
<td>The learners demonstrate an understanding of: the relationship among the locations of volcanoes, earthquake epicenters, and mountain ranges</td>
<td>The learners shall be able to:</td>
<td>The learners should be able to:</td>
<td>S9ES–Ia-j-36.1</td>
</tr>
<tr>
<td>1.1 Distribution</td>
<td></td>
<td>1. demonstrate ways to ensure disaster preparedness during earthquakes, tsunamis, and volcanic eruptions</td>
<td>1. describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts</td>
<td></td>
</tr>
<tr>
<td>1.1.1 volcanoes</td>
<td></td>
<td>2. suggest ways by which he/she can contribute to government efforts in reducing damage due to earthquakes, tsunamis, and volcanic eruptions</td>
<td>2. describe the different types of plate boundaries</td>
<td>S9ES–Ia-j-36.2</td>
</tr>
<tr>
<td>1.1.2 earthquake epicenters</td>
<td></td>
<td>3. explain the different processes that occur along the plate boundaries</td>
<td>3. describe the internal structure of the Earth</td>
<td>S9ES–Ia-j-36.3</td>
</tr>
<tr>
<td>1.1.3 mountain ranges</td>
<td></td>
<td>4. describe the possible causes of plate movement</td>
<td>4. describe the internal structure of the Earth</td>
<td>S9ES–Ia-j-36.4</td>
</tr>
<tr>
<td>1.2 Plate boundaries</td>
<td></td>
<td>5. enumerate the lines of evidence that support plate movement</td>
<td>5. describe the possible causes of plate movement</td>
<td>S9ES–Ia-j-36.5</td>
</tr>
<tr>
<td>1.3 Processes and landforms along plate boundaries</td>
<td></td>
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<tr>
<td>1.4 Internal structure of the Earth</td>
<td></td>
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<tr>
<td>1.5 Mechanism (possible causes of movement)</td>
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<tr>
<td>1.6 Evidence of plate movement</td>
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## Grade 10 – Force, Motion and, Energy
### SECOND QUARTER/SECOND GRADING PERIOD

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<tr>
<th>CONTENT</th>
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<th>LEARNING COMPETENCY</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Electromagnetic Spectrum</strong></td>
<td>The learners demonstrate an understanding of: the different regions of the electromagnetic spectrum</td>
<td>The learners shall be able to:</td>
<td>The learners should be able to:</td>
<td>S10FE-IIa-b-47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. compare the relative wavelengths of different forms of electromagnetic waves</td>
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## K to 12 BASIC EDUCATION CURRICULUM

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<tbody>
<tr>
<td></td>
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<td></td>
<td>2. cite examples of practical applications of the different regions of EM waves, such as the use of radio waves in telecommunications;</td>
<td>S10FE-IIc-d-48</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3. explain the effects of EM radiation on living things and the environment;</td>
<td>S10FE-IIe-f-49</td>
</tr>
<tr>
<td>2. Light</td>
<td></td>
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<tr>
<td>2.1 Reflection of Light in Mirrors</td>
<td>the images formed by the different types of mirrors and lenses</td>
<td>4. predict the qualitative characteristics (orientation, type, and magnification) of images formed by plane and curved mirrors and lenses;</td>
<td>S10FE-IIg-50</td>
<td></td>
</tr>
<tr>
<td>2.2 Refraction of Light in Lenses</td>
<td></td>
<td>5. apply ray diagramming techniques in describing the characteristics and positions of images formed by lenses;</td>
<td>S10FE-IIg-51</td>
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<td></td>
<td></td>
<td></td>
<td>6. identify ways in which the properties of mirrors and lenses determine their use in optical instruments (e.g., cameras and binoculars);</td>
<td>S10FE-IIh-52</td>
</tr>
<tr>
<td>3. Electricity and Magnetism</td>
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</tr>
<tr>
<td>3.1 Electromagnetic effects</td>
<td>the relationship between electricity and magnetism in electric motors and generators</td>
<td>7. demonstrate the generation of electricity by movement of a magnet through a coil; and</td>
<td>S10FE-IIi-53</td>
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<td></td>
<td></td>
<td></td>
<td>8. explain the operation of a simple electric motor and generator.</td>
<td>S10FE-IIj-54</td>
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## K to 12 BASIC EDUCATION CURRICULUM

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<tbody>
<tr>
<td>Grade 10 – Living Things and Their Environment</td>
<td>Third Quarter/Third Grading Period</td>
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</tr>
<tr>
<td>1. Coordinated Functions of the Reproductive, Endocrine, and Nervous Systems</td>
<td>The learners demonstrate an understanding of: 1. organisms as having feedback mechanisms, which are coordinated by the nervous and endocrine systems; 2. how these feedback mechanisms help the organism maintain homeostasis to reproduce</td>
<td>The learners should be able to: 1. describe the parts of the reproductive system and their functions; 2. explain the role of hormones involved in the female and male reproductive systems; 3. describe the feedback mechanisms involved in regulating processes in the female reproductive system (e.g., menstrual cycle); 4. describe how the nervous system coordinates and regulates these feedback mechanisms to maintain homeostasis;</td>
<td></td>
<td>S10LT-IIIa-33</td>
</tr>
<tr>
<td>2. Heredity: Inheritance and Variation</td>
<td>1. the information stored in DNA as being used to make proteins; 2. how changes in a DNA molecule may cause changes in its product; 3. mutations that occur in sex cells as being heritable</td>
<td>5. explain how protein is made using information from DNA; 6. explain how mutations may cause changes in the structure and function of a protein;</td>
<td></td>
<td>S10LT-IIIc-36</td>
</tr>
</tbody>
</table>

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### K to 12 BASIC EDUCATION CURRICULUM

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<tbody>
<tr>
<td><strong>3. Biodiversity and Evolution</strong></td>
<td>how evolution through natural selection can result in biodiversity</td>
<td>write an essay on the importance of adaptation as a mechanism for the survival of a species</td>
<td>7. explain how fossil records, comparative anatomy, and genetic information provide evidence for evolution;</td>
<td>S10LT-III-39</td>
</tr>
<tr>
<td><strong>4. Ecosystems</strong></td>
<td></td>
<td></td>
<td>8. explain the occurrence of evolution;</td>
<td>S10LT-IIIg-40</td>
</tr>
<tr>
<td><strong>4.1 Flow of Energy and Matter in Ecosystems</strong></td>
<td></td>
<td></td>
<td>9. explain how species diversity increases the probability of adaptation and survival of organisms in changing environments;</td>
<td>S10LT-IIIh-41</td>
</tr>
<tr>
<td><strong>4.2 Biodiversity and Stability</strong></td>
<td>1. the influence of biodiversity on the stability of ecosystems</td>
<td></td>
<td>10. explain the relationship between population growth and carrying capacity; and</td>
<td>S10LT-IIIi-42</td>
</tr>
<tr>
<td><strong>4.3 Population Growth and Carrying Capacity</strong></td>
<td>2. an ecosystem as being capable of supporting a limited number of organisms</td>
<td></td>
<td>11. suggest ways to minimize human impact on the environment.</td>
<td>S10LT-IIIj-43</td>
</tr>
</tbody>
</table>

### Grade 10 – Matter

**FOURTH QUARTER/FOURTH GRADING PERIOD**

<table>
<thead>
<tr>
<th>1. Gas Laws</th>
<th>The learners demonstrate an understanding of...</th>
<th>The learners shall be able to:</th>
<th>The learners should be able to...</th>
<th>S10MT-IVa-b-21</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Kinetic Molecular Theory</td>
<td>how gases behave based on the motion and relative distances between gas particles</td>
<td></td>
<td>1. investigate the relationship between:</td>
<td></td>
</tr>
<tr>
<td>1.2 Volume, pressure, and temperature relationship</td>
<td></td>
<td></td>
<td>1.1 volume and pressure at constant temperature of a gas;</td>
<td></td>
</tr>
<tr>
<td>1.3 Ideal gas law</td>
<td></td>
<td></td>
<td>1.2 volume and temperature at constant pressure of a gas;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.3 explains these relationships using the kinetic molecular theory;</td>
<td></td>
</tr>
<tr>
<td>CONTENT</td>
<td>CONTENT STANDARDS</td>
<td>PERFORMANCE STANDARDS</td>
<td>LEARNING COMPETENCY</td>
<td>CODE</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------</td>
</tr>
</tbody>
</table>
| 2. Biomolecules               | 2.1 Elements present in biomolecules  
  2.2 Carbohydrates, lipids, proteins, and nucleic acids  
  2.2.1 Food Labels                                                                                                                                  | the structure of biomolecules, which are made up mostly of a limited number of elements, such as carbon, hydrogen, oxygen, and nitrogen                                                                                     | 2. recognize the major categories of biomolecules such as carbohydrates, lipids, proteins, and nucleic acids;                                                                                                | S10MT-IVc-d-22            |
| 3. Chemical reactions         |                                                                                                                                                                                                                  | using any form of media, present chemical reactions involved in biological and industrial processes affecting life and the environment                                                                                  | 3. apply the principles of conservation of mass to chemical reactions; and                                                                                                                                               | S10MT-IVe-g-23            |
                                                                 |                                                                                                                                                                                                                  |                                                                                                                                                                                                                       | 4. explain how the factors affecting rates of chemical reactions are applied in food preservation and materials production, control of fire, pollution, and corrosion. | S10MT-IVh-j-24            |
**K to 12 BASIC EDUCATION CURRICULUM**

**CODE BOOK LEGEND**

Sample: S8ES-IIId-19

<table>
<thead>
<tr>
<th>LEGEND</th>
<th>SAMPLE</th>
<th>DOMAIN/ COMPONENT</th>
<th>CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Entry</td>
<td>Learning Area and Strand/ Subject or Specialization</td>
<td>Science</td>
<td>S8</td>
</tr>
<tr>
<td>Grade Level</td>
<td>Grade 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uppercase Letter/s</td>
<td>Domain/Content/ Component/ Topic</td>
<td>Earth and Space</td>
<td>ES</td>
</tr>
<tr>
<td>Roman Numeral</td>
<td>Quarter</td>
<td>Second Quarter</td>
<td>II</td>
</tr>
<tr>
<td><em>Zero if no specific quarter</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowercase Letter/s</td>
<td>Week</td>
<td>Week four</td>
<td>d</td>
</tr>
<tr>
<td><em>Put a hyphen (-) in between letters to indicate more than a specific week</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arabic Number</td>
<td>Competency</td>
<td>Infer why the Philippines is prone to typhoons</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DOMAIN/ COMPONENT**

- Living things and their Environment: LT
- Force, Motion, and Energy: FE
- Earth and Space: ES
- Matter: MT
UNIT 2

Force, Motion, and Energy
(The electric and magnetic phenomena around us)
UNIT 2: FORCE, MOTION AND ENERGY
(The electric and magnetic phenomena around us)

Introduction

Each of the three Teacher’s Guide for the second quarter was written to accompany the Learner’s Material in Grade 10 Unit 2 – Force, Motion and Energy (The electric and magnetic phenomena around us). These include introductory information such as the coverage, the content and performance standards, the key questions and the learning competencies. Included also in each guide are the science process skills, the preparation and procedure hints, optional resources and materials, and the activity answers and sample data.

In most of the activity results, the underlying concepts and applications can be found in the Learner’s Material. However, the principles and applications of some activities are discussed in the Teacher’s Guide and not in the Learner’s Materials. As a whole, the selected activities were designed to promote enthusiasm in the teaching and learning of science through technology and scientific inquiry.

The learners also have opportunities to design their own experiments, pursue each, and extend their inquiries. These activities also have definite results just like in structured activities, but the open enquiry can allow for instructional accommodation and creativity suited to the needs of learners.

All modules in Unit 2 integrated the practical work approach and used models for individual or group performances. The activities can be facilitated using varying inductive and deductive approaches so the learners will understand the roles of force, motion and energy in the specific study of naturally occurring magnets, electromagnets, moving charges, and the interaction of the electric fields and the magnetic fields created by such matter. The nature, transmission and uses of the ever present electromagnetic waves, especially light, will be studied in great detail. There are three modules in this quarter, namely:

Module 1 - Electricity and Magnetism

Module 2 - Electromagnetic Spectrum

Module 3 - Light: Mirrors and Lenses
In Grade 9 Science, the students located several power plants in the Philippines and traced the conversions of energy in hydro power, geothermal power, and coal-fired power plants. In general, the students learned how electricity is generated in power plants. They also traced what happened to the voltage during electric power transmissions and distributions.

In this module, the focus of study is on understanding the working principles behind electric motors and generators common in power plants and other important technologies. The students will explore the relationship between electricity and magnetism through activities that will demonstrate the nature of magnetism and the principles of electromagnetism and electromagnetic induction. Thus, different electric and magnetic field patterns will be mapped with its associated forces and directions.

This module is good for twenty to twenty three (23) one-hour sessions. The activities were made simple making use of common materials and science equipment intended for secondary schools in the country.

Specifically, at the end of Module 1, the students should be able to answer the following key questions and use the learning objectives as guide:
Key questions for this module

How is electricity related to magnetism?

How does electricity produce magnetism, and magnetism produce electricity?

How does an electric motor and an electric generator work?

What is electromagnetic induction?

Learning Competencies/Objectives:

1. Make a simple device that shows how a magnetic field exerts a force on a wire.

2. Demonstrate the generation of electricity by movement of a magnet through a coil.

3. Explain the operation of a simple electric motor and generator.

Pre-Assessment

Directions. Choose the letter of the correct answer.

1. In which case or cases is electric field present?
   
   I. A spark jumping between two nearby rods.
   II. A charge that is momentarily at rest.
   III. A rotating bar magnet.

   a. I only
   b. I and II only
   c. II and III only
   d. I, II and III

2. In which case can a magnetic field be produced?
   
   a. A charged comb.
   b. A falling glass rod.
   c. A welder’s arc flash.
   d. A rolling plastic cylinder.
3. Which device can be used to determine the polarity of an unmarked magnet?
   a. a charged glass stirring rod  
   b. a gold-leaf electroscope  
   c. a sprinkle of iron filings  
   d. an improvised compass

4. How will you describe the magnetic field around a straight current-carrying wire?
   a. The magnetic field is strongest near and around the wire.  
   b. The magnetic field consists of straight lines parallel to the wire.  
   c. The magnetic field does not vary with the distance from the wire.  
   d. The magnetic field gets stronger with increasing distance from the wire.

5. Which statement about an electromagnet is TRUE?
   a. The electric field surrounding a battery-powered electromagnet alternates constantly.  
   b. The current in the electromagnet coil temporarily magnetizes the iron core.  
   c. The electric field strength is inversely proportional to the current.  
   d. The magnetic field lines produced are all straight.

6. What can be inferred from the alignment of compass needles in the set-up below?
   a. A permanent magnet is nearby.  
   b. The power switch was turned off for long.  
   c. The current-carrying coil becomes magnetic.  
   d. There is a constant and uniform magnetic field around the coil.
7. As part of a traffic light system, large loops of wire are buried beneath road intersections. Which of the statements is NOT TRUE about the operation of this traffic light system?
   a. Vehicles driven over the buried coils activate a traffic light sensor.
   b. The conducting loops activate a color-dependent field.
   c. The alternating current sent through the buried coils produce an electromagnetic field in each coil.
   d. A fixed number of vehicles over the coils can trigger the traffic light to change green.

8. Complete the following statement: Moving a metallic detector past a 5 peso coin creates a secondary magnetic field that is most likely that of _____.
   a. a horse shoe magnet
   b. a flat refrigerator magnet
   c. a current-carrying, circular loop
   d. a V-shaped straight wire that carries a current

9. During the Student Technologists and Entrepreneurs of the Philippines (STEP) Competition in Landscaping, a water pond transformer changes 216 V across the primary to 12 V across the secondary. If the secondary coil has 10 turns, how many turns does the primary coil have?
   a. 10 turns
   b. 18 turns
   c. 180 turns
   d. 228 turns

10. What basic principle enables ALL electric motors to operate?
   a. Iron is the only element that is magnetic.
   b. Opposite electric charges attract and like charges repel.
   c. A moving conductor within a magnetic field will experience an electromotive force.
   d. A current-carrying conductor placed within a magnetic field will experience a magnetic force.

11. A magnet moves inside a coil. Consider the following factors:
   I. strength of the magnet
   II. number of turns in the coil
   III. speed at which the magnet moves

Which can affect the electromotive force (emf) induced in the coil?
   a. I only
   b. II only
   c. III only
   d. All three factors
12. Which statement about transformers is FALSE?
   a. A step-down voltage transformer steps up the current.
   b. Transformers use mutual induction.
   c. Transformers are an application of Faraday’s and Lenz’s Laws.
   d. A transformer can function with either an alternating current (AC) or a steady direct current (DC).

13. What is TRUE about the intercom system that is shown below?

![Intercom System Diagram]

   a. The part A of the intercom system serves as a microphone only, while part C serves as a loudspeaker only.
   b. Either parts A and C of the intercom when switched as such can be used as a microphone or as a loudspeaker.
   c. The microphone part only basically consists of wires, a cone diaphragm, a magnet, and a coil.
   d. The loudspeaker part only basically consists of wires, a cone diaphragm, a magnet, and a coil.

14. What transformation can take place in an improvised generator?
   a. mechanical energy into electrical energy
   b. electrical energy into mechanical energy
   c. alternating current into direct current
   d. direct current into alternating current

15. A loop of conductor lies flat on a horizontal table. A toy magnet is hanging still over it with the magnet’s north-seeking pole pointing down. What happens next?
   a. The magnet produces a clockwise current in the coil.
   b. The magnet does not produce any current in the coil.
   c. The magnet produces an upward electromagnetic current.
   d. The magnet produces a counterclockwise current in the coil.
Getting Hooked on Electricity and Magnetism Applications

Traditional learning and teaching of the highly abstract electromagnetism principles usually proceed deductively with theories being studied in activities and lesson sequences. An alternative approach would be to help the students see the important Science-Technology-Society-Environment (STSE) links to what they inductively learn in school and in other learning venues and opportunities.

Integrated in the Learner’s Materials were technology-based questions and a sample enrichment output like the “Octo-Challenge Audio-Visual Production (AVP) Using Electromagnetic Induction (EMI).” This was done to ensure that students will continue to take interest in other practical applications of electromagnetic induction aside from those applications in electric generators and motors.

Posing the AVP challenge at the beginning of the module gives the students a good head start in immersing positively into the module. Monitoring the students’ progress in the enrichment activity will help both the learner and teacher see the need to know the science behind the modern-day applications.

The AVP challenge can also be an avenue to showcase Philippine National Celebrations as well as give the students a chance to show their artistic talents at the end of the second quarter.

A sample AVP entitled “Ako’y Malaya (I Am Free)” – Noel Cabangon Official Video may serve as an inspiration for the AVP Challenge. This can be viewed at http://www.youtube.com/watch?v=w1InDNE-rhM.
Performance Task

An Octo Challenge Audio-Visual Production (AVP)
Using Electromagnetic Induction (EMI)
An Enrichment Activity

Objective:

Plan, perform and record a 5-minute audio alone or audio-visual presentation related to any Philippine National Celebration during October using devices that apply both electricity and magnetism.

Materials Needed:
- at least one musical instrument
- audio alone or audio-video recording technology of your choice
- support materials as needed by your team
- printed transcript of spoken parts of AVP

Procedure:

1. Meet as a group and agree on the role of each member according to interests and skills in the making and recording of the AVP presentation.

2. Listed below are eight October national celebrations observed by Filipinos:
   - National Children’s Month
   - Elderly Filipino Week
   - Philippine Consumer Welfare Month
   - Food Safety Awareness Week
   - Moral Guidance Week for Public Servants
   - United Nations Celebration
   - Indigenous People’s Celebration
   - World Teacher’s Day

   Use only one event to highlight in your AVP tribute that will introduce briefly the audience to the making and recording of an audio-only or an audio-visual presentation using electromagnetic induction partially or entirely.
3. Your group has four weeks to plan, perform and record together the five-minute AVP tribute with the following guidelines:

a. Gather information about your selected musical instrument and recording device. Learn how these use electricity and magnetism. Give a multimedia introduction on this for a minute or two.

b. Dedicate the remaining three minutes in highlighting the chosen October event. Decide whether you will record an audio-only or an audio-visual presentation taking into consideration the listening and processing efforts needed to fully appreciate the event or the reason behind it. Plan, perform and record an age-appropriate music-video tribute.

c. Ensure that the AVP is an output of the whole circle of friends. At the end of the AVP include a brief roll of credits.

d. The making and recording of the AVP should be done only during non-class hours inside the school premises only.

e. You are liable for the proper and safe use of all audio-video production and recording devices whether these are personally owned or a school property. Ensure also minimal energy use.

f. Agree on a checklist to help your group monitor your task progress. Prepare also a written transcript of your AVP’s recorded audio.

g. Prepare a digital record of your AVP on a compact disc, ready for premiere viewing in the class at the end of this module period.

Criteria for Success - The making and recording of the October - themed AVP will be rated based on the following criteria:

1. Knowledge and understanding of EMI.
2. Thinking and inquiry on the AVP plans and preparations.
3. Communication through language and style.
4. Communication through music and video presentation conventions.
5. Special Criterion on Technical Quality or Original Song Production.
Use the GRASPS guidelines below to guide your group in the successful completion of the performance task before the end of Module 1.

<table>
<thead>
<tr>
<th>Grade 10 Science, Unit II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Task: An Octo Challenge Audio-Visual Presentation</td>
</tr>
<tr>
<td>(An Enrichment Activity)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GOAL</th>
<th>To introduce electromagnetic induction (EMI) recording technology and lead the audience to a deeper appreciation of an October Philippine National Celebration.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROLE</td>
<td>You and your friends, of varied interests and skills, are currently into the music and video recording using the advantages/features of your personal gadgets. But your group has this one idea. For the last half year of junior high school, you intend to bond as a group with more meaningful memories together and want to make one productive AVP, for a start</td>
</tr>
<tr>
<td>AUDIENCE</td>
<td>The AVP will be shown as an infomercial on EMI and as a tribute during the October Celebration you will showcase.</td>
</tr>
<tr>
<td>SITUATION</td>
<td>It is late September and you are almost through with the first half of Junior High School. The semestral break is a month away. Your group wants to do something worth sharing. Then your friend has this exciting idea . . . Why not set a trend of staging and recording AVPs that are shorter versions of class video outputs like a Yes-O Docu-Kalikasan, an El Filibusterismo documentary teaser, or a dance exercise</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>Mechanics: Within four weeks you will put together, perform and record on a compact disc a 5-minute AVP with a written transcript. This would be shown as a video preview highlighting both the EMI recording technology and the October event. Create the audio-visual presentation of an original performance such as a folk song, slide show with narration and the like. The AVP should start with an introduction on how EMI was applied into the production and recording of the AVP. Dedicate the remaining three minutes in highlighting the chosen October event. Plan and perform an age-appropriate music-video tribute. The roll of credits at the end must show the contributed work of each member as well as the sources of other materials you used.</td>
</tr>
<tr>
<td>STANDARDS</td>
<td>The group of learners shall be able to use a technology that shows the relationship of electricity and magnetism. Content: 50% (Refer to the AVP task rubric criteria 1 – 2.) AVP : 50% (Refer to the AVP task rubric criteria 3 – 5.)</td>
</tr>
</tbody>
</table>

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All groups will use the task rubric below as they assess their progress. The teacher may also use this in assessing individual and group performances.

**Performance Task Rubric for the Development of an Octo Challenge Audio-Visual Presentation (AVP)**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>1 - 2</th>
<th>3 - 4</th>
<th>5 - 6</th>
<th>7 - 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge and Understanding</td>
<td>demonstrates limited research and understanding of EMI in recording AVP</td>
<td>demonstrates some research and understanding of EMI in recording AVP</td>
<td>demonstrates considerable research and understanding of EMI in recording AVP</td>
<td>demonstrates thorough research and insightful understanding of EMI in recording AVP</td>
</tr>
<tr>
<td><em>Topic (EMI in Recording AV)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Thinking and Inquiry</td>
<td>demonstrates limited time and effort in planning and preparing for the performance</td>
<td>demonstrates some time and effort in planning and preparing for the performance</td>
<td>demonstrates considerable time and effort in planning and preparing for the performance</td>
<td>demonstrates extensive time and effort in preparing for an excellent performance</td>
</tr>
<tr>
<td></td>
<td>focus not provided, but follows through with information and brings presentation to a close</td>
<td>focus not provided, but follows through with information and brings presentation to a close</td>
<td>clear beginning, middle and end</td>
<td>clear beginning, middle and end</td>
</tr>
<tr>
<td>Planning and Preparation</td>
<td>presentation is disorganized</td>
<td>presentation lacks structure</td>
<td>presentation flows well</td>
<td>presentation flows seamlessly</td>
</tr>
<tr>
<td>3. Communication</td>
<td>communicates orally with a limited sense of audience and purpose</td>
<td>communicates orally with some sense of audience and purpose</td>
<td>communicates orally with a clear sense of audience and purpose</td>
<td>communicates orally with a strong sense of audience and purpose</td>
</tr>
<tr>
<td>Language and Style</td>
<td>uses few audio visual elements to enhance performance</td>
<td>uses some simple audio-visual elements to enhance performance</td>
<td>uses a variety of audio-visual elements to enhance performance</td>
<td>uses creative and innovative audio-visual elements to enhance performance</td>
</tr>
<tr>
<td>4. Communication</td>
<td>no evident use of support materials (visuals and devices)</td>
<td>uses support materials (visuals and devices) ineffectively or with little success</td>
<td>uses support materials (visuals and devices) effectively and with moderate success</td>
<td>uses support materials effectively with a high degree of success</td>
</tr>
<tr>
<td>Presentation Convention</td>
<td>production techniques need improvement with no originality</td>
<td>production techniques or originality are evident</td>
<td>production techniques and originality show evident skills</td>
<td>production techniques and originality show great skills and creativity</td>
</tr>
<tr>
<td>5. Special Criterion</td>
<td>Technical Quality or Folk Song Originality</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* This criterion must be assessed on the group’s written transcript for the AVP.
Principles of Electromagnetic Induction (EMI) in Recording Systems

In recording systems and technology, whether analog or digital, magnetic recording is the name of the game. In a magnetic recording of a music or video input, the signal is converted into electrical signals via transducers like a microphone.

It then passes through a magnetic recorder like the read/write head of a video disc player, converting and recording the electrical signals into a magnetic pattern on a medium like a laser disc or a cassette tape. During recording and playback, the magnetic medium moves from the supply reel to the take-up reel.

The signals change the magnetic field that cuts through the head inducing a changing electric current in the head relying on the speed and strength of the magnetic field. The induced electrical currents are then amplified and sent to an audio only or an audio-video monitor where another transducer, like a speaker, changes the electrical signals to the desired output.

Figure 1. Read/Write Head of (a) a Disc Player, and (b) a Cassette Tape Player (bottom)
Activity 1

For the Record

This is a two-part activity that highlight the recording and/or the broadcasting technologies as an old yet ever evolving popular application of the relationship between electricity and magnetism known as electromagnetic induction.

Teaching Tips:

PART A. Virtual Tour of a Radio Broadcasting Studio
(Suggested time allotment: 1 hour)

1. Use clear printed photos of a radio station control room and audio room similar to those shown in the Learner’s Materials. Remind the students to identify as much as they can the devices that use electricity and/or magnetism. These will expose their conceptions on current-carrying conductors and materials that exhibit magnetism.

2. Prepare to show ‘Radio Station Tour’ video clips that may be available online similar to the clips cited below:
   - Classic Broadcast TV Control Room at http://www.youtube.com/watch?v=5zGr1d6IcRI
   - Radio station studio tour at http://www.youtube.com/watch?v=9Vlbq5RAKQw
   - WFMY News 2 – Station Tour #1 – Control Room at http://www.youtube.com/watch?v=A-VOdxQpMi0
   - WFMY News 2 – Station Tour #2 – Newsroom and Receive at http://www.youtube.com/watch?v=pntVX0Wdb-U

3. If there is a nearby local radio-television station that accepts visit from secondary school students, attend to the proper arrangements for (a) permits, (b) allowed schedules, (c) available human resources, and (d) safety measures. A tour of the other major components of a radio station may be included, but is not a prerequisite activity for Part B.

4. Showing the video clips or an actual visit will surely help the students with the technical terms, devices and functions. Plus there is that exciting prospect of students being allowed to participate in live AVP production and recordings in the radio station or the recording studio being visited.
Enrichment/Extension Activity:

1. Let the students do the extension activity and the suggested reading support in the LM. Check their concept organizer about the basic recording devices and equipment. Emphasize the need to identify which parts inside the devices makes use of electricity and magnetism. It would be a great help if the students can look at labeled cut-away diagrams of basic AV recording devices and/or dismantle available broken recording devices themselves.

Answers to Questions:

Q1. How many of the devices you identified inside the control room need electricity to operate?

Answers may vary according to what electrical devices the students can identify from the pictures or video clips. Generally, most equipment function using electricity.

Q2. How many of the devices you identified inside the control room need magnetism to operate?

Answers may vary according to what devices the students can identify as generally operating with parts or materials having a permanent or a temporary magnetic nature. Generally, many materials that run on electricity has an associated magnetism to it.
Sample Data for Activity 1 Part A:

**Table 1. Typical Radio Broadcast Studio Equipment**
(Control Room or Announcer’s Booth)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Needs Electricity</th>
<th>Needs Magnetism</th>
</tr>
</thead>
<tbody>
<tr>
<td>microphones (for the broadcaster, spinner or disc jockey and for the station guest/s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>computer unit and accessories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>video web camera (no speaker)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>head phone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>audio console mixer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sound monitors or boxed speakers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“wired” landline telephone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>satellite receiver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lighting units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ventilation and air conditioning units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>audio-video cables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>power supply units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>extension wires</td>
<td></td>
<td></td>
</tr>
<tr>
<td>manual switches</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Radio Broadcast Studio Equipment (Live Audio Room/Newsroom)**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Needs Electricity</th>
<th>Needs Magnetism</th>
</tr>
</thead>
<tbody>
<tr>
<td>microphones (for the anchorman, show host and station guests and music equipment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>video/television monitors and accessories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>video camera and recorder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>head phone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>digital video mixer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>audio mixer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>audio/audio-video media players</td>
<td></td>
<td></td>
</tr>
<tr>
<td>microphone and video camera stands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>audio-video cables and power supply units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lighting units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ventilation/air conditioning units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wireless in-ear monitors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VHS and cassette tapes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDs, VCDs, DVDs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>manual switches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote control</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q3. How many of the devices you identified inside the live audio room need electricity to operate?

*Answers may vary according to what electrical devices the students can identify from the pictures or video clips. Generally, most equipment function using electricity.*

Q4. How many of the devices you identified inside the live audio room need magnetism to operate?

*Answers may vary according to what devices the students can identify as generally operating with parts or materials having permanent or temporary magnetic natures. Generally, many materials that run on electricity also has an associated magnetism to it.*

Q5. What other devices not shown in the photo may be used inside the live audio room locally known as the newsroom?

*Timing devices, musical instruments (non-electric and electronic), alarm devices, etc.*

**Teaching Tips:**

**PART B. My Own Home Recording Studio! For Life…**

(Suggested time allotment: 1 hour)

1. This activity can be used as a Just-in Time Teaching home reading activity if the previous activity is conducted through the use of pictures only. Let the students read on the recording technology equipment that they are not yet familiar with.

2. Primarily, this activity is meant to capture the interest and the inquiry on the audio-recording EMI applications. Mastery of the technical terms and skills in making an AVP comes secondary.

3. It would be wise to tap the students who have adequate ICT knowledge and skills developed through Technology and Livelihood Education lessons on hardware servicing and applications. Get them to identify or discuss basic internal parts of AV recording devices that operates with the use of electricity, magnetism or both.
Enrichment/Additional Information:

1. Let the students do the reading activity on recording technology as suggested in the LM and let them make an illustrated audio recording studio setup or an audio recording studio process flow chart on their science notebook similar to what is shown below regarding music production, recording, editing, mixing, digitizing and mastering of an audio record on a storage device such as a recording disc or a magnetic tape.

Figure 2. A sample typical Recording Studio Set-up

Figure 3. A sample basic Home Studio Set-up
## Sample Data for Activity 1 Part B:

### Table 3. A Home Recording Studio Start up Equipment

<table>
<thead>
<tr>
<th>Picture</th>
<th>Coded Answer</th>
<th>Device Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td>1 F IV</td>
<td>F. condenser or dynamic microphone</td>
<td>IV. Converts sound into electrical signal.</td>
</tr>
</tbody>
</table>

**Working Principle of a Condenser Microphone**
- The varying sound pressure changes the spacing between a thin metallic membrane and a stationary plate, producing electrical signals which “copy” the sound pressure.

**Salient Features:** Works with a wide range of sound frequencies. Although expensive, it is considered as the best microphone for recording applications.

**Working Principle of a Dynamic Microphone**
- The varying sound pressure moves the cone diaphragm and the coil attached to it within a magnetic field, producing an electromotive force that generates electrical signals which “copy” the sound pressure.

**Salient Features:** The inverse of a dynamic loudspeaker and relatively cheap and rugged.

<table>
<thead>
<tr>
<th>Picture</th>
<th>Coded Answer</th>
<th>Device Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td>2 E III</td>
<td>E. computer unit</td>
<td>III. Processor should be reasonably fast enough to record, edit, mix, store, and master a copy of the record.</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td>3 A V</td>
<td>A. headphone</td>
<td>V. Used for “referencing” or for checking what the mix would sound like on the equipment.</td>
</tr>
</tbody>
</table>
Headphone

**Working Principle of a Headphone or an Earbud**

- Wires carry the audio signal from the stereo into the coil and back again. The coil around the plastic cone becomes an electromagnet when current passes through it. And because the coil is within a magnetic field, a force is generated on the coil. In response to the audio signal, the coil moves together with the flexible flat crinkly cone moving the air within the headphone/earbud enclosure and in the ear canal producing sound.

**Salient Features:** Headphones and earphones are small loudspeakers clamped over the ear/s. Basically, each speaker consists of stereo wires, plastic cone diaphragms, coils attached to the cone, and magnets built inside cased or padded sound chambers.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>4 G VI</td>
<td>G. cables</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VI. Used for connecting audio interface, microphones, studio monitors, and different instruments.</td>
</tr>
<tr>
<td>5.</td>
<td>5 B VII</td>
<td>B. studio monitor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VII. Commonly known as speakers but these give a sound close enough to the real sound input.</td>
</tr>
</tbody>
</table>
Working Principle of a Studio Monitor or a Speaker

- The electric current imaging the audio signal is sent through the coil that is within the magnetic field. A force is generated that moves the magnet and the cone attached to it producing the sound corresponding to the analog or digital signal.

**Salient Features:** The studio monitor is a dynamic reference speaker designed to produce an accurate image of the sound source. Most hobby studio use the active type studio monitor. It has a built-in amplifier and functions when plugged into an outlet and a sound source. A dynamic speaker, like the studio monitor, has the same essential parts as a dynamic microphone. But unlike the microphone or headphone where the voice coil is attached to the cone diaphragm, on the studio monitor, it is the permanent magnet that is attached to the cone while the coil is wound around a fixed core.

Q6. Which devices on Table 3 are powered, entirely or partially, by electromagnetic induction (the phenomenon of a changing magnetic or electric field’s effect on electricity or magnetism)?

The microphone, computer unit, headphone, studio monitor, and the audio interface are powered entirely or partially by electromagnetic induction. Although audio cables may be affected by electromagnetic interference, basically these are supposed to be shielded to work most effectively and do not use electromagnetic induction to operate. Moreover, the digital audio software is just a computer application on virtual studios, thus do not also operate on the EMI principles.
Both Activities A and B, show that most, if not all, of the devices in a recording studio use electricity and magnetism.

SOME BASIC PRINCIPLES OF MAGNETISM

The Nature of Magnetism: Electricity’s Silent Partner

Magnetism is a property of a material that enables to attract or repel other materials. The presence and strength of the material’s magnetic properties can be observed by the effect of the forces of attraction and repulsion on other materials. Its polarity, three-dimensional field form, strength, and direction can also be detected by the deflection of a magnetic pointer within its field, like that in a compass or the arrangement of iron filings in magnetic boards.

A material’s individual protons and electrons are basically considered tiny magnets due to the intrinsic magnetic moments of charges. But the magnetism of an electron is a thousand times bigger than that of a proton. So in an atom, the intrinsic magnetic field is mostly due to the ever-moving electrons in the half-filled orbital shell where electrons are unpaired and their tiny intrinsic magnetic moments point in the same direction, thus orbital magnetic field arise.

But not all materials that contain magnetic atoms in the half-filled region of the Periodic Table become magnetic. Only atoms of metals such as iron, nickel, and cobalt have half-filled shells that have many domains pointing mostly in one direction. When these are placed within an external magnetic field, the weaker domains unify with the stronger domains. These line up more uniformly inducing greater magnetic field strength. Materials made from these elements and its alloys are classified as ferromagnetic and make strong permanent magnets.

Thus, magnets brought near materials that contain one of the ferromagnetic metals will induce magnetism in the object and thus attract it. Magnetic induction also makes iron filings and compass pointers align themselves along the magnetic field lines that caused induction. The magnetic field lines go out of the north-seeking poles and loops back continuously going to the other south-seeking end of the magnet closing the loop inside out.
Activity 2

Test Mag . . . 1, 2!
Testing for Evidence of Magnetism
(Suggested time allotment: 1 hour)

Teaching Tips:

1. This activity and the next two activities may be done by students working in small groups according to the available sets of materials. For classes with limited materials and large groups of students, the Interactive Lecture Demonstrations (ILDs) developed from Physics Education Research works at the University of Oregon and at Tufts University or its contextualized variations, may serve as an alternative active teaching and learning strategy.

The Eight Step Interactive Lecture Demonstration calls for the teacher to facilitate the description, demonstration (partially or wholly), and discussion of the short activities. The students make, record, discuss with others, and even modify their own predictions. The teacher then completes the demonstration, while the students observe, record results, discuss the science concepts involved and finally relate understanding to different analogous physical situations.

2. A similar strategy known as the Predict-Observe-Explain (POE) approach is an easier and more common way in giving students a chance to give their predictions openly without regard of its correctness, make observations during the demonstration, and explain the correct principle learned based on their observation.

3. For parts of the activities that call for student-designed inquiry, the teacher may facilitate student demonstrations of the most common design in the class.

4. Remind also the students to use the magnets with care during the activities without dropping or bringing them near materials that can be affected by induced magnetism such as computer disks, monitors, magnetic tapes, mechanical watches and the like.

5. Select pairs of bar magnets that are light and strong enough to show considerably the forces of attraction and repulsion. Some bar magnet’s forces of attraction or repulsion can only be felt by the user’s hand but not observable for others to note.
**Sample Data for Activity 2:**

**Table 4. Interaction between two bar magnets.**

<table>
<thead>
<tr>
<th>What I did to the pair of magnets to cause interaction…</th>
<th>Observed effect/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The students may possibly opt to place the first magnet on a flat, horizontal surface and bring one end of the second magnet near the other magnet’s end.</td>
<td>- The first magnet may move closer or farther from the other and when the unlike poles are close enough, will stick together closing the gap.</td>
</tr>
<tr>
<td>- The students may also place the first magnet on a flat horizontal surface and horizontally bring one end of the second magnet near the first magnet’s middle part OR move the second magnet in circles over the first.</td>
<td>- The first magnet may rotate towards (for attractive forces) or away from (for repulsive forces) the second magnet.</td>
</tr>
</tbody>
</table>

**Table 5. Interaction of a bar magnet with other objects.**

<table>
<thead>
<tr>
<th>Objects that interacted with the magnet…</th>
<th>Observed effect/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample objects may be metallic notebook springs, paper clips, pens with metallic casings, 25 centavo coins, key holder chains, keys, metallic hair pins,</td>
<td>- Objects that are small enough will move towards or attach itself to the test bar magnet.</td>
</tr>
<tr>
<td></td>
<td>- Some parts of big objects will be attracted to any part of the test bar magnet.</td>
</tr>
</tbody>
</table>
Answers to Questions:

Q7. What conditions with observable effects make magnets interact with another magnet?

*Magnets that are in good condition are strong enough to push or pull another magnet close enough to it.*

Q8. In general, what conditions with observable effects make magnets interact with non-magnet objects?

*Magnets, strong or weak, can be made to attract non-magnet objects that is made of or has parts that are magnetic in nature such as those made of iron, nickel, cobalt or its alloys.*

Q9. What type of force/s can magnets exert on another magnet?

*Magnets can both attract and repel other magnets. Like poles of magnets when close enough will cause the magnets to repel each other, while unlike poles of magnets that are close enough will cause the magnets to attract each other.*

Q10. What type of force/s can magnets exert on non-magnet objects with observable effects?

*Both poles of the magnet can attract non-magnet objects that have materials or parts that are magnetic in nature.*

Q11. How will you differentiate magnets from objects made of magnetic materials?

*Only magnets can repel other magnets and already magnetized objects. But non-magnetized objects made of magnetic materials can only be attracted by a magnet.*
Activity 3

Induced Magnetism
(Suggested time allotment: 1 hour)

Teaching Tips:

1. This activity may be done by students working in groups of three or four with the teacher using the Interactive Lecture Demonstrations (ILDs) or contextualized variations of it like the Predict - Observe - Explain (POE).

2. Remind again the students to use the magnets with caution during the activities without dropping these. The bar magnets in use need not be of the same condition (strength, size, etc.) so as to maximize individual engagement in this simple activity. If group results will yield different numbers of magnetically induced nails being capable of inducing further magnetism on other non-magnetized nails, it would be a good source of comparison and inquiry groups can easily discuss among themselves.

Answers to Questions:

Q12. What happens if you bring two iron nails close to (or touching) each other?

There is no observable effect in bringing two iron nails close to (or touching) each other.

Q13. If you bring a bar magnet close to (or touching) the first iron nail, can the first iron nail attract and lift a second nail? A third one?

A bar magnet brought close to (or touching) the first iron nail makes the first iron nail capable to attract and/or lift a second nail and another or so depending on the magnet’s strength.

Q14. What happens when you move the bar magnet far from the nails?

The first nail may still attract the second nail and another one or more depending on the strength of the induced magnetism but not as strong as before when the magnet was still close to (or touching) the first magnetized nail.
Q15. If the north pole of the bar magnet suspends by attracting the first screw shown below, what is the screw’s polarity of induced magnetism in the indicated regions? Why?

![Figure 4. Magnetic induction on hanging screws with induced polarities.](image)

The head of the first screw served as the magnetic south-seeking pole by principle that unlike magnetic poles attract and like magnetic poles repel. Thus, it can be said that the free end of the screw served as the magnetic north pole.

**Sum it Up Challenge!**

The process by which the screws become magnets is called 1. magnetic induction. This same process is the reason why magnets 2. attract non-magnetized magnetic substances such as the screw. The screw becomes 3. an induced magnet with the end nearer the magnet having 4. an opposite polarity to that of the permanent magnet. Hence attraction happens 5. after magnetic induction occurs.
Activity 4

Detecting and Creating Magnetism
(Suggested time allotment: 1-2 hours)

Teaching Tips:

1. This activity may be done by students working in small groups of three or four with the teacher using the Interactive Lecture Demonstrations (ILDs) or contextualized variations of it like the Predict - Observe - Explain (POE).

2. Remind the students to use with care and handle without dropping the magnet, compasses, test tube and gadget with camera.

3. The bar magnets to be used should be strong enough to cause effects on the (a) iron filings inside the test tube or straw and the (b) compasses in use. Check also that the compasses are in good condition with the needle compass still pointing to the north geographic pole and not the other way around. If there are enough compasses for all groups, set aside those that need to be magnetized again to induce the correct polarities. If time permits, students may be asked to resolve this concern as a check that indeed they can apply magnetization by stroking to correct the polarities of magnetic compass needles.

4. It would be best to have the students get use to orienting their compasses along the geographic North-South alignment of the compass needle prior to introducing the magnet into the activity setup.

5. For some classes, there might be a need to review the parts of a typical magnetic compass to remind the students that a compass needle is a small magnet that is free to pivot in a horizontal plane about an axis and that the end of the magnet that points to geographic north is called the north (N) pole. Likewise, the opposite end of the magnet is the south (S) pole.
Answers to Questions:

PART A. North meets south

Q16. What happens when you randomly move the bar magnet roundabout and in circles above the compass one foot or farther? Nearer than a foot?

Answers will vary. Sample answers:

On exploration of the compasses ability to indicate the magnet’s strength:

- For button compasses: When the bar magnet was moved around the compass one foot or farther away from the still compass on a horizontal surface, the compass needle slightly deflected clockwise or counterclockwise or nothing happened to it at all. For moving the bar magnet in circles a foot or farther above the compass, the compass needle slightly rotated in the same direction or nothing at all.

- For button compasses: But when the bar magnet was moved around the compass nearer than a foot from the compass, the compass needle deflected clockwise or counterclockwise more noticeably. For moving the bar magnet in circles nearer than a foot above the compass, the compass needle rotated more easily in the same direction as the rotating magnet.

- For bigger compasses that has magnetic needles twice as long as that of the button compasses, the above observations are much more noticeable even at a two-foot separation from the same magnet. This suggests that the longer needle has greater attractive or repulsive interaction with the magnet.

On exploration of the compasses ability to indicate the magnet’s polarity:

- For all noticeable deflections, when the north end of the bar magnet is brought near the south end of the compass needle, the needle is attracted and moves towards the magnet. So when the magnet is moved around the compass in whatever direction, the compass needle follows with it.

- But when the north end of the bar magnet is brought near the north of the compass needle, the needle rotates away from the magnet’s north end due to repulsion until the south end of the compass needle is nearest the north end of the magnet.
Q17. Compass needles are tiny magnets that are free to indicate the north and south poles of a magnet? What do you need to do to know the magnet’s polarities?

Lay the magnet on a horizontal surface and place the button compass right next to the magnet’s north end. The compass needle will point away from the magnet’s north end.

Move the compass towards the south end of the magnet along the horizontal surface and see the compass needle pointing towards the south pole of the bar magnet.

Q18. What does the two compass needles indicate about the iron nail that is shown below?

![Figure 5](image)

Figure 5. Compass needles for checking an object’s magnetism through the presence of two opposite poles.

Because both compass needles are still aligned along the same North-South geographic direction, it can be inferred that the non-polarized iron nail, though magnetic in nature, has not yet been magnetized.

Sample Data for Activity 4 Part B:

PART B. By the touch of a magnet

Sample results and observations for step 4:

![Figure 6](image)

Figure 6. Magnetization of enclosed iron filings by stroking.

Inside the test tube or transparent straw (cool pearl straw taped on both ends),
the iron filings are attracted to the magnet during stroking, whether the magnet is touching or close to the test tube.

Sample result for step 5:

![Figure 7](image)

**Figure 7.** Testing the induced magnetism on an enclosed iron filings using the compass.

Sample result for the Extension Activity:

![Figure 8](image)

**Figure 8.** Testing the induced magnetism on an iron nail using compasses.

**Answers to Questions:**

**Q19.** Are the iron filings in the test tube or straw magnetized? If yes, which end is the north and which is the south? If no, what else can be done to magnetize it? Try and record your idea.

Yes, the iron filings inside the test tube/straw are magnetized. The iron filings inside the test tube/straw were magnetized by stroking. The end of the test tube/straw (cork/right end) was induced as the south-pole. The starting/left end always have the same induced polarity as the polarity of the magnet’s end that was used for inducing magnetism by stroking.

If no: Run additional strokes to induce stronger magnetism results. See to it that at the coked/right end of the test tube/straw, the bar magnet is totally pulled up and away slowly (detaching iron filings slowly from the straw/test tube’s top side). Then the magnet is made to touch again the test tube/straw at the starting (curved bottom)/left end. Do this until similar results for the magnetized iron filings are observed.

The extension activity on magnetizing an iron nail by stroking has similar results to the more visual magnetization by stroking of the iron filings inside the test tube.

**Q20.** What happened to the iron filings magnetism after several shakes? How do you know this?
The iron filings lose their induced magnetism after an adequate number of shakes.

Activity 4

Oh Magnets, Electromagnets . . .
(Suggested time allotment: 2-3 hours)

Teaching Tips:

1. When needed, prepare in advance the improvised magnetic field mapping apparatus commonly known as a magnetic board based on an adaptation from the DepEd-NSTIC Improvised Projects Manual is described below:

DepEd-NSTIC Project Concept of a Magnetic Field Mapping Apparatus

A magnetic field is a field of force produced by a magnetic object or particle, or by a changing electrical field and is detected by the force it exerts on other magnetic materials and moving electric charges. Magnetic field sources are essentially dipolar in nature, having a north and a south magnetic poles. Characteristics of a magnetic field around a permanent magnet can be examined more closely by studying the pattern of paramagnetic particles brought near the vicinity of the permanent magnet.

Materials:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pc</td>
<td>clear, flat rectangular plastic containers (100 ml)</td>
</tr>
<tr>
<td>100 ml</td>
<td>tap clear water or glycerin</td>
</tr>
<tr>
<td>5 g</td>
<td>bargaja / iron sand or iron filings</td>
</tr>
</tbody>
</table>

Procedure:

A. Gather dark beach sand using a strong magnet placed inside a plastic. If this is not possible, use the common available iron filings. Place these on a cheese cloth before running tap water over until the water washings come out clear.

B. Fill the empty flat bottle with tap water to the brim and add a pinch of washed iron sand or filings. Put the cap and shake the bottle.

C. Add more iron sand or filings until there are enough iron sand/iron filings that will give a distinct field pattern when the magnetic board is placed on top a magnet.
Figure 9. Improvised magnetic board using enclosed iron filings and water.

2. The use of iron sand is better than the iron filings. Iron filings will rust through time as these oxidize in water. If there are no more activities that call for the use of magnetic boards, drain out the water and iron filings from the plastic container so the container will not be colored stained over time by the rusting filings inside if not removed.

3. Iron sand works best in glycerin (which is costlier than baby oil) while the lighter iron filing particles work best in water. Light iron filings in glycerin or baby oil usually move in clumps inside the magnetic board.

4. This activity may be done and answered by students working in groups according to the number of available sets of materials. Group members may work in pairs on an agreed part of the activity so the use of materials and engagement of the members are maximized.

5. For classes with limited materials, rotational learning materials and set ups in good condition may be prepared by the teacher, so all groups get to do all parts of the activity.

6. Remind the students again to use and handle the different kinds of magnets, button compasses as well as the magnetic board (improvised or not) without dropping any of these. The low-cost commercial latch magnets more known, as refrigerator magnets, can be bought from bookstores or craft shops.

7. The neodymium magnet is many times stronger than the ordinary disk magnet that can hold papers on refrigerator doors. Remind the students to be careful not to get their fingers pinched between this kind of magnet and other magnetic materials.
8. Remind also the students to open the switch after sending creating a distinct magnetic field pattern for the current carrying conductors, the current carrying coil and the electromagnetic nail.

9. It might be best to have the students orient their compasses along the geographic North-South alignment of the compass needle, assemble their set up and observe also along the North-South alignment of the compass needle.

10. There is an enlightening short video “Magnets: How do they work” from Veritasium and Minute Physics that can be viewed at http://www.youtube.com/watch?v=hFAOXdXZ5TM.

Sample Data for Activity 5A:

PART A. Watch their domains!

Sample magnetic field pattern of a latch/refrigerator magnet using an improvised magnetic board:

![Magnetic field pattern of a latch or refrigerator magnet.](image)

**Figure 10.** Magnetic field pattern of a latch or refrigerator magnet.

**Table 6.** Interaction of latch magnets when pulled at different orientations

<table>
<thead>
<tr>
<th>START OF THE TILTED DRAG</th>
<th>END OF THE TILTED DRAG</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perpendicular latch magnets lightly dragged at an angle to the horizontal.</td>
<td></td>
<td>For perpendicular orientation: Both latch magnets do not have an observable effect on the other during the movement.</td>
</tr>
</tbody>
</table>
| Parallel latch magnets lightly dragged at an angle to the horizontal. | **For parallel orientation:**
The magnet being dragged over the other magnet moves up and down (at times creating sounds). In certain locations, the touching ends alternately attract and repel thus the observed flapping sound and movement. |
|---|---|
| Obliquely-oriented latch magnets lightly dragged at an angle to the horizontal. | **For oblique orientation:**
The magnet being dragged over the other magnet slightly moves up and down (barely creating sounds) if not at all. |

---

**Answers to Questions:**

**Q21.** How will you describe and explain the magnetic field of a latch/refrigerator magnet?

Most refrigerator magnets will show an alternating pattern of bands formed by the iron filings inside the magnetic board similar to the ones in Figure 10a. The dark bands are created by a concentration of iron filings aligning along magnetic field lines. This is suggestive of a net force of attraction present between unlike poles. On the other hand, the lighter bands are created by the absence of iron filings/magnetic field lines suggestive of a net force of repulsion present between like poles.

**Q22.** How do you relate the flapping interactions of the latch magnets at different orientations to their magnetic domains?

The moving up of the top latch magnet below suggests a net force of repulsion between the two touching ends of the latch magnet. At that instant, it moves up as shown in Figure 11a. The moving down of the top latch magnet suggests a net force of attraction between the two ends of the latch connecting back as shown in Figure 11 (right).
Figure 11. The top magnet moves up due to repulsive forces (left). The top magnet moves down due to attractive forces (right). A continuous light drag from end to end produces the flapping motion.

The flapping effect is greatly evident when the two latch magnets are made to move past each other with their magnetic field lines oriented parallel to each other, and least, if none at all when in perpendicular as shown in Table 6.

Figure 12. Bar magnet representation of aligned magnetic domains in a latch/refrigerator magnet, showing regions of attraction (dark bands) and regions of repulsion (light bands). The North and South poles run in alternating bands. (Students will likely come up with this model.)

Figure 13. Another representation of the refrigerator magnet as an array of very small horseshoe magnets that alternate between north and south. Most of the magnetic field lines, extend past the back of the magnet and very little lines from the front creating stripes about 1-2 mm apart.
Sample Data for Activity 5B:

PART B. Within the lines…

Table 7. Magnetic field patterns surrounding magnets and current-carrying conductors

<table>
<thead>
<tr>
<th>Latch Magnets</th>
<th>U-shaped Magnet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between North – North poles of two bar magnets</strong></td>
<td><strong>Between South – South poles of two bar magnets</strong></td>
</tr>
<tr>
<td>(DepEd Magnetic Board)</td>
<td>(DepEd Magnetic Board)</td>
</tr>
<tr>
<td>(Improvised Magnetic Board)</td>
<td>(Improvised Magnetic Board)</td>
</tr>
<tr>
<td>Between North – South poles of two bar magnets</td>
<td>Single Bar Magnet</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><img src="image1" alt="DepEd Magnetic Board" /></td>
<td><img src="image2" alt="DepEd Magnetic Board" /></td>
</tr>
<tr>
<td><img src="image3" alt="Improvised Magnetic Board" /></td>
<td><img src="image4" alt="Improvised Magnetic Board" /></td>
</tr>
<tr>
<td>Disk Magnet and a Neodymium Magnet</td>
<td>Electromagnetic Nail</td>
</tr>
<tr>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
</tr>
<tr>
<td>Straight current-carrying wire</td>
<td>Current-carrying coil</td>
</tr>
<tr>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Image" /></td>
</tr>
</tbody>
</table>
Answers to Questions:

Q23. How would you describe and compare the magnetic field patterns on Table 7?

- In general, the iron filings that align along the magnetic field lines concentrate most near the poles. The lines from one pole flow outside a magnet or a paramagnetic source and enters the other end, going back inside the magnet to form close loops generally referred to as lines of force.

- The magnetic field patterns of an electromagnetic nail, a current carrying straight conductor, and a current carrying coil are similar to that of the single bar magnet.

- The magnetic field pattern between the poles of a U-shaped magnet resembles the field pattern between unlike poles of two bar magnets.

- If the two bar magnets with two unlike poles which are close in between is brought together, the magnetic field pattern will resemble that of the single bar magnet. Lines from one pole enter the other pole.

- The magnetic field pattern between two north poles of two bar magnets resemble the magnetic field pattern between two south poles of two bar magnets. Lines from one pole bend away from the lines flowing out or flowing into the other pole.

- Both the disk magnet and the neodymium magnet have radial magnetic field lines. The iron filings surrounding radially the disk magnet is less concentrated than the radial magnetic field lines surrounding the neodymium magnet which is many times stronger.

- Because of the neodymium’s strength, it pulls more iron filings towards it, pulling even those that are already far, making a region where the forces between magnetically induced iron filings are weaker than the neodymium magnet’s pull on them. Thus, there is a space without iron filings anymore.

- The latch or refrigerator magnet has parallel alternating magnetic field bands. The dark bands of concentrated iron filings are wider than the bands almost.
Q24. How do the magnetic field patterns shown on the magnetic board indicate the strength of the magnets?

The stronger the magnetic field is, the more concentrated or closer the magnetic lines of force are. There, the greater the force magnetic objects feel. In these regions, the greater magnetic force of induction is experienced by the iron filings that align along the magnetic field lines.

When the lines are uniform, the magnetic field strength is also uniform. So, at the poles where magnetic field lines flow out or flow into, the magnetic field strength is not uniform. It is the strongest where the lines are closest.

Q25. How do the magnetic field patterns indicate the forces of interaction between magnets?

The lines between like poles bend away from each other then goes back towards the other end to form close loops inside out, never meeting. On the other hand, the lines between unlike poles flow out from one end and enter the other end.

Furthermore, the region between two unlike poles have concentrated lines showing the forces of attraction between...

Q26. How will you use the button compasses to trace the magnetic field direction and the kind of forces present in the field?

- Place a button compass over the geometric center of a magnet, say a bar magnet, and move it along the iron filings alignment towards a pole. The compass needle points out from the north-pole end of the magnet.

- Outside the magnet, the compass needle moving along the close loops of iron filings, ends up pointing to the south-pole end.

Activity 6

Electric Field Simulation
(Part I - Of Electric Fields, Forces and Forms)
Suggested time allotment: 1 hour

Teaching Tips:

1. The University of Colorado shares for public use an online and offline version of “The PhET Interactive Simulations Project” under the Creative Commons-Attribution 3.0 license and the Creative Commons GNU General Public License at http://phet.colorado.edu.
2. These simulations can easily be downloaded and made available for science classes. If it is possible, make arrangements regarding the use of the school’s computer laboratory facilities. With the next two activities, the class will be using the PhET simulation programs (and many more activities you plan to). It would be a great help to navigate and explore the different simulations available for the study of electricity and magnetism.

3. In this activity, you will empower your students ICT-wise as they explore the electric field lines and the corresponding directions associated with the negative and positive individual charges and combinations of charges.

4. The simulations can also be shown to the whole class via projector but observations and activity output will be individually done.

5. A printout of Table 8 will be needed for each group if not for each student when possible.

Answers to the Activity:

Of Electric Fields, Forces and Forms


Activity 7

Magnetic Field Simulation

(Part II - Of Magnetic Fields, Forces and Forms)

(Suggested time allotment: 1 hour)

Teaching Tips:

1. This is the second activity in this module that will make use of the PhET Simulation applications on magnetic field. If the students did Activity 5, point out that the results for the bar magnet field patterns would be the same. The difference lies on the clear close loops that can be simulated here compared to the actual discontinuous alignment of iron filings shown on the magnetic board.

2. The discontinuous lines do not mean that the magnetic field lines are broken. It is just that the pull of the magnet on the iron filings near it is greater than the forces induced on iron filings particles by other iron filings next to it.
3. Point out also that the program can also simulate measurements of the magnetic field strength using the field meter. A qualitative as well as quantitative comparison can clearly be shown validating the students' inferences regarding magnetic field strengths and directions in all possible locations in the magnetic field area. In all magnetic field simulations, the compass can also be moved around to show magnetic lines of force direction.

4. Again the simulations can also be shown to the whole class via projector but observations and activity output will be individually done.

5. A printout of Table 9 will be needed for each group if not for each student when possible.

**Answers to the Activity:**

**Of Magnetic Fields, Forces and Forms**

A. 1      B. 6 C. 7           D. 2   E. 8          F. 5    G. 3

6. In this activity, a simulation of the earth's magnetic field pattern and magnetic poles can be shown relative to the geographic pole. Although it is part of Table 7M, it is the only non-answer choice included. But with this feature the students can relate the actual use of a magnetic compass in finding geographic locations. So this simulation part is worth exploring by the students.

**Activity 8**

**Magnetic Field Around Current-Carrying Conductors**

(Suggested time allotment: 2 hours)

**Teaching Tips:**

1. In these experiments, current is sent through a straight and a looped conductor. The students will then observe the response of the compass needle at selected locations around the wire. Each set-up being observed is best assembled and started with the compass needle aligned along the North-South geographic direction.
2. For each location, emphasize to the students that they study carefully how the compass needle is oriented with respect to the copper wire and the direction of current. Emphasize also the need to close the switch only long enough for observations.

3. The short wire and the low current input from the batteries will not be strong enough to show a full clockwise or counterclockwise deflection of the compass needle. Nonetheless, in two of the four locations, the compass needle will be observed as pointing to a clockwise or counterclockwise deflection. Better results can be observed with the use of a 1-m long wire and a 2-3 A direct current from a variable power supply.

4. Introduce the hand rules to your students when needed, and only after the students have recognized that a direct current in a wire will generate a magnetic field, the direction of which, depends on the current’s direction.

5. Using the right-hand rule, the direction of the magnetic field follows the direction of the right hand fingers when the right thumb points in the direction of the conventional current (from positive to negative). Conversely, using the left-hand rule, the direction of the magnetic field follows the direction of the left hand fingers when the left thumb points in the direction of the real flow of current (from negative to positive).
Answers to Questions:

PART A. Magnetic Field around a Straight Conductor

Q27. From a top-view perspective, in what direction does the north pole of the compass needle point to when the compass was positioned around the vertical current-carrying straight conductor?

*With conventional current moving up the vertical wire, the north pole of the compass needle point counterclockwise about the wire.*

![Figure 15](image1)

*Figure 15.* With the circuit close, conventional current is sent up the straight conductor causing a counterclockwise rotation of the compass needle about the wire.

Q28. From a top-view perspective and with the current’s polarity reversed, in what direction does the north pole of the compass needle point to when the compass was positioned around the vertical current-carrying straight conductor?

*With conventional current moving down the vertical wire, the north pole of the compass needle point clockwise about the wire.*

![Figure 16](image2)

*Figure 16.* With the circuit close in (b) and (c), conventional current is sent down the straight conductor causing a clockwise rotation of the compass needle about the wire.
PART B. Magnetic Field around a Coil of Conductor

Q29. From a top-view perspective, in what direction does the north pole of the compass needle, at the center of the current-carrying coil of wire, point?

Figure 17. (a) The north pole of the compass needle points north when the circuit is open and no current flows in the coiled wire. (b) The north pole of the compass needle points south when the circuit is close and current flows in the coiled wire.

Following the right-hand rule, grasp the farthest loop of the coil from the positive end of the coil, with the right thumb in the direction of the conventional current. Note that the direction of the curled fingers point south.

Q30. From a top-view perspective, in what direction does the north pole of the compass needle, at the center of the current-carrying coil of wire, point when the current’s polarity was reversed?

With current flowing in reverse, the compass needle now points north.

Q31. How will you compare the magnitude of the compass needle deflections for the different number of loops in the current-carrying coil?

A decrease in the number of loops in the coil, means a shorter wire and a weaker magnetic field, causing less noticeable, compass needle deflections.
Q32. If you will straighten the shortened coil of wire, how will you compare the magnitude of the compass needle deflection, at the center of the previous current-carrying coil, to the present current-carrying straight conductor? Why?

The magnetic field increases in direct proportion to the number of turns/loops in a coil. Thus, the compass needle, at the center of the coil of wire, deflects more than the compass needle about a straight wire.

Extending Inquiry – A solenoid (a coil of wire in which the length is greater than the width) was made using a 3-meter long magnetic wire wound clockwise from left to right around the iron rod. Current was then made to flow through it using a circuit similar to what is shown to Figure 11 a.

Q33. What would be the direction of the magnetic field around the current-carrying solenoid when the switch is closed?

With the current flowing counterclockwise from the positive end to the negative end, the magnetic field around the current-carrying coil enters the positive end of the coil and leaves the negative end.

Q34. Using arrows, draw the magnetic compass needle directions at the indicated locations in Figure 11b. Then indicate which ends of the solenoid acts similar to the north and south poles of a bar magnet.

The positive end of the current-carrying coil acts similar to a south pole of a bar magnet while the negative end acts similar to a north pole.

Figure 18. The north pole of the compass needle points into the positive end of the current-carrying coil and points out of negative end of the coil.
Activity 9

Homopolar Motors
Making your own Faraday’s Electric Motor
(Suggested time allotment: 2-3 hours)

Teaching Tips:

1. This is a do-it-yourself activity on a simple electric motor that makes use of 2 or 3 neodymium magnets. Each one much stronger than the ordinary disk magnets. These magnets are part of the Basic Science Materials and Equipment made available in most public secondary schools.

2. Make sure that the students do not play with these kind of magnets because it can cause blood blisters on fingers or skin sandwiched between two such magnets. Caution the students to slowly allow the magnets to come together, taking care no finger gets pinched! If the magnets snap on each other by proximity, they may chip or break.

3. Caution also the students to watch out where they place these strong magnets. These could erase recorded memories on magnetic tapes, computer disk drives, magnetic cards or distort signals on TV screen, computer monitors or loosen parts of mechanical watches.

4. Ensure also that the students remove the battery as soon as the rotation effect on the mounted conducting wire is observed. These could get hot.

Answers to Questions:

Q35. What happens to the shaped wire once positioned over the battery’s positive terminal and with both wire ends curled loosely touching the magnets?

With the shaped wire positioned over the battery and with its ends curled loosely about the neodymium magnets, a closed circuit is formed. Current flows through the wire which starts to move, slowly at first, and then rotating faster. The gentle spin may be needed to jump start only the rotational effect caused by an adequate electromagnetic force present when charges in the wire move within the neodymium magnet’s field.
Q36. What additional observations about the electric motor model were you able to experience?

*Answers may vary.* For strong neodymium magnets and preferably a thicker wire shaped differently, it is possible to hold the shaped insulated wire on air and allow the battery to rotate instead of the wire.

Q37. What will happen if the number of neodymium magnets used is varied?

*Decreasing the number of neodymium magnets will take a longer time for the current-carrying wire to rotate at a slower rate (or not at all), because of the weaker electromagnetic force (or not at all for the removal of all magnets) produced within the weaker magnetic field.*

Q38. What are the basic parts/elements of a simple electric motor?

The basic parts/elements of a simple motor are the following: *moving charges in a conductor within the influence or region of a magnetic field.*

Q39. Based on the activity, how will you explain the operation of a simple electric motor?

An electric motor is simply a device that uses electrical energy to do rotational mechanical work or is a device that converts electrical energy into rotational mechanical energy.

*In this activity, a simple DC motor was assembled using a single coil that rotates in a magnetic field. The direct current in the coil is supplied via two brushes (ends of the shaped wire) that make a moving contact with a split ring (During rotations, from time to time, the ends of wire alternately disconnect from their touch with the disc magnet). The coil lies in a steady magnetic field provided by the neodymium magnets. The electromagnetic forces exerted on the current-carrying wire creates a torque (rotation-causing force) on the coil (rotor).*

*Figure 19* A diagram of the simple DC motor showing the directions of the DC current on the shaped wire, the magnetic field by the neodymium magnets and the electromagnetic force causing the rotation.
The rotation can also be considered in terms of the coil becoming an electromagnet that has one side behaving like a north pole and the other side behaving like a south pole. As with all magnets that interact, the pile of neodymium magnets under the electromagnetic coil attracts the opposite pole in the coil and repels the like pole in the coil, causing the coil to spin.

In real motors, the parts, its geometry, assembly and operation is complex, but the operation of these devices work on the same principle: a magnetic field affects the charges in a conductor creating an electromagnetic force.

ELECTROMAGNETIC INDUCTION

Activity 10

Let’s Jump In!

(Adapted from cse.ssl/berkeley.edu/III/lessons/IIIelectromagnetism/mag_electomag.pdf)

(Suggested time allotment: 1-2 hours)

Teaching Tips:

1. This is an activity preferably done outside on a level surface, 6m x 6m area (at the least) using 10 to 20 meters of long flat wire (double wire, stranded, AWG #22, and commonly used for simple extension wires) available in local hardware or electrical stores.

2. If the galvanometer is unavailable, try to use an improvised galvanometer similar to what is shown in Figure 20. Wind a longer wire for a more sensitive current-detecting device. Find a way to make sure the improvised galvanometer will not be moved easily during loop movements.

Figure 20. An improvised galvanometer can be made by looping enough length of wire around a compass fitted into a used rubber mat.
3. With the Earth’s magnetic field readily available at all times, and a resourceful effort to procure the long conductor, a sensitive functioning galvanometer and a compass is all it takes to have this fun activity. Just ensure that the galvanometer will be used with care and must be connected in series to the long conductor.

4. Although results can be observed even without the students jumping over the rotated looped conductor, students taking turns in observing and having fun during the activity will likely lead to higher learning gains. (Special acknowledgement for the activity adaptation consent of the “Multiverse – the education team at the Space Sciences Laboratory, University of California, Berkeley who work to increase diversity in Earth and Space Science through multicultural education.”

Answers to Questions:

Q40. What effect does rotating a part of the loop have on the galvanometer?

*When a portion or half of the length of the loop is rotated, the galvanometer (or the compass needle for the improvised galvanometer) deflects either side of the zero mark or the original direction. This indicates a flow of current along the long loop. The needle then returns to the zero point mark for the galvanometer (or the original geomagnetic orientation in the location."

Q41. What effect does the rotational speed of the loop have on the generated electric current?

*The faster the rotation, the greater is the galvanometer needle’s deflection indicating greater amount of charges flowing in the rotating loop of conductor."

Q42. Which condition or its combination would result to the greatest generated electric current? Smallest current? No current reading?

*The greatest generated electric current as indicated on the galvanometer needle’s greatest deflection is when the longest possible single length of coil, aligned along the East-West direction, is rotated the fastest in either a clockwise or counterclockwise manner.

While, the smallest generated electric current as indicated on the galvanometer needle’s least deflection is when the shortest possible single length of coil, aligned along the North-South direction, is rotated the slowest in either a clockwise or counterclockwise manner."
On the other hand, there is no electric current generated as indicated on the galvanometer needle’s non-deflection when the both half-length of wire is rotated in whatsoever alignment, direction, length, speed in both the clockwise or counterclockwise rotation. Rotating both half-lengths in the same direction within the same magnetic field influence by the Earth results to opposing induced electromotive forces ending in a zero net movement of charges along the close loop of conductor. Thus, no current is generated.

Q43. Why does the geographical alignment of the rotating jump wire affect the galvanometer reading?

The Earth acts like a huge magnet similar to a bar magnet. Its magnetic South-pole is about 1200 km away (offline) from its geographic South-pole. When the loop is rotated along the North-South alignment, the looped conductor cuts the magnetic field lines less frequently than when it is rotated perpendicular to the Earth’s magnetic field. More magnetic field lines cutting across the same length of conductor induces greater electromotive force hence greater current detected by the galvanometer.

Q44. What are the basic components of the jump wire electric generator?

The jump wire electric generator consists of a closed loop of conductor moving within a magnetic field. Any relative motion between the charges in the conductor and the magnetic field by the Earth gives rise to an electromotive force that when big enough will cause free electrons in the conductor to move through the loop.

Q45. How will you explain the operation of a simple electric generator?

A simple electric generator is made when a coil or any closed loop of conductor moves through or cuts across magnetic field lines. The coil will experience an induced voltage or electromotive force and cause current to be generated.

Extending Inquiry. Identify and describe the different basic parts of the generator model shown in the figure on the next page.
The armature is a coil of wire that serves as a rotor. It is surrounded by magnets that serve as stators. When the hand wheel is rotated, the armature also rotates via the belt that connects the hand wheel and the shaft it is attached to. The coil of wire then cuts across the steady magnetic field lines surrounding the pair of magnets. On the other side, the armature is also connected to a split ring commutator that makes the generated current (DC) output to flow in one direction. The commutator in turn is connected to the power source terminal via the brushes.

Q46. How will you show that the generator model still functions?

An ammeter or a test bulb connected to the power source terminals will serve as indicator of the generator output. Rotating the handwheel should produce a current reading on the ammeter or cause the test bulb to glow proportionate to the generated current.
Activity 11

Principles of Electromagnetic Induction
(Adapted from the DepEd-NSTIC Activity on Faraday's Law of Induction)
(Suggested time allotment: 1-2 hours)

Teaching Tips:

1. Learners can wind the coils around cardboard tubes or plastic bottles. A wider 10-turn coil can be made out of a 180 cm wire wound around a 350 ml plastic bottle as guide. A 20 or 22 gauge insulated copper wire can also be used instead of the hook/connecting wire. Commercially made coils are also available.

2. Help the students recognize that, whereas in Activity 9, the principle of the electric motor was demonstrated in the conversion of electrical energy to mechanical energy within a magnetic field, the conversion of mechanical energy to electric energy within a magnetic field is the principle of the electric generator as demonstrated in Activity 10 and 11.

3. Electromagnetic induction is the process in which electric current is generated in a conductor by a moving or changing magnetic field. Help the students realize that both in Activity 10 the conductor is being moved within a magnetic field while in Activity 11 it is the source of magnetic field that is being moved relative to the steady conductor. Current was generated in both activities.

4. Lead the class in recalling their activity observations and understanding of the concept that the magnetic field is strongest at the pole where the magnetic field lines are closest and thus, the magnetic field weakens as distance from the poles increase.
Sample Data for Activity 11:

**Table 8. Inducing current in a coil**

<table>
<thead>
<tr>
<th>condition</th>
<th>coil without a magnet</th>
<th>magnet is moving into the coil</th>
<th>magnet is at rest inside the coil</th>
<th>magnet is moving out of the coil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvanometer pointer’s deflection or non-deflection</td>
<td>No deflection</td>
<td>Deflection is observed</td>
<td>No deflection</td>
<td>Deflection is observed</td>
</tr>
<tr>
<td>Galvanometer pointer’s direction of deflection</td>
<td>-</td>
<td>sideward from the zero point of the scale at the center</td>
<td>-</td>
<td>to the opposite side of the scale</td>
</tr>
</tbody>
</table>

Answers to the Activities and Guide Questions:

Q47. How will you explain the deflection or non-deflection of the galvanometer pointer as observed in the activity?

The pointer deflects when current is induced in a closed circuit conductor within a changing magnetic field. A changing magnetic field is produced when there is relative motion between a source of a magnetic field and a conductor; it does not matter which moves. This change in the magnetic field strength in the coil region occurs as the magnet is moved towards or away from the coil.

The absence of a changing magnetic field cutting across the closed circuit conductor or the absence of the field’s motion relative to the conductor results to non-deflection of the galvanometer’s pointer. On the other hand, the mere presence of a magnetic field that is at rest relative to a closed circuit conductor will also not induce current.

So in the activity, moving the magnet into or out of the coil, caused the pointer to deflect during either movement. The needle of the galvanometer gradually returned to the zero mark and stayed undeflected when the magnet was at rest relative to the coil.

Q48. How will you compare the directions of deflection? Why do you think this is so?

The galvanometer pointer at the center of the scale, deflects in one direction when the magnet was moved into the coil and in the opposite direction when the magnet was pulled out.
As the north pole of the magnet is moved downwards (approaching the top end of the coil), the top end behaves like a south pole, and then reverses when the magnet is pulled out. An induced current in the conductor behaves in such a direction that its magnetic properties oppose the magnetic field change that induces the current.

Q49. For approximately the same speed of moving the magnet into or out of each coil, what happens to the magnitude of the pointer’s deflection as the number of turns in the coil increase?

For approximately the same speed of moving the magnet either into or out of the coil, the galvanometer pointer deflect more with greater number of turns in the coil.

Q50. For approximately the same speed of moving the magnet into or out of the 15-turn coil, what happens to the deflection of the galvanometer pointer as the number of bar magnets (strength of magnetic field) increase?

For approximately the same speed of moving the magnet either into or out of the 15-turn coil, the galvanometer pointer deflect more with the use of two magnets compared to a single source of magnetic field.

Q51. What happens to the deflection of the galvanometer pointer as the bar magnet is moved into or out of the 15-turn coil at different speeds (rate of magnetic field change)?

The galvanometer pointer deflect more when the magnet is moved into or out of the 15-turn coil at a faster speed causing a greater rate of change in magnetic field strength. As the magnet’s north pole comes closer to the coil, the magnetic field becomes stronger with more field lines cutting through the coil. As the magnet’s north pole pass the coil moving farther, less field lines reach the coil and the field weakens. The faster this movement is done, the greater is the rate at which the magnetic field strength changes and the greater is the induced current.

Q52. How would you compare the galvanometer pointer’s deflection when the magnet moves along the coil and when the magnet moves across the coil?

When the magnet was moved parallel or along the coil, the galvanometer pointer barely deflect if it will deflect at all as compared to the galvanometer pointer’s clear deflection when the magnet was moved perpendicular or across the coil. No current will flow when there is no magnetic field line that cuts through the wire.
Q53. In your own words, what are the factors that affect the amount of current and voltage (EMF) induced in a conductor by a changing magnetic field?

The magnitude of induced current and voltage (electromotive force) vary depending on the number of turns or length of conductor, the strength and orientation of the magnetic field, and the speed at which the flux lines cut across the wire or the rate at which the magnetic field moves relative to the conductor.

Q54. An equation for the electromagnetic force (EMF) induced in a wire by a magnetic field is \[ \text{EMF} = BLv \], where \( B \) is magnetic field, \( L \) is the length of the wire in the magnetic field, and \( v \) is the velocity of the wire with respect to the field. How does the results of this activity support this equation?

From Ohm’s Law, if resistance is constant, the current is proportional to the voltage (EMF). This activity showed that the induced current is greater with more number of turns (longer length \( L \)), with more magnets (stronger magnetic field \( B \)), and with greater rate of movement (greater velocity of the magnet with respect to the coil \( v \)). Thus the induced voltage or electromotive force is also greater, supporting the equation \( \text{EMF} = BLv \).

Extending Inquiry. A typical transformer has two coils of insulated wire wound around an iron core. This device changes the AC voltage of the primary coil by inducing an increased or decreased EMF in the secondary coil. In practical applications, why does this device operate only on alternating current and not on direct current?

An alternating current in the primary coil causes a changing magnetic field in the iron core. The changing field moves over the loops in the secondary coil inducing current and an EMF in this coil. Direct current drawn into the transformer will not induce current because it only produces a constant magnetic field. Momentarily, current will be induced only at that instance that the transformer using direct current is switched on or off, which of course has limited applications such as in the mosquito killer racket.
5. Develop a learning sequence for students to understand further their enquiry into the working principles of the basic transformer, its types and some practical applications such as that introduced in the power transmission and distribution during the last quarter in Grade 9 Science. Teach the students explore how the number of turns in the primary and secondary coils affect the induced voltage in the secondary coil and solve sample exercises.

Answers to Summative Assessment

1. In which case or cases is an electric field present?
   I. A spark jumping between two nearby rods.
   II. A charge that is momentarily at rest.
   III. A dead power line.
   B. I and II only

2. Which device can be used to determine the polarity of an unmarked magnet?
   A. a suspended magnetized needle

3. In which device is magnetic field present?
   D. A microphone undergoing a sound check.

4. How will you describe the magnetic field around a current-carrying coil?
   C. The magnetic field is strongest inside the current-carrying coil.

5. Which statement about an electromagnetic nail is NOT TRUE?
   B. The current in the electromagnetic nail demagnetizes the iron nail.

6. What can be inferred from the alignment of compass needles around the pick up coil below?

   A. Current is drawn into the coil.
7. What basic principle enables ALL electric generators to operate?

**C. A closed-loop conductor within a changing magnetic field will have an induced electromotive force.**

8. Which of the following statements can be inferred from the main photo below? (For easier inspection, a paper is inserted halfway between the open disk tray and a magnetic board)

![Main photo](image)

**C. The optical system has an electric motor that drives the reader.**

9. Which arrangement of three bar magnets results to an attraction between the first and the second, and a repulsion between the second and the third magnet.

<table>
<thead>
<tr>
<th>Magnet 1</th>
<th>Magnet 2</th>
<th>Magnet 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>S</td>
<td>N</td>
</tr>
<tr>
<td>S</td>
<td>S</td>
<td>N</td>
</tr>
</tbody>
</table>

**A. N S N S S N**

10. Complete the following statement: A metallic detector was used to check a bag for metallic objects. The transmitter coil

**D. draws a pulsating current to send a changing magnetic field towards the target to induce current in it.**

11. A coil moves away from a magnet. Consider the following factors:

I. strength of the magnet  
II. number of turns in the coil  
III. speed at which the magnet moves

Which can affect the electromotive force (EMF) induced in the coil?

**D. All three factors**
12. Which set ups model the working principle of a transformer and an electric generator respectively?

B. B and D

13. Which statement is TRUE about the illustration below?

D. There is relative motion between the magnet and coil in set up B.
14. What transformation can take place in a ceiling fan’s electric motor?
   A. electrical energy into mechanical energy

15. What is TRUE about the intercom system that is shown below?

   B. Either parts A and C of the intercom when switched as such can be used as a microphone or as a loudspeaker.
References and Links

Books/e-books:


Electronic Sources:


http://hyperphysics.phy-astr.gsu.edu/hbase/audio/mic.html#c1. [Accessed October 29, 2014]


Overview

The concepts of electricity and magnetism and their interconnectedness were introduced in Module 1. In this module, we focus on the different electromagnetic waves, their properties and their uses in the society.

Electromagnetic waves, like any other waves, carry energy. It is discussed in this module how different kinds of this energy are utilized. These waves are used from simple listening to a radio to the highly technological treatment of cancer in the aim to save lives. However, it is inevitable that some of these waves may harm to living things and to the environment. It is therefore important to study and understand these waves so we could maximize their uses and find ways to minimize the negative effects that they may bring.

At the end of module 2, the Learners should be able to answer the following questions:

1. How do the regions in the electromagnetic spectrum differ in terms of wavelength, frequency and energy?
2. How are the different types of electromagnetic waves become relevant to people and environment?
3. What are the consequent effects of electromagnetic waves?
Learning Competencies

1. Discuss the development of the electromagnetic theory.
2. Describe how electromagnetic (EM) wave is produced and transmitted.
3. Compare the relative wavelengths, frequencies and energies of the different regions of the electromagnetic spectrum.
4. Cite examples of practical applications of the different regions of EM waves.
5. Explain the effects of electromagnetic radiation on living things and the environment.

Answers to Pre-Assessment

A. Multiple Choice
1. Which two waves lie at the ends of the visible spectrum?
   a. Infra-red and Ultra-violet rays
   b. Radio waves and Microwaves
   c. Radio waves and X-rays
   d. X rays and Gamma rays

2. In the visible spectrum, which color has the longest wavelength?

3. Which property spells the difference between infra-red and ultra-violet radiation?
   a. Color
   b. Speed in vacuum
   c. Wavelength
   d. None of the above

4. A certain radio station broadcasts at a frequency of 675 kHz. What is the wavelength of the radio waves?
   a. 280 m
   b. 324 m
   c. 400 m
   d. 444 m

5. What type of electromagnetic waves is used in radar?
   a. Infra-red rays
   b. Microwaves
   c. Radio waves
   d. Ultra-violet rays
B. Below are the applications of electromagnetic waves. State the type of electromagnetic wave used in each application.

1. Camera autofocusing - infrared
2. Radio broadcasting – radio broadcasting
3. Diagnosis of bone fractures – x-ray
4. Sterilization of water in drinking fountains - ultraviolet rays
5. Sterilization of medical instruments – gamma rays

C. Answer the following question briefly but substantially.

1. How are EM waves different from mechanical waves?

   Electromagnetic waves are disturbance in a field while mechanical waves are disturbance in a medium. Both carry energy but electromagnetic wave can travel in vacuum while mechanical waves cannot.

2. Give two sources of EM waves in the Earth’s environment.

   Sources of EM waves include the sun and technological equipment such as TV and microwave ovens.

Reading Resources and Instructional Activities

Electromagnetic Wave Theory

Teaching Tips:

1. Divide the class into groups of five members.

2. Let the learners research on the different scientists who made significant contributions to the development of the electromagnetic wave theory. If possible provide them with a list of books that they may refer to and list of websites that they may browse.

3. Let the students perform the first part of this activity. Exchange ideas with the students.

4. Let the students create comic strips about how these scientists made significant contributions to the Electromagnetic Wave Theory.
Activity 1

How it came about…

The Electromagnetic Wave Theory

Answer to Part 1

I. Match the scientists given below with their contributions.

<table>
<thead>
<tr>
<th>Scientists</th>
<th>Contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>c 1. Ampere</td>
<td>a. Contributed in developing equations showing the relationship of electricity magnetism</td>
</tr>
<tr>
<td>d 2. Faraday</td>
<td>b. Showed experimental evidence of electromagnetic waves and their link to light</td>
</tr>
<tr>
<td>b 3. Hertz</td>
<td>c. Demonstrated the magnetic effect based on the direction of current</td>
</tr>
<tr>
<td>a 4. Maxwell</td>
<td>d. Formulated the principle behind electromagnetic induction</td>
</tr>
<tr>
<td>e 5. Oersted</td>
<td>e. Showed how a current carrying wire behaves like a magnet</td>
</tr>
</tbody>
</table>

Guide Questions:

Q1. What new insights / learning did you get about our natural world? How did it change your view about light?

   Answer: We can come up with new ideas from the ideas of others. Things are interconnected with each other.

   (Answers may vary).

(Adapted from APEX Physics LP Chapter 3 Lesson 3: Student Activity 3a: The Electromagnetic Theory)

Recall that waves transfer energy and that mechanical waves need a medium to travel. Compare and contrast Mechanical Waves and Electromagnetic Waves.

Electromagnetic Waves

We are surrounded with thousands of waves. Waves collide with our bodies and some pass through us. Most of these waves are invisible but we can perceive some. The warmth of the sun and the light that we see are just a few of them. These waves share similar characteristics, yet, they are unique in some ways. These waves are called Electromagnetic Waves.
Electromagnetic waves are different from mechanical waves in some important ways. Electromagnetic waves are disturbance that transfers energy through a field. They are also referred to as EM waves. They can travel through medium but what makes them strange is that they can also transmit through empty space.

**Radiation** is the term used to describe the transfer of energy in the form of EM wave. For a mechanical wave to travel, it must vibrate the medium as it moves. This makes use some of the waves’ energy. In the end, it makes them transfer all energy to the medium. As for EM waves, they can travel through empty space or vacuum so they do not give up their energy. This enables EM waves to cross great distances such as that from the sun to the Earth (which is almost vacuum) without losing much energy. In vacuum, EM waves travel at a constant speed of 300 000 000 meters per second. At this rate, the rays of the sun take 8 minutes to reach the Earth.

Electromagnetic waves can also transmit with a material medium. They can also transfer energy to the medium itself. When they interact with matter, their energy can be converted into many different forms of energy. With these characteristics, electromagnetic waves are used for a wide variety of purposes.

For demonstration purposes, the teacher may conduct the following activity to show the learners that Electromagnetic waves characterize similar movement as that of the mechanical waves when they encounter a barrier.

**Demonstration Activity**

**On and Off!**

**Objective:**
- Prove that electromagnetic waves can be reflected.

**Materials**
- TV with remote control
- Mirror with stand

**Procedure:**
1. Turn the TV on and off using a remote control.
2. Position the mirror at an angle with which it could reflect the waves from the remote control to the TV.

3. Turn the TV on and off by aiming the remote control at the mirror.

Guide Questions:

Q1. How did you have to position the remote control in order to turn the TV on and off?

Answer: The remote control should be aimed at the mirror such that the incident beam strikes it at an angle that will direct the reflected beam towards the TV.

Q2. What does this indicate?

Answer: It indicates that EM waves can also be reflected just like mechanical waves.

Adapted from: Littell, McDougal Science. Integrated Course 1, Teacher’s edition. McDougal Littell, a division of Houghton Mifflin Company C73.

The Electric and Magnetic Fields Together

Teaching Tips:

1. Review the parts of a wave.
2. Describe how EM waves are formed.
3. Discuss the two types of fields that make up an EM wave.
4. Explain how a magnetic field arise from the presence of an electric field and vice versa.
5. Include possible sources of EM waves.
Check your understanding!

Answers:

1. Electromagnetic waves can travel through vacuum. True
2. A wave is a disturbance that transfers energy. True
3. Most EM waves are invisible and undetectable. Most EM waves are invisible but detectable.

The Electromagnetic Spectrum

Teaching Tips:

1. Discuss the types of EM wave one by one. Include each wave’s properties, characteristics and practical uses.

Activity 2

Now you go! Now you won’t!

Guide Questions:

Q2. Compare the time taken by the RC car to cover the same distance. Do some go faster or slower?

Answer: The time for the different set-up (wrapping) were different from each other. Some are faster than the other.

Q3. What does this tell you about the transmission of the signal?

Answer: This tells us that the signal can be interrupted.

Q4. What characteristic of EM waves did you discover?

Answer: It tells us that some EM waves if not all can be blocked by some materials.
Radio Waves

Radio waves are the EM waves found at the left end of the EM spectrum (arranged from low frequencies to high frequencies). They are the type of EM waves with the longest wavelength but they are of low frequencies thereby carrying the lowest energy from among the EM waves.

Radio waves have the following characteristics:

1. Not line of sight
2. Can pass through walls
3. Longer range
4. Not light sensitive

Some of the disadvantages of radio frequencies include:

1. Communication devices that make use of the same frequencies interfere with their transmission.
2. It is easier to “eavesdrop” since signals are transmitted in space rather than a wire.
3. More costly than infrared

Teaching Tips:

1. Let the learners perform the following three activities involving radio waves.
2. This will make them understand the characteristics of radio waves.
3. Facilitate their learning through post lab discussions.
Activity 3

Sound check!

Answers to Guide Questions:

Q5. What happens when you stroke the prongs with the wire?

Answer: Noticeable “static” sound is produced.

Q6. How does changing the position affect the results?

Answer: The sound of static may change from one frequency to another.

Q7. What might be the cause when you sometimes hear static sound in your radio? What can be done to resolve it?

Answer: The waves might be interrupted by some factors.


Activity 4

Then there was sound…

Answers to Guide Questions:

Q8. What common problems could arise during transmission and reception of radio waves? Explain the possible cause/s of those problems.

Answers: Radio waves may interfere with other signals. This makes transmission and reception difficult.
Microwaves

Microwaves are applied in so many ways from texting to cooking, and to communications to the rest of the world.

Applications of Microwaves

1. Satellite Communications
2. Radars
3. TV Transmission
4. Microwave Oven

How a microwave oven cook food inside it?

1. A part of the oven produces microwaves.
2. The microwaves are sent to the reflecting fan.
3. The microwaves are reflected in many directions by the fan and the walls of the microwave oven.
4. As microwaves pass through the food, they transfer energy to the water molecules in the form of heat. This will cook the food.

Extension of Learning:

Let the learners research on the negative effects of Low Frequency Waves to people and to the environment and discuss it in class.

Infrared

In the 1800, famous astronomer Sir Frederick William Herschel discovered a form of radiation other than the visible light. He discovered the infrared radiation through a similar activity. He let sunlight pass through a glass of prism and dispersed it into a rainbow of colors called the color spectrum. He was interested in the temperature of the different colors. He then placed the thermometer just beyond the red color and found out that the temperature was even higher. He then concluded that there is a kind of radiation that our eyes can see, hence, the infrared. His experiment was significant not only because of the discovery of the infrared but because of the realization that there are other types of electromagnetic waves that we cannot see.
Infra-red radiation has many useful applications

1. Infrared photographs taken from a satellite with special films provide useful details of the vegetation on the Earth’s surface.
2. Infrared scanners are used to show the temperature variation of the body. This can be used for medical diagnosis.
3. Infrared remote controls are used in TVs, video cassette recorders, and other electronic appliances.
4. Infrared telescopes are used for seeing in the dark.
5. Autofocus camera has a transmitter that sends out infrared pulses. The pulses are reflected by the object to be photographed back to the camera. The distance of the object is calculated by the time lag between the sending and receiving of pulses. The lens is then driven by a built-in motor to adjust to get the correct focus of the object.

Infrared is also used in the following devices:

1. Augmentative communication devices
2. Car locking systems
3. Computers
   a. Mous
   b. Keyboards
   c. Printers
4. Emergency response systems
5. Headphones
6. Home security systems
7. Navigation systems
8. Signages
9. Telephones
10. Some toys

Nowadays, infrared technology provides numerous advantages especially in wireless communication. The following reasons explain why:

1. Low power requirements that makes it ideal for laptops, and other technological devices
2. Low circuitry costs
3. Simple circuitry: can be incorporated in the integrated circuit of a product
4. Higher security than radio waves since it requires “line of sight” transmission
5. Portable
6. Not likely to interfere to signals from other devices
The following characteristics of infrared can be considered as disadvantages:

1. Transmitters and receivers should be directly aligned to connect and communicate
2. Can be blocked by common materials
3. Distance sensitive; performance drops as distance increases
4. Weather sensitive; transmission can easily be affected by weather conditions like rains
5. Can also be affected by light such as sunlight

Activity 5

It’s getting hotter..

Teaching Tips:

1. Let the students perform the activity and answer the Guide Questions that follow.
2. Discuss the importance of infrared radiation and their uses.

Answers to Guide Questions:

Q9. Did you see any trend? Explain if there is any.

Answer: The temperature increases from the blue to the red part.

Q10. What did you notice about the temperature readings?

Answer: The temperature readings in the three thermometers are different from one another.

Q11. Where was the highest temperature?

Answer: The highest temperature is at the point beyond the red end of the color spectrum.

Q12. What do you think exists just beyond the red part of the spectrum?

Answer: This is the infrared portion of the EM spectrum.

Q13. (Answers may vary).
The Visible Spectrum

The visible light shares the thinnest slice in the electromagnetic spectrum. It lies in between the infrared and the ultraviolet rays. It is the only EM wave perceived by the human eye. If not because of the visible light, we will not be able to see the beauty of our surrounding much less appreciate it.

White light, like that of the sunlight is made up of a variety of colors arranged as follows: red, orange, yellow, green blue, indigo and violet. Though these colors travel at the same speed, they come in different wavelengths. From red to violet, the colors come in decreasing wavelength. That is, red has the longest wavelength and violet has the shortest.

Activity 6

Screen the UV out

Answers to Guide Questions:

Q14. How does the newsprint vary in the three divisions of the newspaper cutout after they were exposed to sunlight?

Answer: The newsprint in the fully exposed part of the newspaper faded more dramatically than the other parts.

Q15. What does this indicate?

Answer: It indicates that sunlight, specifically UV rays affect the pigments of different objects.

Q16. How does this realization impact your personal life?

Answers may vary.

Example Answer: I realized that we need to protect our skin from UV rays by using protective clothes or lotion that can block sunlight.

Extension of Learning:

Let the learners observe the effects of UV indoors and during a cloudy day. Make an emphasis that even indoors; UV still has effects on living things.
**Ultraviolet Radiation**

Ultraviolet radiation is the part of the electromagnetic spectrum that consists of frequencies higher than that of the visible light but lower than the x-rays. Having higher frequency, UV rays carry higher amount of energy. They can damage tissue, burn the skin and damage the eyes. For these reasons, protection from such damaging rays were invented such like UV sunscreen/sunblock lotions and eyeglasses that could filter out these frequencies.

Ultraviolet rays also have benefits. Hospitals make use of UV to sterilize medical instruments to kill harmful bacteria.

**Other uses of UV Rays**
1. Production of Vitamin D in our skin
2. Sterilization of water in drinking fountains
3. Identifying original from fake banknotes

**X-rays and Gamma Rays**

The other end of the electromagnetic spectrum is the waves of very high frequencies and high energies. These are the x-rays and the gamma rays.

**Important Concepts about the X-rays**

1. The frequencies of x-rays ranges from $3 \times 10^{16}$ to $3 \times 10^{19}$ Hz.
2. X-rays can pass through soft tissues but are filtered by dense matter such as the bones. This makes x-rays suitable for diagnosing bone fractures and dense tumors.
3. X-rays can damage body tissues.
4. Frequent/Overexposure to x-rays can cause cancer over time.

**Important Concepts about Gamma rays**

1. Gamma rays have the highest frequencies and energies than any EM waves.
2. Emitted by the sun and stars. Can also be produced by radioactive substances.
3. Can penetrate soft and hard body tissues.

**Beneficial Effects of Gamma Radiation:**

1. Used in sterilizing medical equipment.
2. Used to kill cancer cells.
Summary

- A wave is a disturbance that transfers energy.
- Electromagnetic wave is a disturbance in a field that needs no material medium.
- James Clerk Maxwell formulated the Electromagnetic Wave Theory which says that an oscillating electric current should be capable of radiating energy in the form of electromagnetic waves.
- Heinrich Hertz discovered the Hertzian waves which is now known as radio waves.
- Hertz is the unit used to measure the frequency of waves.
- Electromagnetic waves have unique properties.
  - EM waves can travel through a vacuum.
  - EM waves travel at the speed of light ($c = 3.0 \times 10^8$ m/s).
  - EM waves are disturbances in a field rather than in a medium.
  - EM waves have an electric field that travels perpendicular with the magnetic field.
  - EM waves form when moving charged particles transfer energy through a field.
- Most EM waves are invisible to the eye but detectable. Only the visible light is seen by humans. Some animals see infrared and UV light.
- Waves in the EM spectrum include the following from the longest wavelength to the shortest wavelength:
  - Radio waves
  - Microwaves
  - Infrared waves
  - Visible light
  - Ultraviolet
  - X-rays
  - Gamma rays
The order also shows the increasing frequency and energy of the EM waves.

- The waves in the various regions in the EM spectrum share similar properties but differ in wavelength, frequency, energy, and method of production.
- The regions in the EM spectrum have various uses and applications as follows:

<table>
<thead>
<tr>
<th>EM Wave</th>
<th>Applications/Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio waves</td>
<td>Radio and television communication</td>
</tr>
<tr>
<td>Microwaves</td>
<td>Satellite television and communication</td>
</tr>
<tr>
<td>Infrared waves</td>
<td>Remote control, household electrical appliances</td>
</tr>
<tr>
<td>Visible light</td>
<td>Artificial lighting, optical fibers in medical uses, screen of electronic devices</td>
</tr>
<tr>
<td>Ultraviolet</td>
<td>Sterilization, Fluorescence</td>
</tr>
<tr>
<td>X-rays</td>
<td>Medical use, engineering applications</td>
</tr>
<tr>
<td>Gamma rays</td>
<td>Medical treatment</td>
</tr>
</tbody>
</table>

- Each type of EM wave have a certain degree of risk and danger to people and environment.

**Summative Test**

I. **Multiple Choice.** Choose the letter of the correct answer.

1. Which electromagnetic wave carries more energy than the others?
   - a. microwaves
   - b. radio waves
   - c. UV radiation
   - d. visible light

2. What electromagnetic wave is sometimes called heat rays?
   - a. gamma rays
   - b. infrared
   - c. radio waves
   - d. visible light

3. What is the frequency range of UV radiation?
   - a. $3.5 \times 10^8 - 3 \times 10^{11}$ Hz
   - b. $3.5 \times 10^{11} - 3 \times 10^{14}$ Hz
   - c. $7.5 \times 10^{14} - 3 \times 10^{16}$ Hz
   - d. $7.5 \times 10^{16} - 3 \times 10^{19}$ Hz
4. What is the range of frequencies are our eyes sensitive to?
   a. $3 \times 10^9 - 3 \times 10^{11}$ Hz
   b. $3 \times 10^{11} - 4 \times 10^{14}$ Hz
   c. $4 \times 10^{14} - 7.5 \times 10^{14}$ Hz
   d. $7.5 \times 10^{14} - 3 \times 10^{16}$ Hz

5. What is the wavelength of the wave with a frequency of $3 \times 10^9$ Hz?
   a. $1.0 \times 10^{-1}$ m
   b. $1.0 \times 10^1$ m
   c. $1.0 \times 10^{-2}$ m
   d. $1.0 \times 10^{2}$ m

II. Below are the applications of electromagnetic waves. State the type of electromagnetic wave used in each application.

   1. Satellite communications - microwaves
   2. Texting - microwaves
   3. TV broadcasting - radiowaves
   4. Radar - microwaves
   5. Checking bankbook signature – ultraviolet rays

III. Answer the following questions briefly.

   1. Describe the mathematical relationship between frequency and wavelength.
   2. Frequency and wavelength are inversely proportional.
   3. What is the function of a tower in cell phone operation?
   4. The tower receives signals from a cell phone and sends it to a wire-based telephone system or to another cell phone.
   5. What does a radio transmitter do?
   6. A transmitter attaches information about the sound to the radio signal by modulating the waves slightly.
   7. How can infrared radiation be detected if cannot be seen?
   8. It is detected when it is converted to other forms of energy such as heat.
   9. Why are high frequency electromagnetic waves like gamma rays harmful to living things?
   10. High frequency waves like the gamma rays are harmful because they carry very high amount of energy that enables them to penetrate and kill living cells.
Glossary

Electromagnetic wave. A disturbance in a field that carries energy and does not require a medium to travel

Frequency. Number of cycles a wave completes in one second; expressed in Hertz

Radar. Short for radio detecting and ranging. A way of detecting aircrafts and ships from a distance and estimating their locations

Radio Receivers. Receives radio waves and convert them back to sounds

Radio Transmitter. Attaches information to the radio signal by modulating it

Wavelength – the distance measured from one crest of a wave to the next crest or from one trough to the second through
References and Links

Books


Internet

http://www.imaginationstationtoledo.org

http://www.can-do.com/uci/ssi2001/emspectrum.html

http://www.physicsclassroom.com/mmedia/waves/em.cfm

http://science.hq.nasa.gov/kids/imagers/ems/ems2.html


http://enviroadvocacy.com/measure-your-campaign/

http://sciencevault.net/11hscphys/82worldcommunicates/823%20em%20waves.htm

http://www.colorado.edu/

http://school.discoveryeducation.com/lessonplans/interact/electromagneticspectrum.html

http://www.sciencebuddies.org/

http://webs.mn.catholic.edu.au/science/wilko/is94/notes/no2.htm
The learners demonstrate an understanding of the images formed by the different types of mirrors and lenses.

The learners should be able to make informed choices on selecting the right type of mirrors or lenses for specific purposes.

Overview

In the previous module, the students learned about electromagnetic spectrum. They gained an understanding of the different electromagnetic waves and the benefits they bring. One of the most common among these electromagnetic waves is the visible light.

In this module, they will study two properties of visible light namely the reflection and refraction. A closer look into these properties will be studied through different observable examples and experimentations using mirrors and lenses. This will help the teacher in providing tasks and activities that will guide the students in selecting the right type of mirrors and lenses that they can use in their daily lives.

Key questions for this module

At the end of module 3, the students will be able to answer the following questions:

1. How do the laws of reflection explain the functions of some optical instruments?
2. How does changing the location of the object from the lens/mirror affect the image formed?
3. How does changing the focal length of the lens/curved mirror affect the image formed?
Pre-Assessment (Answers)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

Reflection of Light in Mirrors

Teaching Tips:

Start the module by reviewing students' prior knowledge about light since they were able to learn these concepts in their previous years (Grades 7 and 8). The following questions may be asked for review:

- What is the nature of light?
- What is reflection?

To introduce the lesson on Reflection of Light in Mirrors, ask the students to write the word “AMBULANCE” in a sheet of paper in the same manner as it is written in the ambulance car. Ask them also to bring the sheet in front of the mirror and read the word “AMBULANCE”. Ask them why it’s written that way and let them perform the activity to elicit the concept of reflection.

Activity 1

Mirror, mirror, on the wall . . .

In this activity, the students will use a plane mirror to determine the following characteristics of the image formed: a) height, b) width, and c) distance from the mirror. After which, the students will compare the characteristics of the image with the characteristics of the actual object.

Teaching Tips:

1. Make sure that every member has his/her own part in the activity,
   - Student 1 assembles the set up for the activity.
   - Student 2 and 3 do the measurement of distance, height, and width.
   - Student 4 and 5 record the data in the tables.
2. Remind the students to handle the mirror with care because some mirrors have sharp edges.
Enrichment:

Let the students do a brainstorming activity on other possible signage. Ask them to cite the relevance to the society.

• Let the students draw the light rays on a plane mirror using the ray diagram and label the rays as incident and reflected rays.

Sample Data:

Table 1. Distance of the Object and Image from the Mirror

<table>
<thead>
<tr>
<th>Mark</th>
<th>No. of Parallel Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>between the object and the mirror</td>
</tr>
<tr>
<td></td>
<td>between the image and the mirror</td>
</tr>
<tr>
<td>Mark 1</td>
<td>(Answers may vary from each group). The no. of parallel lines of the object from the mirror should be the same as the no. of parallel lines of the image from the mirror</td>
</tr>
<tr>
<td>Mark 2</td>
<td></td>
</tr>
<tr>
<td>Mark 3</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Height and Width of Object and Image

<table>
<thead>
<tr>
<th>Description</th>
<th>Object</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>(Answers may vary from each group). The height and width of the object and the image formed should be the same.</td>
<td></td>
</tr>
<tr>
<td>Width (cm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Answers to Questions:

Q1. The distance (as indicated by the number of parallel lines) of the object from the mirror is the same as the distance of the image from the mirror.

Q2. The height and the width of the object is the same as the height and width of the image as seen from the plane mirror.
Activity 2

Angle of Incidence vs. Angle of Reflection

In this activity, the students will compare the angle of reflection and the angle of incidence. They will also state one of the laws of reflection.

Teaching Tips:

1. The students will form a group of five members. Everybody should have a part in the activity.
   - Student 1 assembles the set up for the activity.
   - Student 2 and 3 do the pointing of laser to the mirror.
   - Student 4 and 5 record the data in the tables.

2. Remind the students to handle the mirror with care because some mirrors have sharp edges.

3. Warn the students to avoid pointing the laser to someone’s eye.

Enrichment:
- Research activity on why the laser light/ laser pointer should not be pointed directly on one’s eye.

Sample Data:

<table>
<thead>
<tr>
<th>Angle of Incidence</th>
<th>Angle of Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>10°</td>
<td>10°</td>
</tr>
<tr>
<td>20°</td>
<td>20°</td>
</tr>
<tr>
<td>30°</td>
<td>30°</td>
</tr>
<tr>
<td>40°</td>
<td>40°</td>
</tr>
<tr>
<td>50°</td>
<td>50°</td>
</tr>
</tbody>
</table>

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Answers to Questions:

Q3. The angle of incidence is equal to the angle of reflection.

Q4. Light enters the periscope and reflected at an equal angle and again reflected by another mirror. The diagram of the light ray entering and leaving the periscope is shown below.

A periscope is an instrument for observation over, around or through an object, obstacle or condition that prevents direct line-of-sight observation from an observer’s current position.

Activity 3

Mirror Left-Right Reversal

In this activity, the students will describe the images in a plane mirror. Students will also show an understanding of reversal effect in plane mirrors by writing laterally inverted letters and words.

Teaching Tips:

1. If an alphabet chart is not available, construct one using a clear sheet of paper. Letters should be written in capital letters.

2. The teacher may give additional tasks to students like writing a letter to their loved one (parent) written in reverse and reading it requires a plane mirror in front of it.
Answers to Questions:

Q5. The letters of the alphabet that can be read properly in front of the mirror are A, H, I, M, O, T, U, V, W, X, Y.

Q6. Some words that can be read properly both with a mirror and without a mirror are MOM, WOW, TIT, TAT, TOOT, etc.

Q7. **Honesty is the best policy.**

Activity 4

**Who Wants to be a Millionaire?**

In this activity, students will identify the relationship between the number of images formed and the angle between the two mirrors. They will also use the gathered data to derive the formula for determining the number of images formed when two mirrors are kept at a certain angle.

Teaching Tips:

1. Remind the students to handle the mirror with care because some mirrors have sharp edges.
2. After answering the activity, the teacher may instruct students to make a table of other angles and let them answer how many images are formed.

Additional Information/Enrichment:

- Brainstorming activity on the application of reflection of light in mirrors as in hallways, parlors, etc.
Sample Data:

<table>
<thead>
<tr>
<th>Angle</th>
<th>No. of Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>90°</td>
<td>3</td>
</tr>
<tr>
<td>60°</td>
<td>5</td>
</tr>
<tr>
<td>45°</td>
<td>7</td>
</tr>
<tr>
<td>30°</td>
<td>11</td>
</tr>
</tbody>
</table>

Answers to Questions:

Q8. As the angle between two mirrors decreases, the number of images increases. Conversely, as the angle between the mirrors increases, the number of images formed decreases.

Q9. From the data in Table 4, the number of images is inversely proportional to the angle between two mirrors.

Q10. Using the data from Table 4, the following formula will be derived.

\[ N = \frac{360}{\theta} - 1 \]

where \( N \) = no. of images
\( \theta \) = angle between

Q11. The mirrors should be placed parallel facing each other to see an infinite number of images.

Activity 5

Image Formed by Curved Mirrors

In this activity, students will determine the location and size of the images formed by curved mirrors. They will also compare the location and size of images formed by a concave mirror with that of a convex mirror.
Teaching Tips:

1. To introduce reflection on non-flat mirrors, ask the following questions:
   - Have you seen your image on the two sides of clear spoon?
   - What do you notice about your image on each of the two sides of the spoon?
   - How will you compare your image from the two sides of the spoon?

2. The teacher can also show spherical mirrors and label them as concave and/or convex mirror. Pass around the mirrors so the students will be able to see the difference between the two in terms of shape and images formed.

3. NSTIC materials may be used in this activity.

4. Check the focal lengths of the mirrors to be used before hand. Also, make sure that the values of f are clearly written on the mirrors.

5. Show a demo on how light rays are reflected in concave and convex mirrors. You can use spoon if no mirrors are available. You can also use the segment in CONSTEL: Physics in Everyday Life to show this. (Episode 32 – Light, Sight and Color).

6. For a better understanding show illustrations of concave and convex mirrors with labels of their important points and terminologies.

Additional Information:

Images Formed by Curved Mirrors

The law of reflection that applies for plane mirrors, namely $\angle i = \angle r$, also applies to curved mirrors. The extremely small area involved in the reflection of a ray of light from a curved mirror surface can be regarded as a plane area at that point.

As convex mirrors give a wider range of view than plane mirrors of the same size, they are sometimes used in shops and supermarkets to watch for shoplifters. Shaving and make-up mirrors are often concave because they produce a magnified image when held close. Parabolic reflectors are used in motor car headlights and searchlights and the light source is placed at the focus of the reflector, since this gives way to a concentrated, straight beam. Satellite tracking stations also use parabolic reflectors. The reflector is used to bring microwave signals from satellites to a focus since these waves also follow the same laws of reflection as light.
Concave (Converging) Mirrors

Because concave mirrors cause parallel light rays to converge or meet they are known as converging mirrors. In order to understand the various types of images formed by curved mirrors, several terms must be defined. The terms defined in this section refer to concave mirrors.

The center of curvature (C) of a spherical mirror (see Figure 2) is the center of the sphere of which the mirror is a part of.

The radius of curvature (R) is the radius of the sphere of which the mirror forms a part.

The center of the reflecting surface of the mirror is called the vertex (V) of the mirror. The principal axis is the line drawn through the center of curvature and the vertex of the mirror. The aperture is the diameter of the reflecting surface.

By convention we shall regard the light incident on a curved mirror as coming from the left. Fig. 3 shows incident rays of light parallel to the principal axis hitting the mirror at point A, and being reflected at an angle until it intersected with the principal axis at point F. This point, F, is called the principal focus, or focal point and it lies on the principal axis of the mirror.

In a converging mirror, incident rays parallel to the principal axis converge as the focal point.
The distance of the focal point, F, from the vertex, V, of the mirror is known as the focal length, f.

Consider a ray of light parallel to the principal axis of a concave mirror. After reflection, this ray will pass through the focus of the mirror. This ray follows the law of reflection that $\theta_i = \theta_r$. The normal to the mirror surface at A must pass through the center of curvature C as the normal must be a radius of the sphere of which the mirror forms a part. Hence, the angles marked $\theta_i$ and $\theta_r$ are equal. This means that FC = FA since triangle AFC is an isosceles triangle and FA = VF.

**Ray Tracing**

It is possible to use scale drawings and graphical methods to obtain the location of the image of a small object placed in front of a concave mirror. The method is based on the straight-line transmission of light. Since it involves geometric constructions, the process is known as geometrical optics. The diagrams that are drawn are referred to as ray diagrams.

In order to locate the image of a point on an object, two rays can be drawn from the point to the mirror. These rays can be drawn after reflection and their point of intersection will give the image of the point.

In locating the image, any two of four so-called principal rays may be considered. These rays are used because their paths can be easily predicted.

*Source: TRM: PASMEP*

**Answers to Questions:**

Q1. When you bring the flashlight near to the concave mirror, the size of the image increases and the location moves farther from the mirror. Conversely, the size of the image decreases and the location becomes farther the observer.

Q2. The images formed by a concave mirror can be seen on screen and on the mirror while the images formed by a convex mirror can be seen only on the mirror. Therefore, images formed by concave mirrors can be real and virtual, depending on the location of the object. The images formed by convex mirrors are virtual.
Activity 6

Are you L-O-S-T after Reflection?

In this activity, students will construct ray diagrams to determine the location, orientation, size, and type of images formed by the curved mirror. They will also describe the image formed in a curved mirror.

Teaching Tips:

1. Emphasize the accuracy of measurement of the focal point, F and center of curvature, C. (Note: The radius of curvature is twice the focal length).
2. The center of curvature, C can be determined easily if a protractor is used as a curve in the diagramming.
3. Instruct the students to use different colors of ink for incident and reflected rays (e.g. blue for incident ray and red for reflected ray).
4. Instruct them to use the four rays as much as possible but tell them that at least two rays are needed to locate the image.
5. In the problem solving part, make sure that following information (sign conventions) were made clear among the students:
   - focal point is positive (+) if the mirror is a concave mirror
   - focal point is negative (-) if the mirror is a convex mirror
   - distance of image from mirror is positive (+) if the image is a real image and located on the object’s side of the mirror.
   - distance of image from mirror is negative (-) if the image is a virtual image and located behind the mirror
   - orientation of image with respect to original image is positive (+) if the image is an upright image (and therefore, also virtual)
   - orientation of image with respect to original image is negative (-) if the image is an inverted image (and therefore, also real

Enrichment:

- Concept Map making on the difference of the images formed on a concave mirror and convex mirror
Sample Data:

Concave Mirror

A. 

B. 

C. 

D. 

E. 

Convex Mirror

F. 

G.
Table 6: Location, Orientation, Size, and Type of Image
Formed in Curved Mirrors

<table>
<thead>
<tr>
<th>Location of Object</th>
<th>Location</th>
<th>Orientation</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. CONCAVE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Farther than the Center of Curvature</td>
<td>Between C and F</td>
<td>Inverted</td>
<td>reduced</td>
<td>real</td>
</tr>
<tr>
<td>• At the Center of Curvature</td>
<td>At C</td>
<td>Inverted</td>
<td>same</td>
<td>real</td>
</tr>
<tr>
<td>• Between the Center of Curvature and</td>
<td>Beyond C</td>
<td>Inverted</td>
<td>enlarged</td>
<td>real</td>
</tr>
<tr>
<td>the Focal point</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• At the Focal point</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Between the Focal point and the</td>
<td>Behind the</td>
<td>Upright</td>
<td>enlarged</td>
<td>virtual</td>
</tr>
<tr>
<td>Center of the lens (Vertex)</td>
<td>Mirror</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. CONVEX</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• All locations</td>
<td>Between F and V</td>
<td>Upright</td>
<td>reduced</td>
<td>Virtual</td>
</tr>
</tbody>
</table>

**Answers to Questions:**

Q14. The location of the object affects the characteristics and location of the image in such a way that as the object comes nearer the concave mirror, its image appears farther away from the mirrors and becomes larger and inverted. As it comes closer to the surface of the concave mirror (between F and V), the image appears upright and becomes virtual. For all locations of object in front of a convex mirror, the image formed is always upright, reduced, virtual, and located between F and V.

Q15. A dentist's mirror is a concave mirror because the image appears larger or magnified, making it easier for the dentist to see the details of the object (teeth). This happens because the object (teeth) is located between the mirrors focal point and the vertex or optical center of the mirror.

Q16. Most of the department stores use convex mirrors because it gives a wider range of view.
Answers to Try solving this… (Concave Mirror)

1. Given:

height of the object, \( h = 7.00 \text{ cm} \)

distance of the object, \( p = 30.0 \text{ cm} \)

focal point, \( f = 10.0 \text{ cm} \)

Find:

distance of the image, \( q = ? \)

height of the image, \( h' = ? \)

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]

\[
\frac{1}{10.0 \text{ cm}} = \frac{1}{30.0 \text{ cm}} + \frac{1}{q}
\]

\[
\frac{1}{10.0 \text{ cm}} - \frac{1}{30.0 \text{ cm}} = \frac{1}{q}
\]

\[
\frac{30.0 \text{ cm} - 10.0 \text{ cm}}{(10.0 \text{ cm})(30.0 \text{ cm})} = \frac{1}{q}
\]

\[
q = 15 \text{ cm}
\]

\[
\frac{h'}{h} = \frac{-q}{p}
\]

\[
\frac{h'}{7.00 \text{ cm}} = \frac{-15 \text{ cm}}{30.0 \text{ cm}}
\]

\[
h' = \frac{(7.00 \text{ cm})(-15 \text{ cm})}{30.0 \text{ cm}}
\]

\[
h' = -3.5 \text{ cm}
\]
2. Given:
distance of the image, \( q = 30.0 \text{ cm} \)
focal point, \( f = 15.0 \text{ cm} \)

Find:
distance of the object, \( p = ? \)

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]
\[
\frac{1}{15.0\text{ cm}} = \frac{1}{p} + \frac{1}{30.0\text{ cm}}
\]
\[
\frac{1}{15.0\text{ cm}} - \frac{1}{30.0 \text{ cm}} = \frac{1}{p}
\]
\[
30.0 \text{ cm} - 15.0 \text{ cm} = \frac{1}{p}
\]
\[
(15.0 \text{ cm})(30.0 \text{ cm}) = \frac{1}{p}
\]
\[
\frac{15}{450} = \frac{1}{p}
\]
\[
15p = 450
\]
\[
15p = 450
\]
\[
p = 30 \text{ cm}
\]

**Answers to** Try solving this… (Convex Mirror)

1. Given:
f = -10.7 cm
p = 33.7 cm

Find:
q = ?

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]
\[
\frac{1}{-10.7\text{ cm}} = \frac{1}{33.7 \text{ cm}} + \frac{1}{q}
\]
\[
\frac{1}{-10.7\text{ cm}} - \frac{1}{33.7 \text{ cm}} = \frac{1}{q}
\]
\[
\frac{1}{q} = \frac{33.7 \text{ cm} + 10.7 \text{ cm}}{(-10.7 \text{ cm})(33.7 \text{ cm})}
\]
\[
\frac{1}{q} = \frac{49.4}{-360.59}
\]
\[
q = -8.12 \text{ cm}
\]
2. Given:

\[ h = 7.00 \text{ cm} \]
\[ p = 37.5 \text{ cm} \]
\[ f = -12.5 \text{ cm} \]

Find:

\[ q = ? \]
\[ h' = ? \]

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]
\[
\frac{1}{-12.5\text{ cm}} = \frac{1}{37.5\text{ cm}} + \frac{1}{q}
\]
\[
\frac{1}{-12.5\text{ cm}} - \frac{1}{37.5\text{ cm}} = \frac{1}{q}
\]
\[
\frac{37.5\text{ cm} + 12.5\text{ cm}}{(-12.5\text{ cm})(37.5\text{ cm})} = \frac{1}{q}
\]
\[
\frac{50\text{ cm}}{-468.75\text{ cm}} = \frac{1}{2}
\]
\[
q = -9.38\text{ cm}
\]
\[
\frac{h'}{h} = -\frac{q}{p}
\]
\[
\frac{h'}{7.00\text{ cm}} = -\frac{(-9.38\text{ cm})}{37.5\text{ cm}}
\]
\[
h' = \frac{(7.00\text{ cm})(-9.38\text{ cm})}{37.5\text{ cm}}
\]
\[
h' = \frac{65.66\text{ cm}}{37.5\text{ cm}}
\]
\[
h' = 1.75\text{ cm}
\]

**Refraction of Light in Lenses**

**Teaching Tips:**

Start the lesson by asking the students to recall their previous lesson/s on light in grade 8. Ask them to share what they learned and/or still remember about the refraction property of light. The following questions may be asked:

- *What is refraction of light?*
- *What causes refraction of light?*

Distribute a concave and a convex lens to the class and let them examine the two lenses. Then call on them to differentiate the two in terms of appearance, etc. Write descriptions on the board under the column headings: concave lens and convex lens.
Activity 7

You can be Magnified?

In this activity, students will measure the focal length and linear magnification of a convex lens. They will also describe and find the location of the images of the object when placed at different locations from the convex lens.

Teaching Tips:

1. Show a demo on other ways to locate the focal length of the convex lens like the procedure below.

   a. Look for any object (tree, etc.) outside your window.
   b. Hold up the lens facing the window.
   c. Move a sheet of paper (screen) behind it. See figure on the right.
   d. Adjust the paper until a clear image of the distant object (tree, etc.) outside the window is observed on the paper.
   e. Measure the distance from the image to the lens. This is the focal length of the lens.

   Source: Science and Technology IV Textbook, SEMP

2. For a better understanding show illustrations of concave and convex mirrors with labels of their important points and terminologies.
Additional Information:

Focal Length

For both convex and concave lenses, the distance from the principal focus to the center of the lens is called the \textit{focal length} of the lens, \( f \). See Figure 6.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{focal_length.png}
\caption{Focal length of a convex lens and a concave lens}
\end{figure}

\textbf{Sample Data:}

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|}
\hline
\textbf{Description of Image} & \textbf{Distance from the Lens} & \\
& \textbf{Object (cm)} & \textbf{Eye (cm)} \\
\hline
\textit{Answers may vary depending on the focal length of the lens used} & & \\
Enlarged and upright & \( p < f \) & \( q > f \) \\
Enlarged and inverted & \( f < p < 2f \) & \( q > 2f \) \\
Reduced and inverted & \( p > 2f \) & \( f < q < 2f \) \\
\hline
\end{tabular}
\caption{Distances from the Lens of Object and your Eye}
\end{table}

\textbf{Answers to Questions:}

Q17. \textit{Answers may vary.}

Q18. The image produced by a very distant object is inverted.

Q18. Convex lenses are used as magnifying glasses. To produce a magnified and upright image, the object is located between the lens’ focal point and vertex or optical center.

Q19. A magnifying glass should be placed nearer the object than the eye. This is because the eye serves as the screen where the image is formed and the image distance should be greater than the object distance.
Activity 8

Are you L-O-S-T after Refraction?

In this activity, students will construct ray diagrams for lenses and determine the location, orientation, size, and type of image formed.

Teaching Tips:

1. Use separate sheets of paper in constructing ray diagrams for objects at different locations in front of convex and concave lenses.
2. Emphasize the correct measurement for points F, F', 2F, and 2F'. An imaginary vertical line in the center lens may be drawn and used as the center of the lens.
3. Instruct them to use different colors of ink for incident and refracted rays (e.g. blue for incident ray and red for refracted ray).
4. Remind them to use the three rays as much as possible.
5. In the problem solving part, make sure that the following information (sign conventions) are made clear among the students:
   o $f$ is + if the lens is a double convex lens (converging lens)
   o $f$ is - if the lens is a double concave lens (diverging lens)
   o $q$ is + if the image is a real image and located behind the lens
   o $q$ is - if the image is a virtual image and located on the object’s side of the lens
   o $h'$ is + if the image is an upright image (and therefore, also virtual)
   o $h'$ is - if the image is an inverted image (and therefore, also real)
Sample Data:

Convext Lens

A. B. C. D. E.
Convex Lens

Table 9: Location, Orientation, Size, and Type of Image Formed by Lenses

<table>
<thead>
<tr>
<th>Location of Object</th>
<th>Image</th>
<th>Location</th>
<th>Orientation (upright or inverted)</th>
<th>Size (same, reduced or enlarged)</th>
<th>Type (real or virtual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. CONVEX LENS</td>
<td></td>
<td>Beyond 2F'</td>
<td>inverted</td>
<td>reduced</td>
<td>real</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At 2F'</td>
<td>inverted</td>
<td>same</td>
<td>real</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Between 2F' and F'</td>
<td>inverted</td>
<td>enlarged</td>
<td>real</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At the Focal point, F'</td>
<td></td>
<td>No Image Formed</td>
<td></td>
</tr>
<tr>
<td>B. CONCAVE LENS</td>
<td></td>
<td>Between F' and V</td>
<td>upright</td>
<td>enlarged</td>
<td>virtual</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Between F and V</td>
<td>upright</td>
<td>reduced</td>
<td>virtual</td>
</tr>
</tbody>
</table>
Answers to Questions:

Q21. As the object comes nearer the convex lens, the image appears farther and magnified. As it comes closer to the convex lens (between F and V), the image appears upright and becomes virtual. For all locations of object in front of a concave lens, the image formed is always upright, reduced, virtual, and located between F and V.

Q22.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photocopy &quot;Xerox&quot; Machine</td>
<td>At 2F'</td>
</tr>
<tr>
<td>Camera</td>
<td>Beyond 2F'</td>
</tr>
<tr>
<td>Telescope</td>
<td>At Infinity</td>
</tr>
<tr>
<td>Projector</td>
<td>Between 2F' and F'</td>
</tr>
<tr>
<td>Magnifying Glass</td>
<td>Between F' and V</td>
</tr>
</tbody>
</table>

Q23. A concave lens cannot form real image because a real image is formed by intersection of real refracted rays, and concave lens spreads out the real rays.

Answers to Try solving this… (Lenses)

1. Given:

   h = 8.00 cm  
   p = 46.5 cm  
   f = 16.0 cm

Find:

   q = ?      
   h' = ?

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \\
\frac{1}{16.0\text{cm}} = \frac{1}{46.5\text{cm}} + \frac{1}{q} \\
\frac{1}{16.0\text{cm}} - \frac{1}{46.5\text{cm}} = \frac{1}{q} \\
46.5\text{cm} - 16.0\text{cm} = \frac{1}{q} \\
\frac{30.5\text{cm}}{(16.0\text{cm})(46.5\text{cm})} = \frac{1}{q} \\
30.5\text{cm} = 744\text{cm} \cdot \frac{1}{q} \\
744\text{cm} = 30.5\text{cm} \cdot q \\
q = 24.4\text{cm}
\]
2. Given:

diameter = h = 3.10 cm
p = 25.0 cm
f = -11.0 cm

Find:
q = ?
h' = ?

\[
\frac{h'}{h} = \frac{-q}{p}
\]

\[
\frac{h'}{8.00 \text{ cm}} = \frac{-24.4 \text{ cm}}{46.5 \text{ cm}}
\]

\[
h' = \frac{(8.00 \text{ cm})(-24.4 \text{ cm})}{46.5 \text{ cm}}
\]

\[
h' = \frac{-195 \text{ cm}}{46.5 \text{ cm}}
\]

\[
h' = -4.20 \text{ cm}
\]

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]

\[
\frac{1}{-11.0 \text{ cm}} = \frac{1}{25.0 \text{ cm}} + \frac{1}{q}
\]

\[
\frac{1}{-11.0 \text{ cm}} - \frac{1}{25.0 \text{ cm}} = \frac{1}{q}
\]

\[
\frac{25.0 \text{ cm} + 11.0 \text{ cm}}{(-11.0 \text{ cm})(25.0 \text{ cm})} = \frac{1}{q}
\]

\[
q = -7.64 \text{ cm}
\]

\[
\frac{h'}{h} = \frac{-q}{p}
\]

\[
\frac{h'}{3.10 \text{ cm}} = \frac{-(-7.64 \text{ cm})}{25.0 \text{ cm}}
\]

\[
h' = \frac{(3.10 \text{ cm})(7.64 \text{ cm})}{25.0 \text{ cm}}
\]

\[
h' = \frac{23.68 \text{ cm}}{25.0 \text{ cm}}
\]

\[
h' = 0.947 \text{ cm}
\]
Activity 9

Making Improvised Optical Device

In this activity, students will improvise optical device such as pinhole camera, periscope, microscope, and telescope.

Teaching Tips:

Before performing the activity, the students are tasked to do some researches on how to make or improvise optical device such as pinhole camera, periscope, microscope, and telescope. The students may also use other materials other than the materials indicated in the activity. The students accomplish the Problem Solving Sheet and the teacher may employ group reporting about their output. If possible, encourage them to employ or use ICT (Information and Communications Technology) in their report. A rubric should be prepared by the teacher in grading the report of the students considering their resourcefulness, appearance/design of the device, durability of the device, oral report, etc.

Additional Information:

Optical Instruments and their Functions

The following are some optical instruments, their uses and functions.

Magnifying glass is a single positive lens that will add convergence to the visual system. As an object is brought near the eye, the retinal image increases in size. There is a limit to this increase in size, however, in the sense that at a very short distance between the eye and the object, the rays will diverge so much that a magnifying lens becomes necessary. The main function of a magnifying glass is to provide an image of an object that is bigger than that seen by the naked eye.
A **compound microscope** consists of a combination of lenses for magnifying an object several hundred times. It uses two converging lenses with short focal lengths. The lens near the object is the objective lens, while the one nearer the eye is the eyepiece. The objective lens forms a real and enlarged inverted image. The eyepiece, on the other hand, forms a further enlarged, erect, but virtual final image.

A **telescope** allows us to see distant objects. It contains two converging lenses, namely, the objective and the eyepiece. The objective lens forms a real image of a very distant object within the focus of the eyepiece lens. Meanwhile, the focal length of the objective lens must be relatively longer than the eyepiece lens for bigger magnification.

The **camera** is a box-like device used for taking pictures. It uses a lens that produces a real image on photographic film. It has a shutter that opens just long enough to allow the image to fall on the film before closing again.

**Binoculars** consist of a pair of telescopes mounted together, each having an objective lens and an eyepiece. The image formed by the objective lens of binoculars is upside-down, and the left and right sides are reversed. Binoculars use a system of prisms to switch the image left to right and right to left. Then the eyepieces create enlarged, virtual, upright images.

An **endoscope** is a long flexible tube that is inserted in the body so that a doctor can observe internal passages such as a person’s esophagus or intestine. It has a converging lens and bunches of optical fibers that convey the image to the end of the tube, where the image can be observed through a computer monitor or screen. An endoscope uses the concept of total internal reflection.

The **spectrometer** uses the principle of diffraction to create a spectrum of colors emitted by a light source. This aids scientists and engineers in identifying different substances.

An **overhead projector** has a mirror, which focuses light from an intense source onto a pair of converging lenses. These lenses direct the light through the slide to a projection lens. The lens is mounted on a sliding tube so that it can be adjusted to be able to focus the real image on the screen.
A **periscope** is an optical device consisting of a tube attached to a set of mirrors or prisms, through which an observer (typically in a submerged submarine or behind a high obstacle) can see things that are otherwise out of sight.

**Interferometer** is an optical device that uses the concepts of diffraction and interference to make precise measurements of very small distances. It can also be used to measure changes in the index of refraction.

---

### Summative Assessment (Answers)

1. A  
2. D  
3. C  
4. D  
5. A  
6. B  
7. D  
8. B  
9. A  
10. C  
11. A  
12. B  
13. C  
14. B  
15. A  
16. D  
17. A  
18. A  
19. C  
20. A
References and Links

A. Books


B. **Electronic Sources**


http://books.google.com/books?id=71zxDuunAvMC&pg=PA136&dq=appear-normal+focal-length-lens+print-size+diagonal+viewer+distance&lr=&as_brr=3&ei=x8L3R6mMJI-KswPRspyFCg&sig=X65o2ElkUmnobKyKOIZR7Z0y1I.

http://www.physicsclassroom.com/class/refln/Lesson-3/The-Mirror-Equation

http://www.physicsclassroom.com/Class/refln/U13L3d.cfm#note
