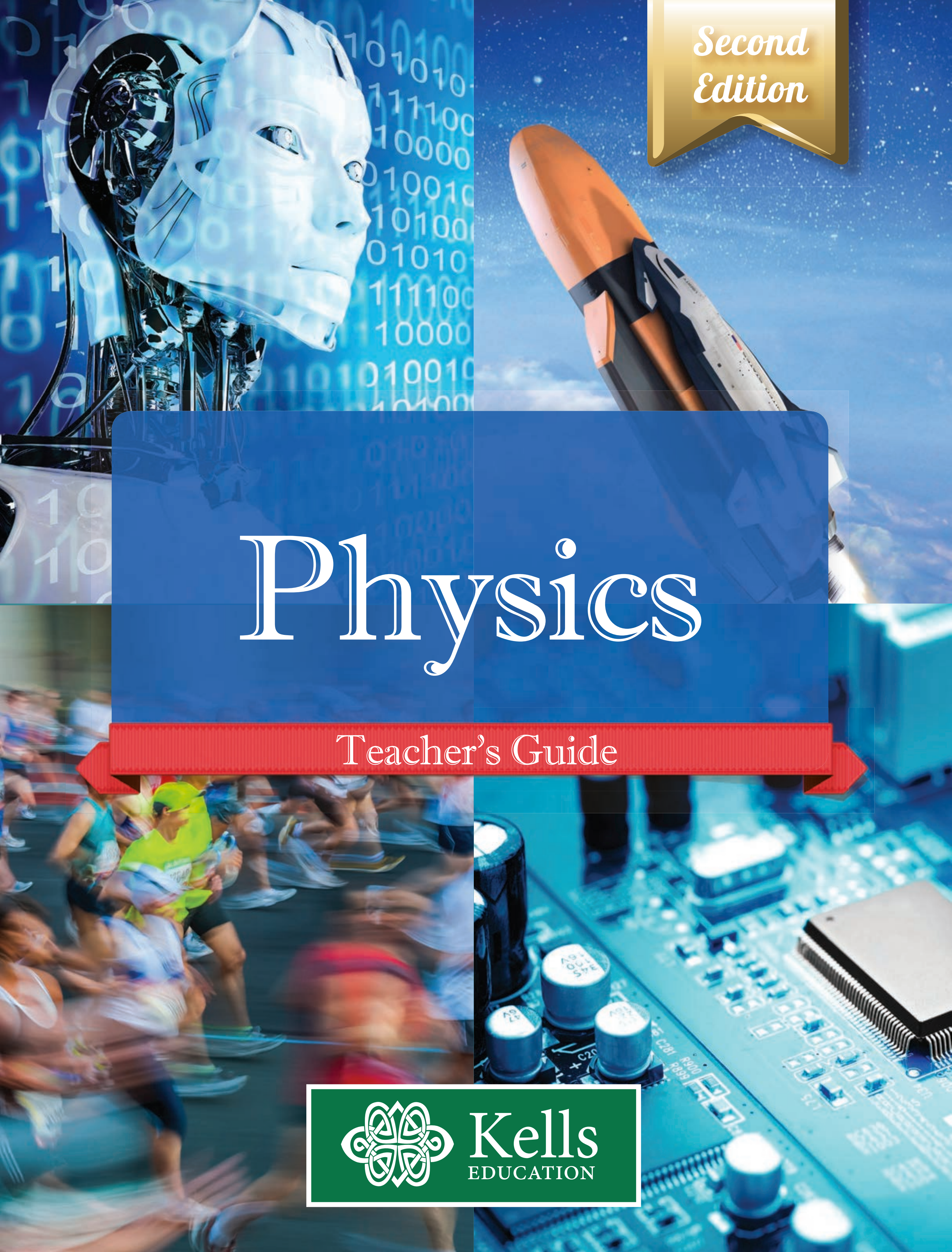

Second Edition

Physics

Teacher's Guide

Kells
EDUCATION

Physics

Teacher's Guide

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EDUCATION

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Physics Teacher's Guide

Kells
EDUCATION

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Table of Contents

To the Teacher

Dear teacher,

This book is intended to help you teach Physics. As you know, Physics is everything around you and the universe, from the largest galaxies to the smallest subatomic particles. Physics is basic to all sciences and from where all other sciences derive.

You will teach the structure of matter, motion, energy and force and the role physics plays in modern technology development. You will guide students to take well-informed decisions about their health and the environment. Throughout the book, the focus is leading students to work in teams and reaching consensus.

There are projects that guide students to understand that physics can offer solutions to local and world problems. There are recommendations of books, videos and articles to help students expand their knowledge. There are also activities and experiments that were designed to enhance knowledge and boost learning beyond the book to have a clear understanding of Physics.

We hope you enjoy teaching this fascinating subject. We are certain that the book can help you guide students to think critically, develop problem solving skills and use their logical/ mathematical skills to analyze every day phenomena and give a mathematical interpretation.

The author

Unit 1 covers the topics related to motion and force, velocity and the relationship between displacement and time. The unit looks at how to interpret tables and position-time graphs to describe different kinds of motion. Finally, Aristotle and Galilei contributions to physics are studied.

Unit 2 presents the Laws of Motion and how to use Newton's rules to predict effects of forces in everyday situations to later focus on the Solar System Bodies movement and the effects of gravitational force. Finally, kinetic energy and other movements that occur in the environment are studied.

Unit 3 focuses on the Kinetic Particle theory based on the basic properties of matter such as mass, volume, density and its states of aggregation as well as the interpretation of algebraic expressions of the Conservation of Energy Principle.

Unit 4 covers the atom components and constitution studying the effects of electrostatic interactions in everyday situations as well as ideas that led to the discovery of electromagnetic induction and energy to finally develop actions for its sustainable consumption.

Unit 5 describes the universe exploration. The unit focuses on the characteristics of bodies found in the universe and how astronomy has led to discoveries of new technologies that influence modern life.

How to use this book

Session information: In this section, you will see the course pacing as week and session. Consider each session is fifty minutes long to cover a 40 week course and you also have the expected learning outcome.

Content Delivery: In this section, you will see recommendations to deliver information in class.

Skills Development: This is the list of strategies you will be using in the session.

Evaluation of content: This is the description of how you should evaluate learning outcomes.

SESSION INFORMATION

Week: 2

Sessions: 10, 11

Expected learning outcome: Describe the characteristics of wave motion, based upon the wave model: crest, trough, node, amplitude, length, frequency and period. Differentiate transverse and longitudinal wave-motion in terms of direction and propagation. Describe sound waves behavior: tone, intensity and speed based upon the wave model.

CONTENT DELIVERY

Start: Students should answer the question in the section *Reflect, Explain and Share.*

Development: Students should do the experiment. Help as necessary.

Closing: Students should answer the questions in the experiment.

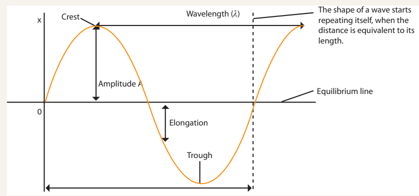

FIG. 1.8 Parts of a wave.

- This type of wave is called transverse wave. The displacement of the medium is perpendicular to the direction of propagation of the wave. Some examples of transverse waves are found in the movement of a rope, seismic waves and the waves of the sea.

Reflect, Explain and Share

If there were no air, as in a vacuum in outer space, do you think sounds could be heard?

The type of wave you just studied is called **transverse**. The parts of the medium move perpendicularly to the direction of the wave.

GLOSSARY

Coil. A ring or loop in a spring. Suddenly. Quickly, unexpectedly.

Experiment

Longitudinal and transverse waves

MATERIAL

- A plastic spring.

PROCEDURE

One student must stretch the plastic spring and hold it on a table or on the floor. Holding it tightly on one extreme, compress two or three **coils** and **suddenly** release them.

Answer the following questions and carry out the activities.

a) What is the difference between the rope and the motion of the spring?

b) Did the matter (material) move in either of the cases?

c) What is the direction of the spring's pulses compared to the motion of the coil?

Share your answers with the class.

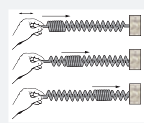

FIG. 1.9 Experiment with a spring.

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SKILLS DEVELOPMENT

Critical thinking skills: Observing, experimenting.

Interpersonal skills: Working as a team.

EVALUATION OF CONTENT

Students should get their experiment checked by the teacher.

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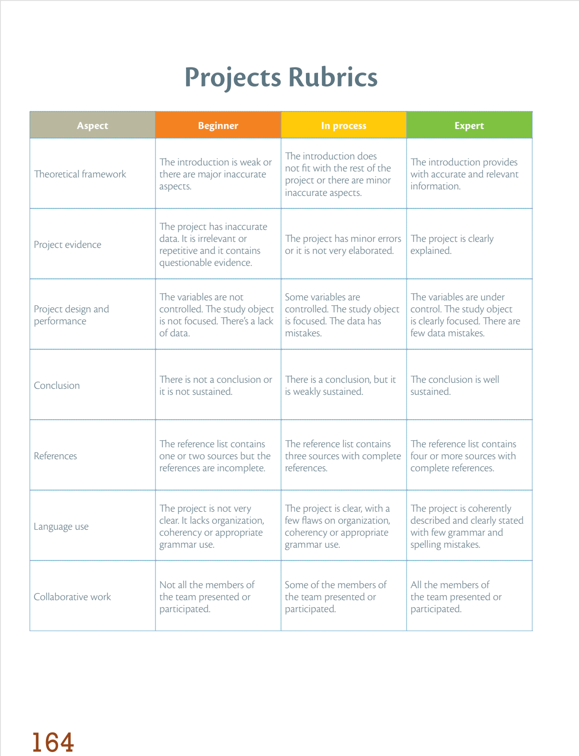

Projects Rubrics

Aspect	Beginner	In process	Expert
Theoretical framework	The introduction is weak or there are major inaccurate aspects.	The introduction does not fit with the rest of the project or there are minor inaccurate aspects.	The introduction provides with accurate and relevant information.
Project evidence	The project has inaccurate data. It is irrelevant or repetitive and it contains questionable evidence.	The project has minor errors or it is not very elaborated.	The project is clearly explained.
Project design and performance	The variables are not controlled. The study object is not focused. There's a lack of data.	Some variables are controlled. The study object is focused. The data has mistakes.	The variables are under control. The study object is clearly focused. There are few data mistakes.
Conclusion	There is not a conclusion or it is not sustained.	There is a conclusion, but it is weakly sustained.	The conclusion is well sustained.
References	The reference list contains one or two sources but the references are incomplete.	The reference list contains three sources with complete references.	The reference list contains four or more sources with complete references.
Language use	The project is not very clear. It lacks organization, coherency or appropriate grammar use.	The project is clear, with a few flaws on organization, coherency or appropriate grammar use.	The project is coherently described and clearly stated with few grammar and spelling mistakes.
Collaborative work	Not all the members of the team presented or participated.	Some of the members of the team presented or participated.	All the members of the team presented or participated.

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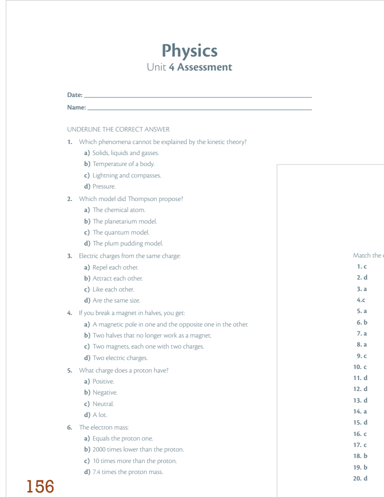
Rubrics: Rubrics to evaluate students' performance in science.



Physics
Unit 4 Assessment

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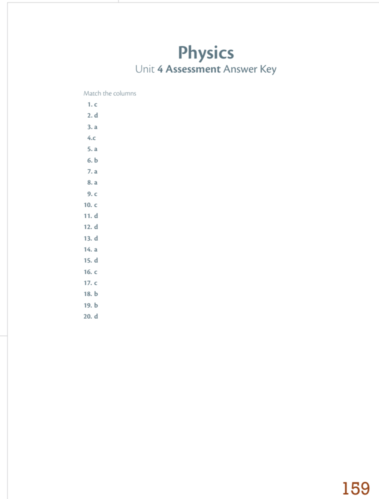

Physics
Unit 4 Assessment Answer Key

Match the columns

1. c
2. d
3. a
4. c
5. a
6. b
7. a
8. a
9. c
10. c
11. d
12. d
13. d
14. a
15. d
16. c
17. c
18. b
19. b
20. d

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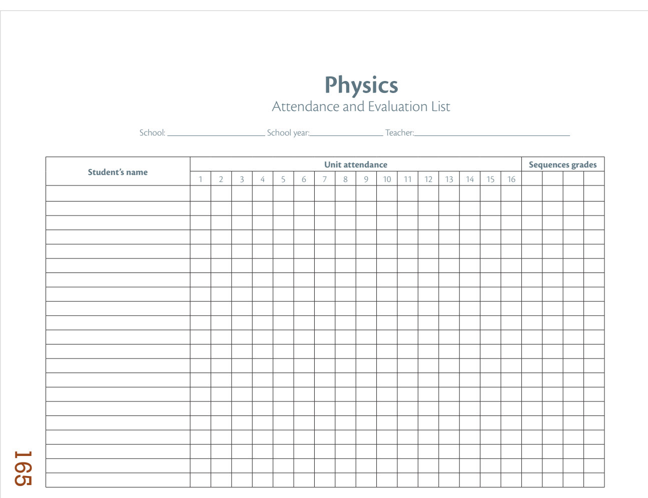
Summative Assessment: Unit evaluation instruments with answer key.

Attendance list and Evaluation format: These formats will help you keep track of the evaluation procedure specially designed for the content of this book.



Physics
Attendance and Evaluation List

School: ______ School year: ______ Teacher: ______

Student's name | Unit attendance | Sequences grades

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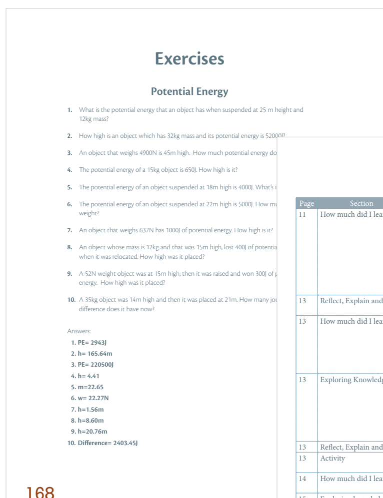

Exercises

Potential Energy

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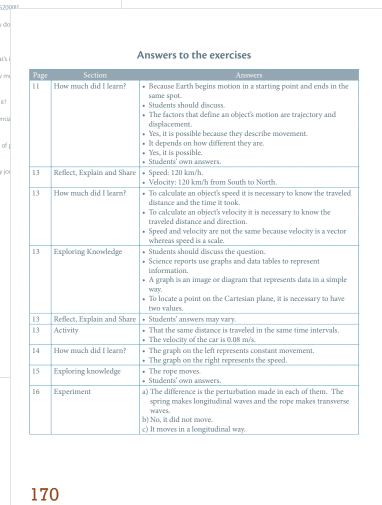

Answers to the exercises

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Exercises: Extra problem practices with answer key on the hardest topics: Potential and Kinetic energy.

Answers to exercises: Exercises which do not depend on students' own answers have answer key.

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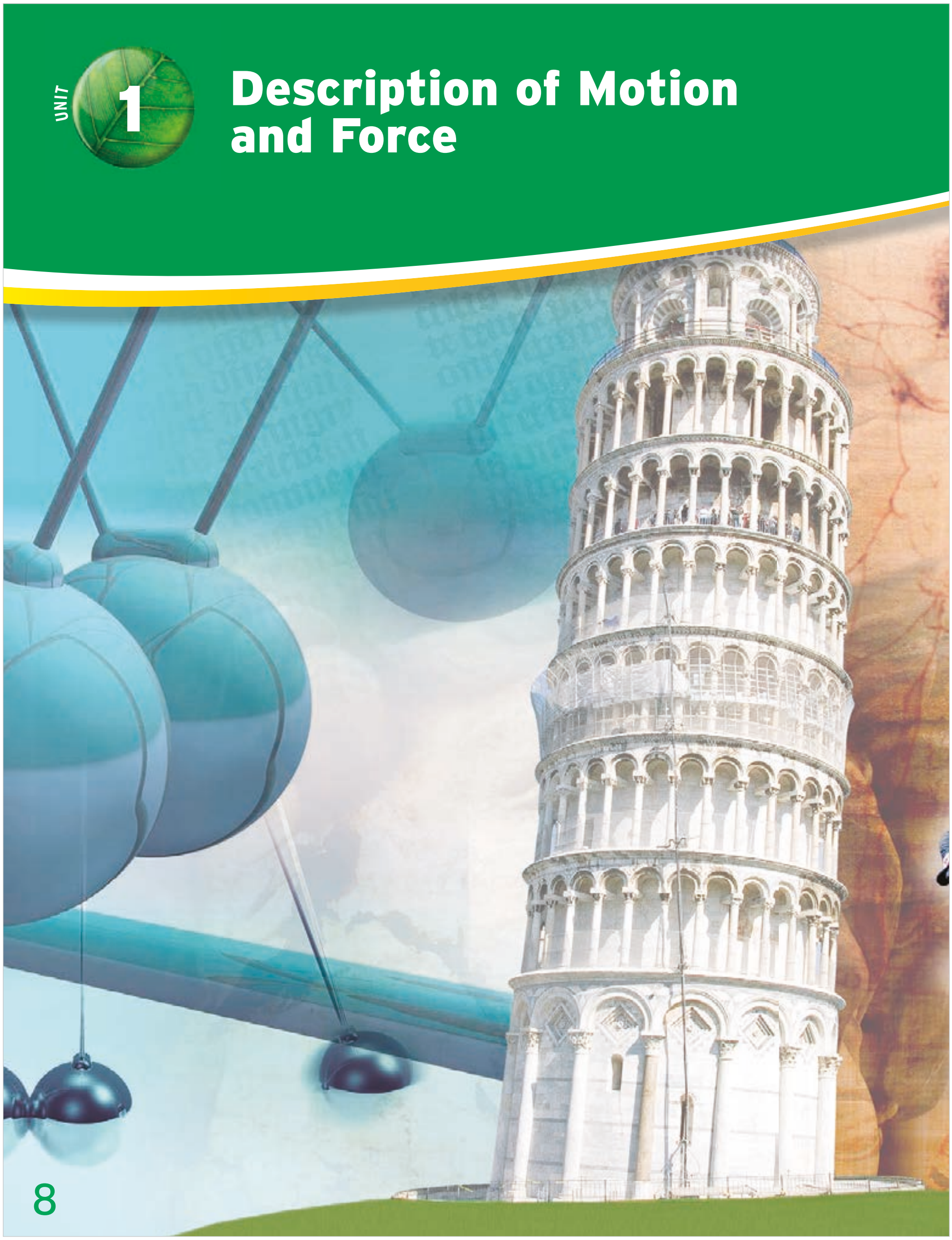
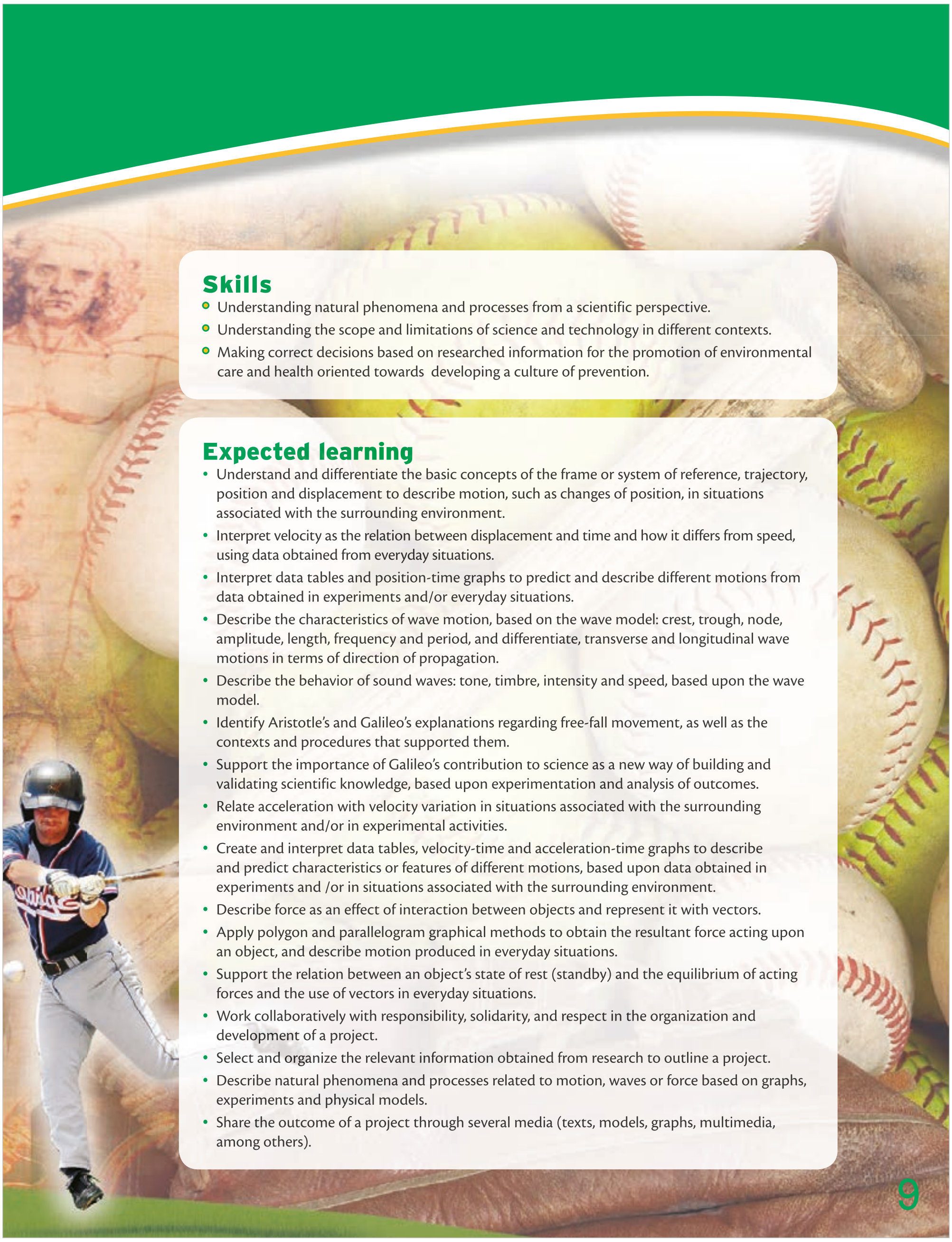

UNIT 1

Description of Motion and Force

8



Skills

- Understanding natural phenomena and processes from a scientific perspective.
- Understanding the scope and limitations of science and technology in different contexts.
- Making correct decisions based on researched information for the promotion of environmental care and health oriented towards developing a culture of prevention.

Expected learning

- Understand and differentiate the basic concepts of the frame or system of reference, trajectory, position and displacement to describe motion, such as changes of position, in situations associated with the surrounding environment.
- Interpret velocity as the relation between displacement and time and how it differs from speed, using data obtained from everyday situations.
- Interpret data tables and position-time graphs to predict and describe different motions from data obtained in experiments and/or everyday situations.
- Describe the characteristics of wave motion, based on the wave model: crest, trough, node, amplitude, length, frequency and period, and differentiate, transverse and longitudinal wave motions in terms of direction of propagation.
- Describe the behavior of sound waves: tone, timbre, intensity and speed, based upon the wave model.
- Identify Aristotle's and Galileo's explanations regarding free-fall movement, as well as the contexts and procedures that supported them.
- Support the importance of Galileo's contribution to science as a new way of building and validating scientific knowledge, based upon experimentation and analysis of outcomes.
- Relate acceleration with velocity variation in situations associated with the surrounding environment and/or in experimental activities.
- Create and interpret data tables, velocity-time and acceleration-time graphs to describe and predict characteristics or features of different motions, based upon data obtained in experiments and /or in situations associated with the surrounding environment.
- Describe force as an effect of interaction between objects and represent it with vectors.
- Apply polygon and parallelogram graphical methods to obtain the resultant force acting upon an object, and describe motion produced in everyday situations.
- Support the relation between an object's state of rest (standby) and the equilibrium of acting forces and the use of vectors in everyday situations.
- Work collaboratively with responsibility, solidarity, and respect in the organization and development of a project.
- Select and organize the relevant information obtained from research to outline a project.
- Describe natural phenomena and processes related to motion, waves or force based on graphs, experiments and physical models.
- Share the outcome of a project through several media (texts, models, graphs, multimedia, among others).

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SESSION INFORMATION

Week: 1

Session: 1

Expected learning outcome: Students will identify the learning outcomes of the unit in order to make a study plan.

CONTENT DELIVERY

Start: Welcome students. Write on the board your name, your subject, the class schedule, the evaluation and project presentation dates, ask them to write down their names on a piece of paper to call the roll from the very first class. Explain the grading criteria you will follow.

Development: Ask students to open their book to page 9. Students will read the expected learning outcomes and underline the topics they consider will be hard to accomplish. Then, they must select the best way to study the topics: Making diagrams, talking to partners, doing sample exams, doing experiments or doing choral repetition.

Closing: Students should create a study plan in order to work with the content and especially the hardest one.

SKILLS DEVELOPMENT

Metacognitive skills: Planning, organizing, and creating a study plan.

EVALUATION OF CONTENT

Students should get their study plan checked by the teacher.

SESSION INFORMATION

Week: 1

Sessions: 2, 3

Expected learning outcome: Understand and differentiate the basic concepts of the frame or system of reference, trajectory, position and displacement to use them in the description of motions, such as changes of positions, in situations associated with the surrounding environment.

CONTENT DELIVERY

Start: Students should read and answer the introductory questions in the section *Exploring knowledge*. Elicit answers in whole class so they can understand what they should analyze.

Development: Students should work in pairs to do the activity.

Closing: Students should answer the question in the section *Reflect, Explain and Share* Is the Sun still if we use the center of our galaxy as frame of reference?

Project preparation: Divide the group in teams. Students should take to the following class these materials: a piece of marble, paint, cardboard, markers and a tape measure.

Expected Learning

Understand and differentiate the basic concepts of the frame or system of reference, trajectory, position and displacement to use them in the description of motions, such as changes of positions, in situations associated with the surrounding environment.

Motion of Objects

Frame of Reference and Trajectory; Difference between Displacement and Traveled Distance

Exploring Knowledge

Observe the objects and people in your classroom.

- How can you locate them?
- Which of them are still and which are in motion?

You have surely heard that the entire universe is in constant motion, but what does this really mean? With the help of your teacher, present your ideas and answer the questions above as a group.

Reflect, Explain and Share

- Imagine you are sitting on a bus on the way home. If somebody standing on the street sees you, does he think you are moving, or that you are completely still? Why?

Activity

In pairs, make a list of three objects in the classroom. Take turns describing the place where they are located using a single object as a reference.

- Were you able to locate all the objects your classmate pointed out?
- What reference did each of you use?
- Did you use the same reference?

In science, we use the concept of **frame or system of reference** to describe **positions** and motions of objects in any given place.

In our Solar System, for example, we use the Sun, astronomic measurements and terrestrial cardinal points as a frame of reference to understand location and movements of planets..

Reflect, Explain and Share

- Is the Sun still if we use the center of our galaxy as frame of reference?

FIG. 1.1 Location of objects in the classroom.

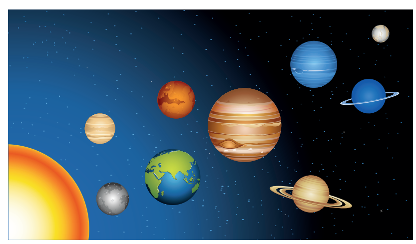

FIG. 1.2 Model of the Solar System.

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SKILLS DEVELOPMENT

Critical thinking skills: Observing, comparing and contrasting, analyzing.

EVALUATION OF CONTENT

Students should be able to identify objects that are still from the ones that are in motion

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Experiment

Trajectory of an object and difference between distance and **displacement**.

MATERIAL

- One marble
- Three small jars of paint, different colors (tempera)
- Cardboard
- Markers
- Measuring tape

PROCEDURE

Get into teams of five. One of you covers the marble in paint and puts it on the cardboard, then, the other four move the cardboard around. The marble will leave a track. Remove the marble after 15 seconds and mark **A** on the spot where the marble started to move and **B** on the spot where it stopped. Repeat the procedure twice with different colored paints.

Discuss and answer the following questions and carry out the activities:

a) What was the marble's track, or trajectory, like? Did it move the same way each time?

b) Measure the marble's tracks. What was the total **distance** that the marble traveled in each case?

c) Measure the distance between spot A and spot B for each trajectory. What was the marble's displacement in each case?

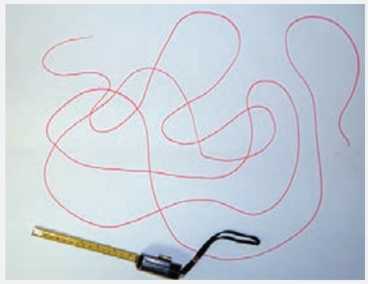


FIG. 1.3 Measuring tape and trajectory of a marble.

Reflect, Explain and Share

Is the trajectory you travel from your house to your school equivalent to the displacement between the two spots?

- How far is it from your house to your school?
- What is the distance you travel to reach your school from your house?
- When can your displacement be zero?

In the experiment, we measured the total distance traveled by the marble, with its turns and **random** shape. The track left by the marble is its **trajectory**. The straight-line distance between the starting point and final spot is called **displacement**. **Zero displacement** is when an object moves from a starting point and returns to the same spot.

Glossary

Random. Depends on a fortuitous event.

Displacement. The movement of an object from its place or position to another site.

Zero displacement. When an object moves from a starting point and returns to the same spot.

Closing

How much did I learn?

If we observe the movement of our planet around the Sun, we will find a typical example of motion with the possibility of zero displacement. Why? Explain in your own words.

To close, answer and discuss the following questions with your teammates. Share them with the entire group and, with the help of your teacher, reach a final answer.

- What factors define an object's motion? Why?
- Is it possible for an object to appear still and yet be moving? Why?
- Some movements show longer trajectories than their displacement. What does this depend on?
- Is it possible for a motion to have shorter trajectory than its displacement?
- In your own words, describe what zero displacement is.

SESSION INFORMATION

Week: 1

Session: 4

Expected learning outcome: Understand and differentiate the basic concepts of the frame or system of reference, trajectory, position and displacement to use them in the description of motions, such as changes of positions, in situations associated with the surrounding environment.

CONTENT DELIVERY

Start: Students should bring the materials in order to do the experiment.

Development: Students should follow the instructions in the experiment and later answer the questions in the section *Reflect, Explain and Share*. Elicit answers, and help accordingly.

Closing: Students should discuss the questions in the section *How much did I learn?* Elicit answers in whole class.

Project preparation: Divide the group in teams. The following session, students should take to class: a toy car, a stopwatch, masking tape and a tape measure.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting.

Critical thinking skills: Analyzing.

Interpersonal skills: Working as team members.

Verbal/Linguistic skills: Discussing.

EVALUATION OF CONTENT

Students should get their experiment checked by the teacher.

SESSION INFORMATION

Week: 1

Session: 5

Expected learning outcome: Interpret velocity as the relation between displacement and time and how it differs from speed, using data from every day situations.

CONTENT DELIVERY

Start: Organize students in teams to discuss the answers to the questions in the section *Exploring knowledge*. Elicit answers and help accordingly.

Development: Students should go over the experiment following the instructions. Help them analyze the data they get.

Closing: Students should answer the questions in the experiment as well as the two questionnaires on top of page 13.

→ Expected **Learning**

Interpret velocity as the relation between displacement and time and how it differs from speed, using data obtained from every-day situations.

Velocity: Displacement, Direction and Time

Exploring Knowledge

In teams of five, answer the following questions. Discuss your answers to reach a common answer per team. Share your answers with the class.

- What do you think speed is? Is it the same as velocity? Why?
- Imagine you are sitting on a bus on the way home. How could you know if the bus is moving over the velocity limit?

Speed vs. Velocity

It is common to hear expressions as "That car is really speeding!" or "What is the athlete's velocity?" But the words **speed** and **velocity** do not have the same meaning in physics, although it is very common to use them indistinctively in our daily lives (Fig. 1.4). It is not the same to walk inside the classroom from right to left as to walk from left to right. You travel the same distance and take the same time but the movements take place in opposite **directions**. Speed is usually understood as the distance traveled by an object within a given time.

FIG. 1.4 The concepts of speed and velocity are used indistinctively in our daily life.

Experiment

MATERIAL:

- Toy car
- Stopwatch
- Masking tape to mark two spots
- Measuring tape

Procedure:

In teams of four or five, mark point A and B on a flat surface and measure the distance between them in meters. Place the toy car on point A and push it to send it to point B. Write down the time in seconds it took to go from point A to B. Divide the distance by the time.

- What was the car's speed?
- Repeat the procedure, this time from point B to point A.
- What was the car's speed in this case?
- If you could make the speed the same in both cases, what would the difference be between both movements?
- Can we speak of velocity here?
- What is the difference between the car's speed and velocity?
- As you can see, speed and velocity are not the same.

Velocity is a vector quantity. That is, it possesses magnitude (number), direction (the imaginary line on which the object moves) and orientation (left and right, up and down). On the other hand, speed is a scalar quantity, expressed only with magnitude. However, both velocity and speed are units of distance divided by time (for instance, m/s).

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting.

Critical thinking skills: Analyzing data, imagining, predicting.

EVALUATION OF CONTENT

Students should get their experiment checked by the teacher.

Reflect, Explain and Share

If a car is moving at 120 km/hr from south to north, what is its speed and what is its velocity?

Closing

How much did I learn?

Answer and discuss the following questions with your teammates. Share with the class and with the help of your teacher, reach a final answer.

- What do you need to know to calculate an object's speed?
- What do you need to know to calculate an object's velocity?
- Are speed and velocity the same? Why?

Interpretation and Representation of Position-Time Graphs

Expected Learning

Interpret data tables and position-time graphs to predict and describe different motions from data obtained in experiments and/or everyday situations.

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a common answer per team. Share your answers with the class.

- Why do you think science reports use graphs and data tables?
- What is a graph?
- How many values do you need to locate a point on the Cartesian plane?

Reflect, Explain and Share

In your daily life, where have you seen the use of graphs to represent statistics?

Data and tables

Activity

The car in the picture is moving in a straight line from a wall to the end of an aisle.

In the following table, the datum of the car's position at different points has been obtained by measuring the distance between the starting point (the wall) and the times when these positions were reached.

Distance (meters)	Time (seconds)
0	0
0.4	5
0.8	10
1.2	15
1.6	20
2.0	25
2.4	30

- What conclusions can be drawn from the information on the table? Is there any important relationship that allows you to describe the car's motion?
- What is the velocity of the car in the example?

The graph representing the data in the table is a straight line. The same distance is traveled in the same time intervals.

SESSION INFORMATION

Week: 1

Session: 6

Expected learning outcome: Interpret data tables and position-time graphs to predict and describe different motions from data obtained in experiments and/or everyday situations.

CONTENT DELIVERY

Start: Students should discuss in teams the questions in the section *Exploring knowledge*. Then, elicit answers in whole class.

Development: Students should do the activity in teams. Help them do the analysis.

Closing: They should respond the questions in the activity. Elicit answers and help accordingly.

Project preparation: Divide the group in teams of five. Next session they should take to class: one wooden car, a stopwatch, paper tape, thread, marker, a pulley and a marble jar.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing data, observing.

Logical/Mathematical skills: Deducing.

EVALUATION OF CONTENT

Students should be able to respond to the questions of the activity.

SESSION INFORMATION

Week: 2

Sessions: 7, 8

Expected learning outcome: Interpret data tables and position-time graphs to predict and describe different motions from data obtained in experiments and/or everyday situations.

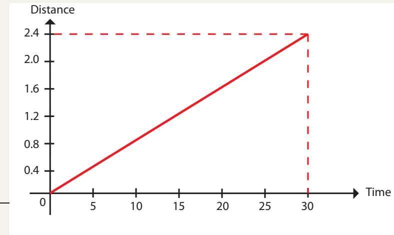


FIG. 1.5 Distance vs. time graph

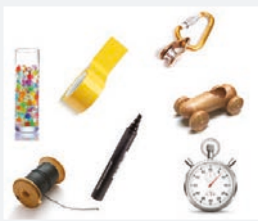
Experiment

Data registration and recording table

MATERIAL:

- One wooden car
- One stopwatch
- Paper tape
- Thread
- One marker
- One pulley
- One marble jar

FIG. 1.6 Materials to be used in the experiment.



PROCEDURE:
In teams of five, set up your experiment with the pulley on one side of your desk and the wooden car tied to the marble jar (figure 1.6).

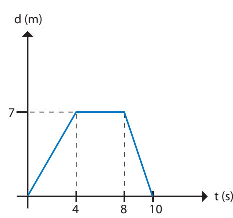
Tie the car to the jar and hold it still.
Register the car's motion by making a mark on the paper tape every second. Measure the distance between the starting point and every marked spot. With these figures, make a data table for every second in time and a distance-time graph. On the horizontal axis, place the time measurements (seconds). On the vertical axis, place the distance using a convenient scale.
As you can see on the graph, there is a change in velocity, it actually increases.

GLOSSARY
Versus (vs). Opposite or against.

Closing

How much did I learn?

From the distance-time graph, it can be concluded whether an object's velocity changes or remains constant. In your teams, analyze and explain the following motion graph. To make it easier, break the description down by intervals: from 0 to 4 seconds, from 4 to 8 seconds and from 8 to 10 seconds.



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CONTENT DELIVERY

Start: Students should answer some questions about data registration that you can make using the information from the previous session..

Development: In teams, they should do the experiment. Guide them in the process.

Closing: Students should solve the problem in the closing section *How much did I learn?* help accordingly. Elicit answers.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, classifying, observing details.

EVALUATION OF CONTENT

Students should get their experiment checked by the teacher.

Wave Motion, Wave Model and Explanation of the Characteristics of Sound

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a conclusion per team. Share your conclusions with the class.

- Tie a rope to a tree and make waves from the point of the rope. Watch closely. When the wave is going forward, what is moving? That is, what is displacing?
- If you shout under the water, do you think your shout will be heard? Why?

→ Expected Learning

Describe the characteristics of wave motion, based upon the wave model: crest, trough, node, amplitude, length, frequency and period, and differentiate transverse and longitudinal wave-motion in terms of direction of propagation.

Describe the behavior of sound waves: tone, timbre, intensity and speed, based upon the wave model.

FIG. 1.7 Oscillations on the water surface.

Glossary

Oscillation. Action and effect to oscillate. Each one of the swinging movements, that conform an oscillatory motion.

→ Activity

With your team, closely observe an analog clock or a watch.
You will notice that every hand goes around a central axis. This repeated kind of motion is called periodic motion. In our daily activities, we are surrounded by periodic motion, for example, when we oscillate a rope, causing a continuous wave motion. In a wave, we can observe several characteristics:

- **Amplitude (A):** Distance between the highest point of the wave and its equilibrium point.
- **Crest:** Highest point of a wave motion.
- **Trough:** lowest point of a wave motion.
- **Node:** point where the wave has zero amplitude, i.e. where it crosses the equilibrium line.
- **Wavelength (λ):** distance between crests or troughs of a wave.
- **Elongation:** distance between any point of the wave and its equilibrium line.

SESSION INFORMATION

Week: 2

Session: 9

Expected learning outcome: Describe the characteristics of wave motion, based upon the wave model: crest, trough, node, amplitude, length, frequency and period. Differentiate transverse and longitudinal wave-motion in terms of direction and propagation.

Describe sound waves behavior: tone, intensity and speed based upon the wave model.

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring Knowledge*. Elicit answers.

Development: Students should start with the activity, which they will finish the following classes.

Closing: Students should be ready to finish the experiment the following class; with all the previous information complete.

Project preparation: In teams, students should get a plastic spring and take it to the following class.

SKILLS DEVELOPMENT

Interpersonal skills: Working as a team.

Verbal/Linguistic skills: Discussing.

EVALUATION OF CONTENT

Students should be able to describe the characteristics of wave motion by starting with the project.

SESSION INFORMATION

Week: 2

Sessions: 10, 11

Expected learning outcome: Describe the characteristics of wave motion, based upon the wave model: crest, trough, node, amplitude, length, frequency and period. Differentiate transverse and longitudinal wave-motion in terms of direction and propagation. Describe sound waves behavior: tone, intensity and speed based upon the wave model.

CONTENT DELIVERY

Start: Students should answer the question in the section *Reflect, Explain and Share.*

Development: Students should do the experiment. Help as necessary.

Closing: Students should answer the questions in the experiment.

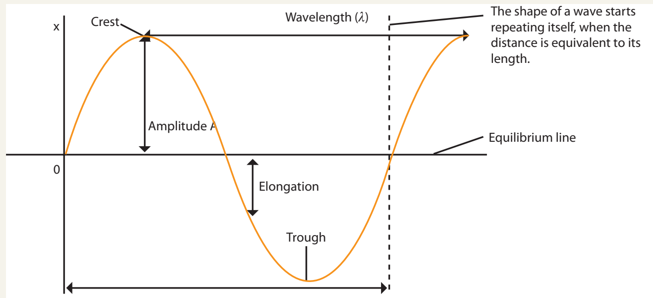


FIG. 1.8 Parts of a wave.

- This type of wave is called transverse wave. The displacement of the medium is perpendicular to the direction of propagation of the wave. Some examples of transverse waves are found in the movement of a rope, seismic waves and the waves of the sea.

Reflect, Explain and Share

If there were no air, as in a vacuum in outer space, do you think sounds could be heard?

The type of wave you just studied is called **transverse**. The parts of the medium move perpendicularly to the direction of the wave.

GLOSSARY

Coil. A ring or loop in a spring. **Suddenly.** Quickly, unexpectedly.

Experiment

Longitudinal and transverse waves

MATERIAL

- A plastic spring.

PROCEDURE

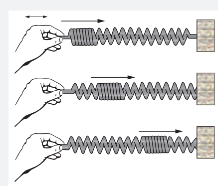
One student must stretch the plastic spring and hold it on a table or on the floor. Holding it tightly on one extreme, compress two or three **coils** and **suddenly** release them.

Answer the following questions and carry out the activities.

a) What is the difference between the rope and the motion of the spring?
b) Did the matter (material) move in either of the cases?
c) What is the direction of the spring's pulses compared to the motion of the coil?

Share your answers with the class.

FIG. 1.9 Experiment with a spring.



16

SKILLS DEVELOPMENT

Critical thinking skills: Observing, experimenting.

Interpersonal skills: Working as a team.

EVALUATION OF CONTENT

Students should get their experiment checked by the teacher.

From this periodic motion, two variables related to time are defined: **period** and **frequency**. Period is the time needed for a wave to complete a cycle, for example, from node to node.
Frequency is the amount of completed cycles that are formed in one second. If in one second you can make three complete waves in a rope, your wave train will have a frequency of 3 cycles/second or 3 Hertz.

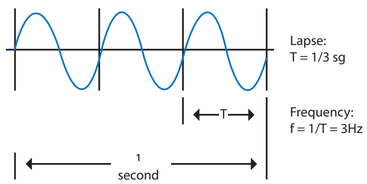


FIG. 1.10 Period and frequency of a wave.

GLOSSARY
Perturbation. A secondary influence on a system that causes it to deviate.

In the last experiment, you could watch the **perturbations** made on a spring. Here, as opposed to the rope, you were able to see the pulse traveling in the same direction as the perturbation.

These kinds of waves are called **longitudinal**. Sound waves belong to this type of waves. When you produce a sound air compresses, and when it expands it compresses an adjacent air layer. This is a very similar motion to that of the spring.

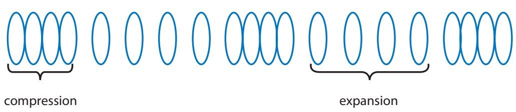


FIG. 1.11 Compression and expansion.

As sound travels through the air, when there is no air there is no sound. This is because the waves need a means of communication made of matter to be transmitted, a material that allows their particles to travel in order to oscillate.

However, not all sounds are appreciated the same way. For instance, the musical note "A", sounds different, depending on the instrument playing the note. An "A" sound played by a flute is not the same as an "A" sound played on a guitar or on a piano. The difference is called **timbre**.

Another characteristic of sound is intensity, commonly known as volume.

With the same instrument, say a flute, we can obtain different volumes, according to how hard we blow.

The third characteristic of sound is **tone**, which is what makes an "A" note different from an "F" note in the same instrument.

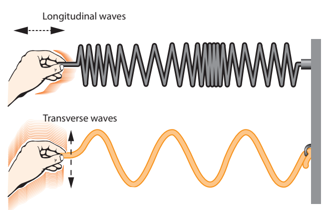


FIG. 1.12 Comparing waves.

Closing

How much did I learn?

Answer and discuss the following questions with your teammates. Share them with the entire group and, with the help of your teacher, reach a final answer.

- What is a wave?
- What types of waves are there?
- What type of wave is a sound wave?
- Which are the three main characteristics of sound?
- Are there sounds we cannot hear?
- What happens if we shout under the water?
- Can sound travel in a vacuum?

ICT

Visit:
http://www.acs.psu.edu/drussell/Demos/waves/wavemotion.html
to find out about longitudinal and transverse waves and other concepts related to wave motion.

SESSION INFORMATION

Week: 2

Session: 12

Expected learning outcome: Describe the characteristics of wave motion, based upon the wave model: crest, trough, node, amplitude, length, frequency and period. Differentiate transverse and longitudinal wave-motion in terms of direction and propagation. Describe sound waves behavior: tone, intensity and speed based upon the wave model.

CONTENT DELIVERY

Start: Students should read the information on the page. Ask comprehension check questions.

Development: Students should discuss the answers to the questions in the section *How much did I learn?*

Closing: Students should get their answers checked by the teacher.

Project preparation: Organize the group in teams. The following session they should take: one toy wrestler, one big plastic bag, sewing thread and scissors.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing.

Verbal/Linguistic skills: Discussing.

Interpersonal skills: Working as a team member.

EVALUATION OF CONTENT

Students should clearly name the wave model characteristics.

SESSION INFORMATION

Week: 3

Sessions: 13, 14

Expected learning outcome: Identify Aristotle's and Galileo's explanations regarding free-fall movement, as well as the contexts and procedures that supported them.

CONTENT DELIVERY

Start: Organize the group in teams to discuss the answers to the questions in the opening activity and ask them to share their conclusions with the rest of the group.

Development: Students should bring the materials and do the experiment.

Closing: Students should identify why the wrestler falls slowly.

Project preparation: Students should take one piece of letter-size paper and a letter-sized notebook.

Expected Learning

Identify Aristotle's and Galileo's explanations regarding free-fall movement, as well as the contexts and procedures that supported them.

Galileo's Work

Aristotle and Galileo Explain the Free-Fall Movement

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a consensus per team. Share your answers with the class.

- Before carrying out the experiment, what do you think falls first, a sheet of paper or a stone, if dropped from the same height? Why?
- If you have a small stone that you can hold between two fingers and a stone the size of your palm, which one falls to the ground first if dropped from the same height? Why?

Aristotelian or Galilean?

Reflect, Explain and Share

When you wave a hand fan you can feel the air on your face. What effect does air have on moving objects?

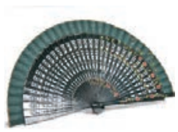


FIG. 1.13 Air produces effects on bodies.

Experiment

MATERIAL

- One toy wrestler
- One big plastic bag
- Sewing thread
- Scissors

PROCEDURE

Individually, make a parachute with the plastic bag, the thread and the wrestler. Form teams of five and throw each of your parachutes from a two story height or throw it upwards to get the bag open and fall slowly.

Choose the slowest-descending parachute out of the five you made. Answer the following questions and carry out the activities:

1. Wrap the thread and plastic around the wrestler to keep the parachute closed when it falls. What happens during the fall, either from the two story height or thrown upwards?
2. Now let the parachute open up when falling. What happens? If the wrestler is the same, why does it fall more slowly in the first case than in the other? Does it have anything to do with the body's mass?

FIG. 1.14 Materials for the experiment.

Answer the last question and share with the class.

SKILLS DEVELOPMENT

Interpersonal skills: Working as a team member.

Critical thinking skills: Observing, analyzing.

EVALUATION OF CONTENT

Students should be able to name the reason why the toy falls slowly.

When bodies fall on Earth (where the **atmosphere** is), they are affected by the presence of air. Sometimes air slows them down, and sometimes it does not and they fall quickly. This is due to the body's shape, as it affects the way it falls, no matter what its mass may be.

GLOSSARY
Atmosphere. Layer of air surrounding the Earth.


FIG. 1.15 A feather has more resistance on air.

Experiment

MATERIAL
- One letter-sized sheet of paper (you may recycle it from your notebook).
- One letter-sized notebook.

PROCEDURE
1. Lay the sheet of paper under the notebook and drop them, let them both fall. What happens to the sheet of paper? How does it fall? Why?
2. Now lay the sheet of paper on top of the notebook. What happens to the sheet? How does it fall? Why? Why doesn't the sheet slide away from the notebook and fall slowly, if that is what we have been seeing when we drop it? Answer these questions with your teammates.
3. Read your answers to the class. Note that in the second case, the notebook "faces" the air before the sheet of paper does. The notebook, keeps the air from stopping the sheet of paper from falling. Therefore, in the absence of air, all the bodies would fall at the same speed.


FIG. 1.16 Materials and procedure for the experiment.

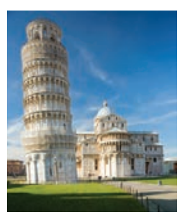


FIG. 1.17 The Tower of Pisa.

Reflect, Explain and Share

It has been said that Galileo dropped stones from the Tower of Pisa to watch them fall. How could he conclude that all the objects fell the same way in the absence of air?

Kells

19

SESSION INFORMATION

Week: 3

Sessions: 15, 16

Expected learning outcome: Identify Aristotle's and Galileo's explanations regarding free-fall movement, as well as the contexts and procedures that supported them.

CONTENT DELIVERY

Start: Ask students questions to remind them of the free-fall movement concept.

Development: Have students do the experiment. Guide them in the process.

Closing: Students should interpret the information they get from the experiment and then, they should respond the questions in the section *How much did I learn?* which are on top of page 20.

SKILLS DEVELOPMENT

Critical thinking skills: Remembering, experimenting, interpreting.

Interpersonal skills: Working as a team member.

Logical/Mathematical skills: Discovering relations.

EVALUATION OF CONTENT

Students should be able to respond to the questions of the experiment.

Kells

SESSION INFORMATION

Week: 3

Session: 17

Expected learning outcome: Support the importance of Galileo's contribution to science as a new way of building and validating scientific knowledge, based upon experimentation and outcome analysis.

CONTENT DELIVERY

Start: Organize a group discussion to answer the questions in the sections *Exploring knowledge and Reflect, Explain and Share.*

Development: Organize teams to do the activity described on page 21 and organize a discussion to answer the questions in the activity.

Closing: Draw conclusions in whole class with the closing activity on page 21.

Aristotle and Galileo

The idea that bodies fall differently, prevailed for centuries, according to what Aristotle established in Ancient Greece. He was an authority on explaining physical phenomena. His theories were based on uncontrolled and incomplete observations of these phenomena.

Many years later, during the Renaissance, it was Galileo Galilei who interpreted the phenomena based on experiments and the results he obtained from them. Galileo is known as the father of physics.

Closing

How much did I learn?

Answer and discuss the following questions with your teammates. Share your answer with the class.

- What falls faster, a paper ball or a flat piece of paper? Why?
- How would the bodies fall if there were no air?
- In your own words, explain the differences between Aristotle's and Galileo's theories.

Expected Learning

Support the importance of Galileo's contribution to science as a new way of building and validating scientific knowledge, based upon experimentation and analysis of outcomes.

Galileo's Contributions to the World of Science

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a common answer per team. Share your answers with the class.

- Mention five situations in which it is important to carry out experiments and why.
- How can length be measured without a ruler or measuring tape?
- What can you use to measure time if you don't have a stopwatch?

Reflect, Explain and Share

In which age did Galileo live and what was the main characteristic of this period of time in history?

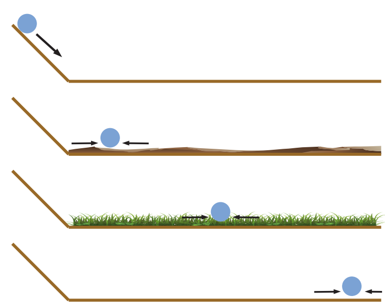


FIG. 1.18 An automobile's trajectory.

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Verbal/Linguistic skills: Discussing.

Critical thinking skills: Observing, drawing conclusions.

Logical/Mathematical skills: Discovering relations.

EVALUATION OF CONTENT

Students should be able to say how Galileo's contribution was valid through the experiment.

➔ Group Work

In teams of five, measure the length of any object the teacher gives you. It may be something inside the classroom, such as the board or a desk. Only one team will use a ruler. The other teams will use parts of the body. Measure them first to know the length in centimeters.

- The width of every finger.
- One span (the distance there is between your thumb and your little finger with your hand wide-open).
- One foot.
- One elbow (the distance there is between your elbow and the tip of your middle finger).

Once everybody is done, write down the figures and answer the questions.

1. Which measurement not made with a ruler is closer to the one with the ruler?
2. What causes the difference in results?
3. Determine the farthest measurement from the one made with the ruler. Why is the difference bigger?
4. Did you obtain a precise measurement with the ruler? Discuss your answer.

FIG. 1.19 A pendulum can be used to measure time.

In the last experiment you used different ways of measurement and obtained different results. You were even able to conclude why they were not precise and the mistakes they had.

In fact, in old times, measurements were not always made with the instruments or measurement units we have today. Galileo had to use his pulse to measure time in some of his experiments (fig.1.20)

Closing

How much did I learn?

Answer the questions and do the activities.

1. What happens if we don't have the proper instruments to take measurements in an experiment?
2. What happens if we don't take the appropriate measurements in an experiment?
3. Find on the web or in a library three cases of misinterpreted results in experiments and their negative outcomes.
4. Research to find out when a second started to be measured with an instrument, and when it began to be considered as a unit of time.

FIG. 1.20 You can feel your pulse on your neck.

SESSION INFORMATION

Week: 3

Session: 18

Expected learning outcome: Support the importance of Galileo's contribution to science as a new way of building and validating scientific knowledge, based upon experimentation and outcome analysis.

CONTENT DELIVERY

Start: Organize a group discussion to answer the questions in the sections *Exploring knowledge*, and Reflect *Explain and Share*, which are on page 20.

Development: Organize teams to do the activity described in the section *Group Work* on page 21 and organize a discussion to answer the questions in the activity.

Closing: Draw conclusions in whole class with the closing activity on page 21.

Project preparation: In teams, students should get for the experiment next session: A 200cm long wood or Styrofoam board, with marks every 50 cm., one steel ball 3 or 4 cm diameter, a stopwatch. Investigate accelearation and the difference with velocity.

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Verbal/Linguistic skills: Discussing.

Critical thinking skills: Observing, drawing conclusions.

Logical/Mathematical skills: Discovering relations.

EVALUATION OF CONTENT

Students should be able to say how Galileo's contribution was valid through the experiment.

SESSION INFORMATION

Week: 4

Session: 19

Expected learning outcome: Relate acceleration with the variation in velocity in situations associated with the surrounding environment and/or experimental activities.

CONTENT DELIVERY

Start: Students should discuss the answers to the questions in the section *Exploring knowledge*. Elicit answers in whole class.

Development: Ask students for their research about acceleration vs. velocity. Help them with examples so that they can see what the difference is.

Closing: Students should read the experiment on page 23. Help them understand what they should do.

→ Expected **Learning**

Relate acceleration with the variation in velocity in situations associated with the surrounding environment and/or experimental activities.

Acceleration and the Difference with Velocity

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a consensus per team. Share your answers with the class.

- If you are in a vehicle with constant velocity, for example, 90 km/hr, what does your body feel? How is it different from the way it feels when it is motionless or at rest?
- What happens to your body when a vehicle breaks suddenly or, in other words, if the velocity suddenly decreases?

When a body is at rest and starts moving, there will be a change in velocity, as it goes from starting velocity zero to another of a given value. This change of velocity in a time interval is called **acceleration**. Likewise, when a body stops, even suddenly, deceleration will happen. A body with constant **velocity** will travel the same distances within the same time intervals. However, if the body accelerates, it will travel more distance every time in the same time interval.

FIG. 1.21 If the bicycle rider has a constant velocity, he will travel the same distance in the same time intervals.

Experiment

MATERIAL

- One 200 cm long wood or Styrofoam board, with marks every 50 cm.
- One steel ball, 3- or 4-cm diameter
- One stopwatch

SKILLS DEVELOPMENT

Verbal/Linguistic skills: Discussing.

Critical thinking skills: Analyzing, remembering, observing and discriminating data.

EVALUATION OF CONTENT

Students should be able to identify the difference between acceleration and velocity.

Experiment

PROCEDURE
Set up the board with a 6-**degree inclination**, use an object on one side to raise it and lay the other side on the floor.
Have the steel ball roll down from the higher side while you jot down the time it takes to pass by every mark. Fill in the second column of the following table:

Distance	Time
50 cm	
100 cm	
150 cm	
200 cm	

Does the steel ball have a constant velocity or is it accelerating?
Now change the inclination of the board to 5 degrees or less to allow the steel ball to run the distances at the same speed, this is, without acceleration. Fill in the second column of the table below, with the results you obtained.

Distance	Time
50 cm	
100 cm	
150 cm	
200 cm	

In the first case, gravity makes the steel ball roll with a certain acceleration. In the second case, the ball was pulled by gravity also, but it has a constant velocity on the flat floor.

How much did I learn?

Answer the questions and do the activities.

- How do you calculate the velocity of a car that has traveled 60 km in 1 hour?
- How do you calculate the acceleration of a cyclist who starts from rest and has reached a velocity of 5 m/s in 10 seconds?
- What is the acceleration of a boat with a constant speed?

FIG. 1.22 Dummy used to measure the effects of car impacts.

SESSION INFORMATION

Week: 4

Session: 20

Expected learning outcome: Relate acceleration with the variation in velocity in situations associated with the surrounding environment and/or experimental activities.

CONTENT DELIVERY

Start: Students should name the difference between acceleration and velocity.

Development: They will do the experiment, following the steps in the procedure and completing the tables with the results.

Closing: Students should answer the questions and do the activities in the section *How much did I learn?*

SKILLS DEVELOPMENT

Critical thinking skills: Remembering, observing, and drawing conclusions.

Interpersonal skills: Working as team members.

EVALUATION OF CONTENT

Students should use be able to explain the relation between acceleration with the variation in velocity.

SESSION INFORMATION

Week: 4

Session: 21

Expected learning outcome: Create and interpret data tables, velocity-time and acceleration-time graphs to describe and predict characteristics of different motions, based upon data obtained in experiments and/or situations associated with the surrounding environment.

→ Expected **Learning**

Create and interpret data tables, velocity-time and acceleration-time graphs to describe and predict characteristics or features of different motions, based on data obtained in experiments and / or situations associated with the surrounding environment.

Interpretation and Representation of Graphs: Velocity-Time and Acceleration-Time

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a consensus per team. Read your answers out loud to the group.

- For motion with **constant velocity**, what does a distance-time **graph** look like?
- In a **velocity-time** graph, what does the vertical axis represent, and what does the horizontal axis represent?
- In an acceleration **graphic**, what would the vertical axis and the horizontal axis represent respectively?

→ Activity

We have the following table of times and **distance** traveled by an athlete in a marathon.

FIG. 1.23 Runners in a marathon.

TIME	DISTANCE	VELOCITY
10 s	30 m	
20 s	60 m	
30 s	90 m	
40 s	120 m	
50 s	150 m	
60 s	180 m	

Create a graph taking into account that the horizontal axis represents time and the distance is represented by the vertical axis.
For each time and distance, calculate the velocity and with the results you obtain, complete the third column in the table. Create the velocity vs. time graph.
You will notice that the velocity does not change. Therefore, what is the acceleration value of the runner? Make the **acceleration vs. time** graph.
Now consider the following results for another athlete:

CONTENT DELIVERY

Start: Students should discuss the questions in the section *Exploring knowledge*. Elicit answers in whole class.

Development: Students should do the activity on pages 24, 25. Guide them in the process.

Closing: Students should be able to interpret data tables.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Discovering relations.

Critical thinking skills: Analyzing, observing, deductive reasoning.

EVALUATION OF CONTENT

Students should clearly explain what each graph represents.

Time	Velocity
0	0 m/s
1 s	0.5 m/s
2 s	1 m/s
3 s	1.5 m/s
4 s	2 m/s
5 s	2.5 m/s

Create the velocity vs. time graph.
What would the acceleration-time graph be like?
Remember acceleration is the change of velocity. In the first second, velocity changed from 0 to 0.5 m/s, this is, there was an increase of 0.5 m/s in velocity. In the following second, there was another increase of 0.5 m/s in velocity reaching 1m/s, and so forth. In this case, acceleration is constant.
In the tables above you obtained different graphs. In the first case, the athlete runs at a constant speed, therefore his graph will look like this:

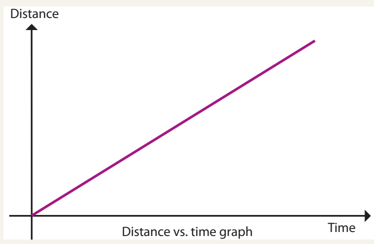
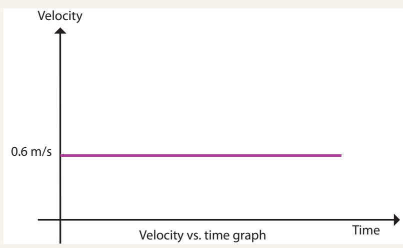
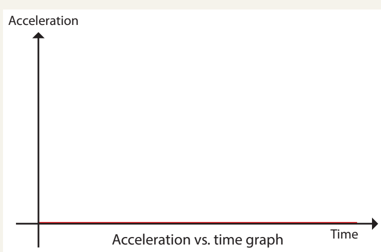


FIG. 1.24 Movement with constant velocity.

A)



B)



C)

SESSION INFORMATION

Week: 4

Sessions: 22, 23

Expected learning outcome: Create and interpret data tables, velocity-time and acceleration-time graphs to describe and predict characteristics of different motions, based upon data obtained in experiments and/or situations associated with the surrounding environment.

CONTENT DELIVERY

Start: Students should discuss the questions in the section *Exploring Knowledge* on page 24. Elicit answers in whole class.

Development: Students should do the activity on pages 24 and 25. Guide them in the process.

Closing: Students should be able to interpret data tables.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Discovering relations.

Critical thinking skills: Analyzing, observing, deductive reasoning.

EVALUATION OF CONTENT

Students should clearly explain what each graph represents.

SESSION INFORMATION

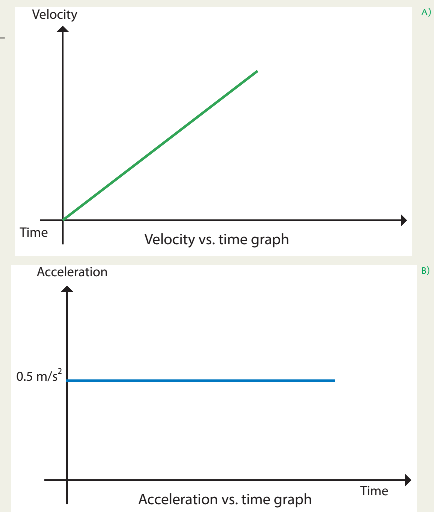
Week: 4

Session: 24

Expected learning outcome: Create and interpret data tables, velocity-time and acceleration-time graphs to describe and predict characteristics of different motions, based upon data obtained in experiments and/or situations associated with the surrounding environment.

As for the second athlete, the graphs will look as follows:

FIG. 1.25 Movement with constant velocity.



Glossary

Slope. Degree of inclination of a straight line or a plane.

The **slope** in the distance vs. time graph (fig. 1.24) corresponds to velocity, while acceleration, is represented by the one in the velocity-time graph. When the line is horizontal, the graph's value is constant; in the case of constant velocity, acceleration is also constant but the value is zero.

Closing

How much did I learn?

Work in pairs. Create your own examples and then share them with the class.

1. For motion with constant velocity, make the distance vs. time, velocity vs. time and acceleration vs. time graphs.
2. For motion with constant acceleration, make the velocity vs. time and acceleration vs. time graphs.

CONTENT DELIVERY

Start: Students should have finished with the activity described on pages 24 and 25.

Development: Students should answer the questions in the section *How much did I learn?* and make the graphs.

Closing: Students should be able to create the graphs correctly.

SKILLS DEVELOPMENT

Visual/Spatial skills: Graphing.

Critical thinking skills: Analyzing data.

EVALUATION OF CONTENT

Students should be able to create graphs according to instructions or data tables.

Description of Forces around us

Force; Result of Interaction by Contact (Mechanical) and at Distance (Magnetic and Electrostatic) and Vector Representation Forces as Interactions

→ Expected Learning

Describe force as an effect of interaction between objects and represent it with vectors.

FIG. 1.26 Why can we say that an excavator has a lot of force?

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a consensus per team. Read your answers out loud to the group.

- You have heard expressions such as:
  - Winds are hurricane force on the coast.
  - The armed forces are the pride of the country.
  - May the force be with you.

  In which of these situations is the word *force* used with its meaning in Physics?
- How would you describe force in a person? Why?

Forces of nature are present in situations where two objects interact, whether they are in physical contact or not. In order to study these interactions as forces, we represent them with arrows known as **vectors**, and they indicate the direction on which forces are applied to each object. If we leave a book on the table, how can we know if there is a force between these two objects? How are these forces applied? What is their direction?

Curious Facts

Gravitational force is what the Earth exerts on us. It does not require physical contact with bodies in order to act upon them.

FIG. 1.27 Waves are the effect of the force of wind on the ocean's surface.

SESSION INFORMATION

Week: 5

Session: 25

Expected learning outcome: Describe force as an effect of interaction between objects and represent it with vectors.

CONTENT DELIVERY

Start: Organize a discussion to respond to the questions in the section *Exploring Knowledge*. Elicit answers in whole class.

Development: Students should read the information on the page. Help them understand it with examples.

Closing: Students should describe force in their own words.

Project preparation: Students should take the following materials: a powerful magnet, a piece of iron with the same amount of mass as the magnet, a one-meter plastic ruler, confetti or shredded paper.

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Critical thinking skills: Inductive reasoning.

EVALUATION OF CONTENT

Students should be able to describe what force is.

SESSION INFORMATION

Week: 5

Sessions: 26, 27

Expected learning outcome: Describe force as an effect of interaction between objects and represent it with vectors.

CONTENT DELIVERY

Start: Ask students what force is. Elicit answers, and write them on the board.

Development: Students should do the activity and the experiment. Guide them in the process; elicit answers for both, the activity and the project questions.

Closing: Students should be able to describe how force is an effect of interaction between objects. Elicit answers and have students write them on the board.

Project preparation: Students should take to class two balloons.

Curious Facts

There are two kinds of electric charges: positive and negative. Magnetic poles are also divided in two: north and south. This is why electrostatic and magnetic interactions can be either for attraction or repulsion, this happens because opposite poles and opposite electric charges attract each other, while equal poles and equal electric charges repel each other. An example of a direct application of magnetic forces is the use of a compass. Its magnetized needle is oriented towards the North Pole and attracted by the magnetic nucleus of our planet.

Activity

Open your hand and lay it on a table. Start placing books or notebooks on top of your hand, one by one, until you reach ten, if possible. What happens while you place more and more books? What difference do you feel between having one or 10 books on top of your hand?

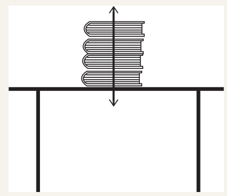


FIG. 1.28

FIG. 1.29 Group of forces on a table.

Curious Facts

Gravitational force is what the Earth exerts on us. It does not require physical contact with bodies in order to act upon them.

Experiment

MATERIAL

- One powerful magnet
- One piece of iron with the same amount of mass as the magnet
- One plastic ruler
- Confetti or shredded paper

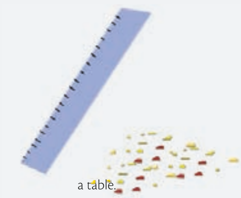


FIG. 1.30 Ruler and confetti.

PROCEDURE

First, rub the ruler against your hair three times and slowly place it near the confetti. What happens?

Now rub the ruler against your hair again, but do it 10 times, and place it near the confetti. What happens and why do you think this happens?

Now, as a second step,, take the magnet and hold it tightly as you slowly bring the piece of iron closer. What do you feel? Now hold the piece of iron tightly and slowly bring it closer to the magnet. What do you feel now? Is there a difference in both situations?

FIG. 1.31 A magnet attracts other metallic objects.

Share your answers with the class and reach a conclusion with the help of your teacher.

Magnetic or electrostatic forces show the interaction between bodies with no physical contact, such as the plastic and the confetti in the electrostatic situation and the magnets in the magnetic interaction.

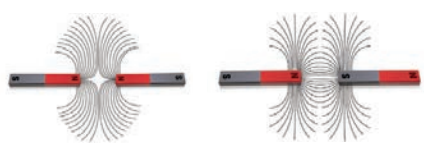


FIG. 1.32 Interaction of magnetic forces.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing.

Logical/Mathematical skills: Experimenting.

Verbal/Linguistic skills: Explaining.

EVALUATION OF CONTENT

Students should be able to describe how force is an effect of interaction between objects.

➔ Activity

You will need 2 balloons to play this "magic trick". Blow both of them up, rub one against your hair and bring it closer to a wall. What happens? Now rub both of the balloons against your hair and bring them closer to each other. What happens now? Discuss the questions with your team and then share the answers with the class and teacher.

Electrostatic and magnetic **interaction** which are different to **gravitational interaction**, can be of **attraction** or **repulsion**, and this is the reason that interacting bodies attract or repel.

Glossary

Interaction. Reciprocal activity exerted between two or more objects, forces, situations, etc.

Curious Facts

Gravitational force is what the As in any scientific variable, force has a unit of measure, **newtons**. It is called so to honor Sir Isaac Newton, considered the most important modern scientist for his contributions to the development of study of motion and mechanics. Earth exerts on us. It does not require physical contact with bodies in order to act upon them.

We can now describe forces as interaction between objects, by contact or distance. They are represented as arrows indicating their direction, since they are vectorial amounts.

The arrows representing vectors have certain value indicating the forces' size, and they are drawn larger or smaller. For example, if two people move an armchair applying different forces, the representation is:

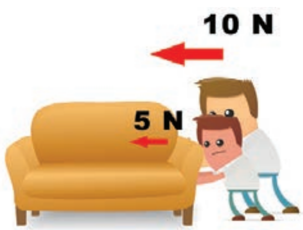


FIG. 1.33 Two people moving an armchair.

When forces interact between two objects, they are represented as vectors, to indicate their acting directions. This is why the arrows that represent forces of attraction or repulsion are drawn opposite ways.

⋙ Closing

➔ How much did I learn?

Answer and discuss the following questions with your teammates. Share them with the class to come to a consensus.

FIG. 1.34 A horse pulling a wagon.

1. If you are sitting on a chair now, are you exerting some force on the chair?
2. How do you know?
3. What forces are acting on an old cart like the one in Fig. 1.33?
4. What forces are acting on the horse? Draw and explain them.
5. Is it possible to have no force at all acting on us?

SESSION INFORMATION

Week: 5

Session: 28

Expected learning outcome: Describe force as on effect of interaction between objects and represent it with vectors.

CONTENT DELIVERY

Start: Students should do the activity with the balloons. Guide them in the process.

Development: Students should analyze the information explained on the page. Guide them and help them understand it.

Closing: Students should do the activities in the section *How much did I learn?* Guide students in the process.

SKILLS DEVELOPMENT

Metacognitive skills: Planning, organizing and delivering.

EVALUATION OF CONTENT

Check their drafts.

29

SESSION INFORMATION

Week: 5

Sessions: 28, 29

Expected learning outcome: Apply polygon and parallelogram graphical methods to obtain the resultant force acting upon an object, and describe motion produced in everyday situations.

CONTENT DELIVERY

Start: Ask students to do the experiment in the section *Exploring knowledge* on page 30. Have them answer the questions in it; elicit answers in whole class and have a students write down the answers on the board.

Development: Students should do the activity on page 30. Little by little, help them to analyze the polygon and parallelogram graphic methods in order to obtain the result force acting upon an object, which are explained on pages 30 to 32.

Closing: Students should practice. Look for more problems in which they apply both methods to find the resulting force acting upon an object.

➔ Expected Learning

Apply polygon and parallelogram graphical methods to obtain the resultant force acting upon an object, and describe motion produced in everyday situations.

Resulting Force, Graphical Methods of Vector Addition

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a consensus per team. Share your answers with the class.

- Let's suppose you want to move a 100-kg box of apples with the help of a friend. So it's only you and your friend applying forces as shown in Fig. 1.34. Which one of the green **vectors** is the best to represent the motion of the box?

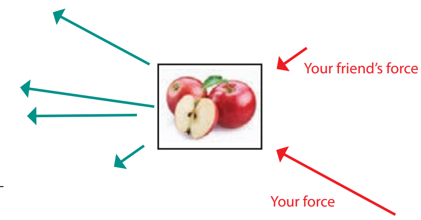


FIG. 1.35 Forces exerted on a box of apples.

- How would you know if the force applied by your friend is more than yours? Why?

Glossary

Vector. Any force in which, besides the amount, application point, direction and orientation must be considered.

Curious Facts

When we cross a river, we must always walk in a certain direction that allows us to counteract the force of running water.

In order to add forces, you have to consider the **direction** and orientation of each one. Addition of scalar and vectorial amounts are different. If you add 3 liters of milk plus 5 liters of milk, the result will always be 8 liters of milk. However, if you add a force of 3 newtons (N, la fuerza se mide en Newtons) plus one of 5 N, it will not always be 8 N.

➔ Activity

Sit in a chair with wheels and have two classmates push you down the hall, outside the classroom, applying the forces shown in the Fig. 1.35 Before being pushed, where do you think you will be moved?

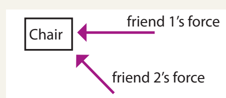


FIG. 1.36 Two friends pushing the chair.

After you were pushed, in which direction did you move? How could you know exactly the direction of the motion taking into consideration the direction of the forces?
Discuss the situation with your teammates and share your answers with the class and teacher.

In general, in order to add two forces and find the resulting force, the vector addition is done graphically using either, the parallelogram or the triangle method. To use the **parallelogram method**, we draw two vectors (A and B) to represent the forces making their starting points coincide leaving an opening. What you see then is two vectors forming an angle (C), where each vector represents one side of the parallelogram. Then, we draw the other two sides with parallel lines to complete the parallelogram. Finally, trace a vector starting at the angle corner where A and B started to the opposite corner of the parallelogram (D).

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing.

Logical/Mathematical skills: Discovering relations, experimenting.

EVALUATION OF CONTENT

Students should answer the questions in the final activity correctly.

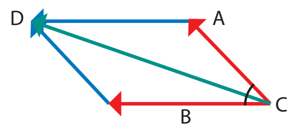


FIG. 1.37 The parallelogram method.

In order to precisely know the **addition of** two **forces**, or **resulting force**, the **polygon method** is applied. On a Cartesian plane we trace the two applied forces. This representation is known as **diagram of forces**.

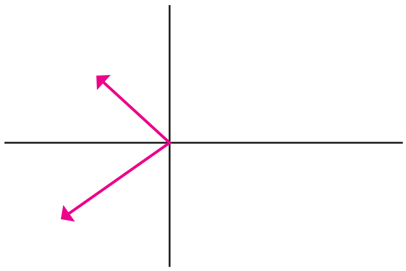


FIG. 1.38 Diagram of forces.

In order to add these two vectors using the triangle method, one of them remains as is and the other one is moved so that its starting point coincides with the ending point of the other vector. Its original magnitude and direction must be translated. The resulting force will be the vector uniting the starting point of the fixed vector with the ending point of the other vector.

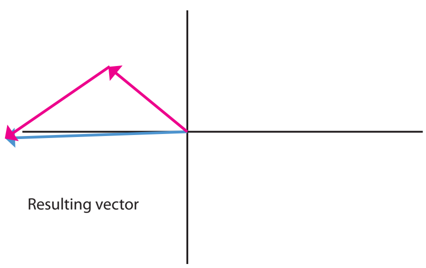


FIG. 1.39 Resulting vector.

When you have to add three or more vectors a similar method is used, but instead of a triangle, a polygon is used.

General method: the vectors representing the forces are added placing the starting point of a vector on the ending point of another one, keeping their orientation no matter how many forces there are. The resulting force vector is that which goes from the starting point of the first force through the ending point of the last added force. It is important to draw the vector in a scale that correspond to the magnitude of the force. For example: 1 newton = 1cm, 6 N= 6 cm.

This way, the magnitude of the force will correspond to the scale.

SESSION INFORMATION

Week: 5, 6

Sessions: 30, 31

Expected learning outcome: Apply polygon and parallelogram graphic methods to obtain the resultant force acting upon an object, and describe motion produced in everyday situations.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, problem solving.

EVALUATION OF CONTENT

Students should be able to solve problems that find resultant force vectors.

SESSION INFORMATION

Week: 6

Sessions: 32, 33

Expected learning outcome: Apply polygon and parallelogram graphic methods to obtain the resultant force acting upon an object, and describe motion produced in everyday situations.

CONTENT DELIVERY

Start: Ask students to do the experiment in the section *Exploring knowledge* on page 30. Have them answer the questions in it; elicit answers in whole class and have a students write down the answers on the board.

Development: Students should do the activity on page 30. Little by little, help them analyze the polygon and parallelogram graphic methods in order to obtain the result force acting upon an object, which are explained on pages 30 to 32.

Closing: Students should practice. Look for more problems in which they apply both methods to find the resulting force acting upon an object.

GLOSSARY

Polygon. Plane geometric figure with straight sides.

Curious Facts

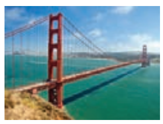


FIG. 1.41 The Golden Gate Bridge, San Francisco.

When a hanging bridge is built, like The Golden gate in San Francisco, the tension forces on the cables must be balanced to keep it from falling due to the force of gravity.

Let's suppose three forces are applied to the following body.

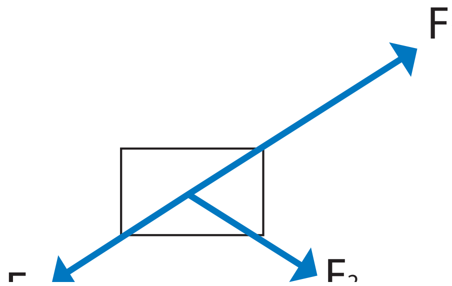


FIG. 1.40 Three forces are applied to one same body.

If we transfer these forces to a Cartesian plane, we would have:

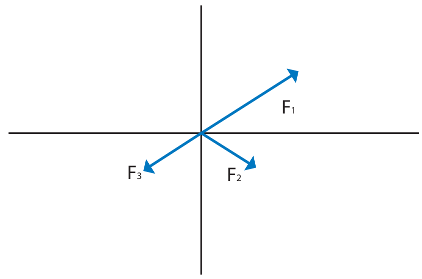


FIG. 1.42 The three forces on the Cartesian plane.

As the method states, we must keep one of the forces fixed, for example F1. Then we place F2's starting point on F1's ending point and F3's starting point on the ending point of F2's.

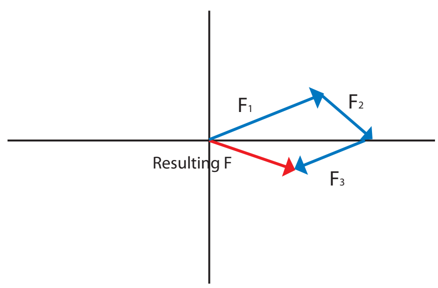


FIG. 1.43 Resulting force.

The resulting vector is the one that goes from F1's starting point to F3's ending point. This is, if the three original forces were applied on a body, this would move as if just one single force had been applied, with the magnitude and direction of the resulting force.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, problem solving.

EVALUATION OF CONTENT

Students should be able to solve problems that find resultant force vectors.

This procedure is known as **method of polygon** for vector adding.

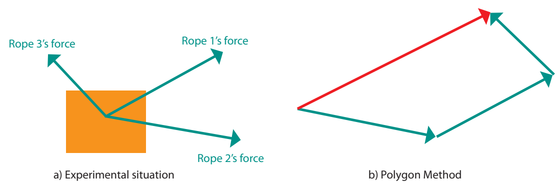


FIG. 1.44 Polygon Method.

Closing

How much did I learn?

Adding applied forces means to find a single vector to replace them.
Answer and discuss the following questions with your teammates. Share them with the class to reach a concensus.

1. How do forces act on a carrier container being lifted by a crane added? Draw them.
2. How many forces act on a hanging lamp? Draw them.
3. Four classmates are pulling a potato sack, as shown in the figure. Which direction will the sack move towards? Draw the vectors.

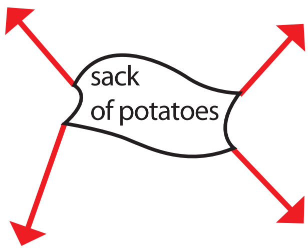


FIG. 1.45 Forces exerted on a sack of potatoes.

4. What are the differences between the polygon method and the parallelogram method? How do you choose which method to use?

Equilibrium of Forces; Use of Diagrams

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach a consensus per team. Share your answers with the class.

- What do you understand by **rest**? Explain situations considering the force.
- If a body is not moving, are there any forces acting on it? Describe three cases: a parked car, a lamp hanging from the ceiling and loudspeakers in a football stadium.

Expected Learning

Support the relation between an object's state of rest (standby) and the equilibrium of acting forces and the use of vectors in everyday situations.

SESSION INFORMATION

Week: 6

Session: 34

Expected learning outcome: Apply polygon and parallelogram graphic methods to obtain the resultant force acting upon an object, and describe motion produced in everyday situations.

CONTENT DELIVERY

Start: Students should respond to the section *How much did I learn?* Elicit answers in whole class.

Development: Students should practice the methods to obtain the resultant vector acting upon an object. If more practice is necessary or a mini-quiz, this session can help you provide with more practice.

Closing: Students should successfully apply the formulas to solve problems. Look for more problems to be solved.

Project preparation: Students should take to class: Two toothpicks, two metal forks and a salt or peppershaker.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, applying information.

Logical/Mathematical skills: Solving problems.

EVALUATION OF CONTENT

Students should get problems checked with the help of the teacher in whole class.

SESSION INFORMATION

Week: 6

Session: 35

Expected learning outcome: Support the relation between an object's state of rest (standby) and the equilibrium of acting forces and the use of vectors in everyday situations.

CONTENT DELIVERY

Start: Have students look at the video at https://www.youtube.com/watch?v=tm9amEoq_QE and replicate the experiment.

Development: They should try to explain how it is possible that the forks balance. Then, they should read page 34 and analyze the experiment. Was it equilibrium? How did it work? Encourage students to explain the relation among the forks and toothpicks

Closing: Students should do the activity on page 34.

Project preparation: Students should get a mini-piñata filled with candy and a rope.

The Most Common Forces and Their Applications

We have all seen a book on a table, an ornament hanging from the ceiling or a pedestrian bridge. These are situations of rest and **equilibrium**, since the forces acting in each case are balanced; when added, they equal zero.

Glossary

Equilibrium. A state of motion where the addition of forces equals zero. This state, doesn't always imply being at rest.

FIG. 1.46 Statue of Buddha in a situation of rest.

But, how can we know which forces are acting on each object in these situations? Which direction are these forces pointing to?

➔ Activity

Place a box full of books on the floor of the classroom. If we tie the box with two ropes and drag it with the help of a classmate. What kind of force should a third classmate apply to keep the box from moving?

Since the box has to move in one specific direction, the force applied to keep it from moving must counteract the action of both forces applied by the ropes. In other words, we have to apply the same force in magnitude but in opposite direction, shown below:

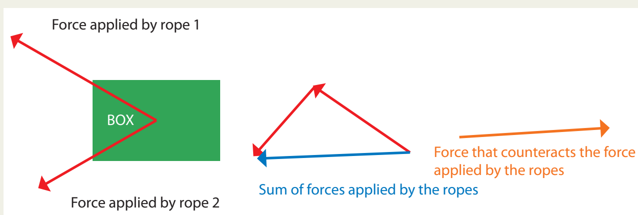


FIG. 1.47 Diagram of forces applied on a box of books in a situation of rest.

The same happens when an ornament is hanging from the ceiling. There is a rope, chain or thread holding it and applying the necessary force to balance the force of gravity.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing.

Visual/Spatial skills: Looking and replicating.

EVALUATION OF CONTENT

Students should be able to explain equilibrium.

➔ Activity

Look at the following piñata hanging from two ropes. It is evidently at **rest**. How many forces are acting on it?

In the case of the piñata, not only are the two ropes' **tension forces** acting on it, but also its own **weight**. The fact that it doesn't move tells us that the tension forces are in **equilibrium** with the weight of the object and both add up to zero.

A **diagram of forces**, as we have already seen, is used to study situations of motion and equilibrium. This is the diagram of forces of the piñata, seen from the front:

FIG. 1.48 A piñata hanging from two ropes.

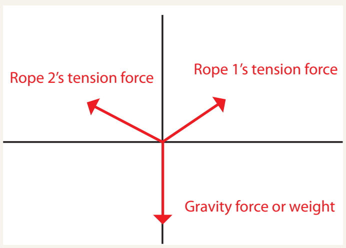


FIG. 1.49 Diagram of forces applied on a piñata.

Use the polygon method to add the three forces and check for the resulting force to equal zero.

Closing

How much did I learn?

Answer and discuss the following questions with your teammates. Share your answers with the class to reach a concensus.

1. Can you say you are in equilibrium right at the moment? Why?
2. Why do you think bridges have beware signs showing the maximum weight allowed for vehicles to go over them?
3. Suppose we have an object tied to three ropes. Ropes 1 and 2 apply forces of 30N and 40N respectively, as shown in Fig. 1.49. What direction and value should the tension force in rope 3 be in order to keep the object in equilibrium?

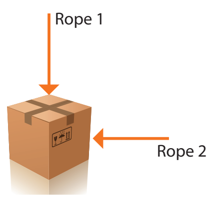


FIG. 1.50 Forces exerted on an object.

SESSION INFORMATION

Week: 6

Session: 36

Expected learning outcome: Support the relation between an object's state of rest (standby) and the equilibrium of acting forces and the use of vectors in everyday situations.

CONTENT DELIVERY

Start: Students should do the activity using the piñata and rope. Guide them to analyze how equilibrium is acting in the piñata.

Development: Students should do the section *How much did I learn?*

Closing: Students should be able to answer the last questions correctly.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing.

Logical/Mathematical skills: Solving problems.

EVALUATION OF CONTENT

Students should be able to answer the last questions correctly.

SESSION INFORMATION

Week: 7

Sessions: 37 – 42

Expected learning outcome: Work collaboratively with responsibility, solidarity and respect in the organization and development of a project.

Select and organize the relevant information from research to outline a project.

Describe natural phenomena and processes related to motion, waves or force based on graphs, experiments and physical models.

Share the outcome of a project through several media (texts, models, graphs, multimedia, among others).

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations.

Project — Measurements in Complex Motions for Prediction and Prevention

➔ Expected Learning

Work collaboratively with responsibility, solidarity, and respect in the organization and development of a project.

Select and organize the relevant information obtained from research to outline a project.

Describe some natural phenomena and processes related to motion, waves or force based on graphs, experiments and physical models.

Share the outcome of a project through several media (texts, models, graphs, multimedia, among others).

➔ Proposed problems to define the project:

1. What is the motion of earthquakes and tsunamis like? How is this information used to prevent and reduce risks towards these natural phenomena?
2. How can the speed of people and objects be measured in some sports as baseball, track & field and swimming?

Remember that if you or your team have another question or problem you want to research and solve, you are free to do so; never let your enthusiasm disappear since these are only proposals. Try to choose something you find useful for you and your community.

➔ Developing the Project

With your team, answer the following questions:

1. Have we defined the main idea or problem of the project?

____

2. What is it? Why is it relevant?

____

3. What is the plan to carry it out? What resources do we need? What have we done so far? What are we missing?

____

4. How and when will we carry it out? What impact are we expecting? What will we do if it does not work out? Do we have a plan B? What is it?

____

5. How are we going to communicate the outcome of this project to the rest of the class? And to the school body? And to the rest of the community?

____

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

With your team, go over your answers before analyzing them with the teacher. To go over the project in general, define the steps to follow for the next two weeks, so you are able to reach the proposed results. Make sure the information you are using is correct and comes from reliable sources. Once your research is done, write it down in an orderly manner, including charts, tables and graphs to show your results as well as the corresponding analysis. Do not forget to include your conclusions and future projections.

➔ Communicating the results of the project

With your team, propose several kinds of communication media to help you present the project to the rest of the class and school body and to your community if you find it necessary.

Take into account that Information and Communication Technologies (ICT) may help you in communicating the results of your project, but consider as well other kinds of media, such as billboards and newspapers, or something more educational, such as lectures, workshops with the school community, etc.

Do not forget to share everything you have done in the project. It may be useful to have a preliminary outline in writing, which you can back up with models at the moment of presenting it.

➔ Evaluating the Project

Once the project is finished and shared, meet with your team and reflect on what you have done during this time to carry it out. Consider the following questions:

6. Were the objectives of the project met? Why?
7. How did you evaluate the results? Are they positive or negative? What grade would you give it?
8. What obstacles did you face? How did you work them out? In case one of the obstacles was not worked out, why did it happen?
9. What could you have done better?
10. How was the participation of each of the team members during the project? Did everyone do their part?

In your notebook, write down a personal thought about what you have learned regarding the topic while working on this project. Also include, what personal experience you gained through this project. Think about how you carried out the search for answers, faced obstacles and made decisions throughout the project.

SESSION INFORMATION

Week: 7

Sessions: 37 – 42

Expected learning outcome: Work collaboratively with responsibility, solidarity and respect in the organization and development of a project.

Select and organize the relevant information from research to outline a project.

Describe natural phenomena and processes related to motion, waves or force based on graphs, experiments and physical models.

Share the outcome of a project through several media (texts, models, graphs, multimedia, among others).

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations.

SESSION INFORMATION

Week: 8

Sessions: 43, 44

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 38 and 39 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages 144 to 147 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

Evaluation

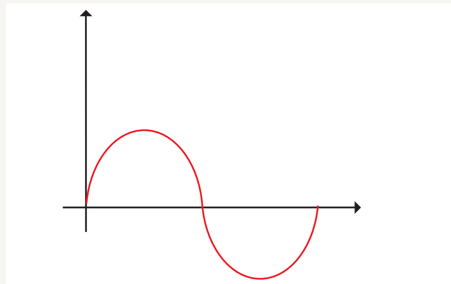
FIG. 1.51 Yuri Gagarin.

1. Yuri Gargarin was the first man to travel to space (fig.1.5). His spaceship, Vostok 1 went around Earth at 28,000 km/hr for 28 minutes, therefore we can say that the spaceship held:

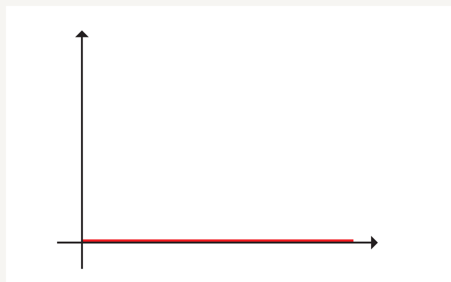
   a) Its velocity. **b)** Its acceleration. **c)** Its speed. **d)** Its displacement.

2. If a car maintains a constant acceleration different from cero, its velocity vs. time graph will be:

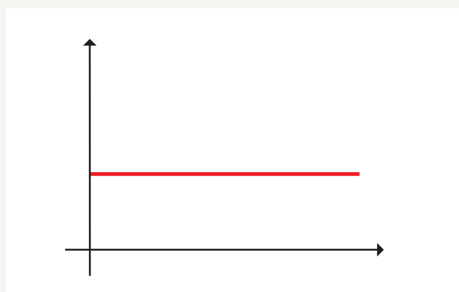
a)



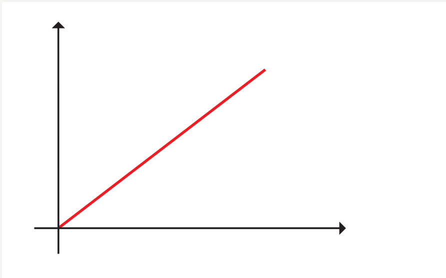
b)



c)



d)



3. In a longitudinal wave , such as sound waves, the oscillation of the wave is:

a) Transversal to the wave's propagation.

b) Perpendicular to the propagation motion of the wave.

c) The same as the oscillation of ocean waves.

d) Similar to the one generated by a spring.

4. The method to sum up vectors in which you place the initial points of vectors to coincide is called:

a) Triangle Method.

b) Parallelogram Method.

c) Polygon Method.

d) Aristotelic Method.

5. Write about what you liked best in this unit.

Student´s own snswers

SESSION INFORMATION

Week: 8

Session: 45

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 38 and 39 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages 144 to 147 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

SESSION INFORMATION

Week: 8

Sessions: 46, 47

SELF EVALUATION

Evaluation

Self-Evaluation

Evaluate your own way of working; check in the boxes what you are able to do with the themes in this unit.

SKILLS	YES	NO
I can apply physics to solve problems in my community, country and around the world.		
I can relate the knowldege of physics with the surrounding environment and with the ethical, economic, sociopolitical and cultural matters of my country and the world.		
I can use technical physics terms to communicate information.		
I use graphs, tables and models in my reports, homework and projects.		
I can search for information in the correct sources and organize it according to the report, project or assignment I'm working on, mentioning the sources of information.		
I establish mathematical models and solve problems related to physics.		
I analyze physics problems and can break up a whole in its parts, finding the relationship among the parts as well as identify cause and effect of the problem.		
Organize and analyze data, represent it in graphs and tables, evaluate the validity of ideas and the quality of work.		
Come to conclusions based on scientific reasoning.		
Make decisions related to my health and that of others, as I promote the culture of prevention.		
I am responsible and committed, work well with others and respect their point of view.		
I apply my knowledge and skills to solve problems in my community.		

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

SESSION INFORMATION

Week: 8

Session: 48

SELF EVALUATION

Peer Evaluation

Rubric

POINTS	VALUE	MEANING
10	Excellent	Perfect collaboration without mistakes.
8	Very good	Little, involuntary or justified mistakes.
6	Good	Has shown mistakes and lack of a helping attitude.
4	Barely accomplishes	Total lack of helping attitude, mistakes and excuses constantly present.
2	Not accomplished	Has not accomplished the task, shows irresponsibility.

Characteristics To Evaluate

	CHARACTERISTICS
A	Prepares his share of the work in a responsible way.
B	Makes his best effort at sharing his learning.
C	Handles conflicts constructively.
D	Shows trust, respect, acceptance, listens and support towards others.
E	Points out strengths and areas of opportunity during group processing.
F	Gives feedback to the group to improve on assignments and responsibilities.

Peer Evaluation

Write the name of each of your teammates and check the box for each trait your partner has.

TEAM TO BE EVALUATED						
NAME OF STUDENT	A	B	C	D	E	F
	2-10	2-10	2-10	2-10	2-10	2-10
1						
2						
3						
4						
5						

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

Project preparation: In teams of four, students should prepare a TV show in which they will interview Isaac Newton. They should ask about his biography and movement laws. They should do rehearsals the following session and then, the teacher should choose a team to present in front of everyone. The student who plays Newton should dress up. His costume should be made with paper and recyclable materials.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

SESSION INFORMATION

Week: 9

Session: 49

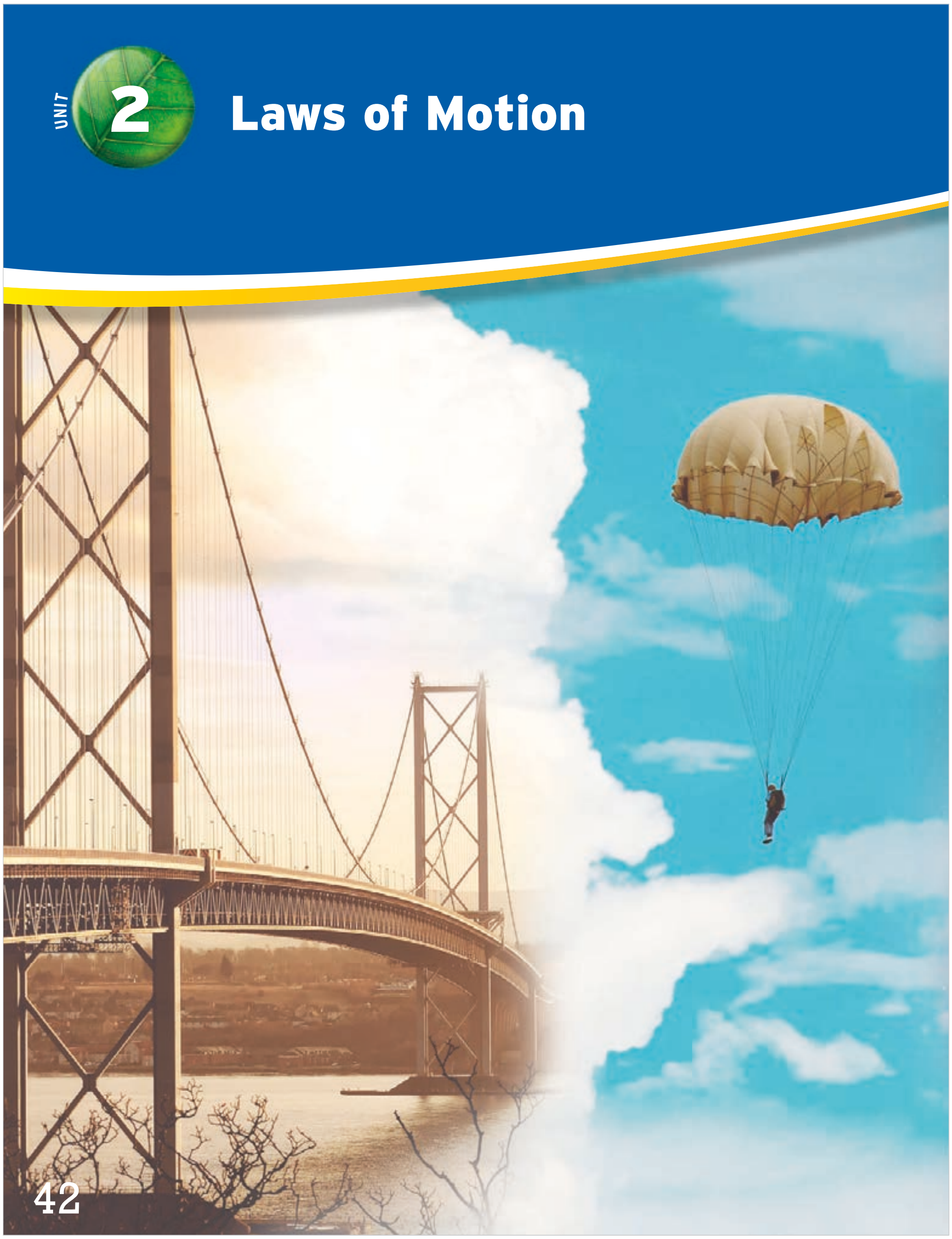
Expected learning outcome: Students should identify Newton as one of the most important characters in science history by naming the movement laws he created.

CONTENT DELIVERY

Start: Prepare some of Newton's main achievements list and write them on the board.

Development: In teams of four, students should prepare a TV show in which they will interview Isaac Newton. They should ask about his biography and movement laws. They should do rehearsals; the teacher should choose a team to present in front of everyone. The student who plays Newton should dress up. His costume should be made with paper and recyclable materials.

Closing: Students should mind map Newton's accomplishments.



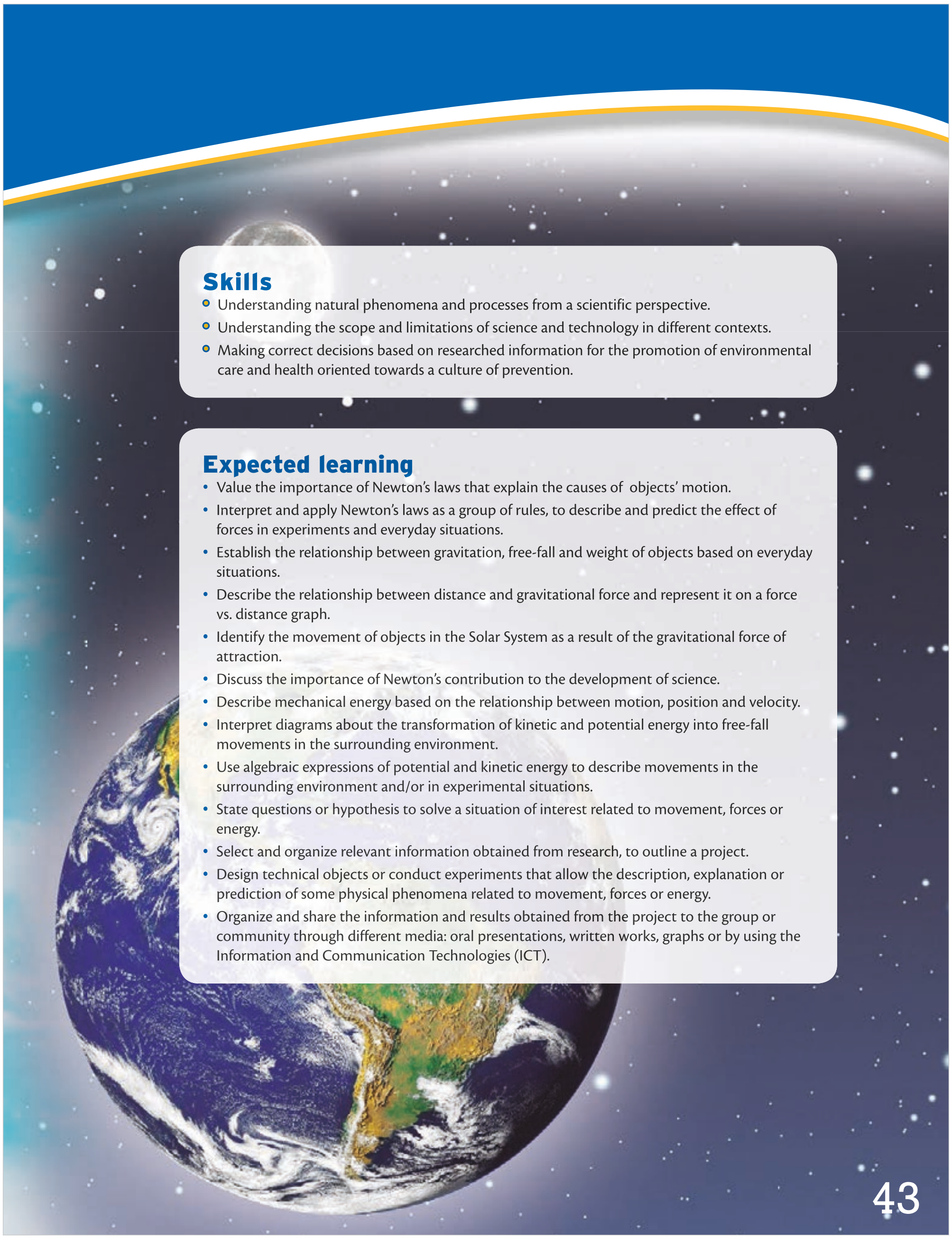
SKILLS DEVELOPMENT

Bodily/Kinesthetic skills: Acting.

Critical thinking skills: Summarizing, mind mapping.

EVALUATION OF CONTENT

Students should get their mind map checked by the teacher.



Skills

- Understanding natural phenomena and processes from a scientific perspective.
- Understanding the scope and limitations of science and technology in different contexts.
- Making correct decisions based on researched information for the promotion of environmental care and health oriented towards a culture of prevention.

Expected learning

- Value the importance of Newton's laws that explain the causes of objects' motion.
- Interpret and apply Newton's laws as a group of rules, to describe and predict the effect of forces in experiments and everyday situations.
- Establish the relationship between gravitation, free-fall and weight of objects based on everyday situations.
- Describe the relationship between distance and gravitational force and represent it on a force vs. distance graph.
- Identify the movement of objects in the Solar System as a result of the gravitational force of attraction.
- Discuss the importance of Newton's contribution to the development of science.
- Describe mechanical energy based on the relationship between motion, position and velocity.
- Interpret diagrams about the transformation of kinetic and potential energy into free-fall movements in the surrounding environment.
- Use algebraic expressions of potential and kinetic energy to describe movements in the surrounding environment and/or in experimental situations.
- State questions or hypothesis to solve a situation of interest related to movement, forces or energy.
- Select and organize relevant information obtained from research, to outline a project.
- Design technical objects or conduct experiments that allow the description, explanation or prediction of some physical phenomena related to movement, forces or energy.
- Organize and share the information and results obtained from the project to the group or community through different media: oral presentations, written works, graphs or by using the Information and Communication Technologies (ICT).

43

SKILLS DEVELOPMENT

Metacognitive skills: Planning, organizing studies content.

EVALUATION OF CONTENT

Students should get their study plan checked by the teacher.

SESSION INFORMATION

Week: 9

Session: 50

Expected learning outcome: Identify topics in the unit students consider will be hard to understand in order to make a studies plan.

CONTENT DELIVERY

Start: Have students analyze and identify what they could do well in unit 1; as well as what they should improve in unit 2. Ask them, for instance: What topics were easy? Did your previous study plan work? Didn't it work? Why? Did you really follow your study plan? Students should write down their reflections.

Development: Have students check the skills, learning outcomes and key concepts in unit 2. Ask them to identify the topics they consider the hardest ones. Then, they should plan how to study them. If a strategy didn't work, then they should find another one. Help them with ideas. (Drawing mind maps, discussing with partners, making their own exams, making timelines, making associations, etc.)

Closing: Students should write down their study plan and have it checked.

Homework: Students should do research about Newton's three laws of motion.

SESSION INFORMATION

Week: 9

Sessions: 51, 52

Expected learning outcome: Value the importance of Newton's laws to explain why objects have motion.

CONTENT DELIVERY

Start: Students should read The introductory notes about Newton's First Law of Motion and then, answer the questions in the section *Exploring knowledge*. Guide them to analyze the questions and answers.

Development: Students should read the rest of the page and contrast with the information they found in their research about Newton's first law of motion. Elicit the first law of motion. Write it on the board and illustrate it with examples. Have students do the activity, which is described on page 45.

Closing: Students should respond the questions in the section *How much did I learn?*

Expected Learning

Value the importance of Newton's laws to explain why objects have motion.

Newton's Laws

Newton's First Law: State of Rest or Uniform Linear Motion. Inertia and Its Relationship With Mass

Did you know that the state of **rest** is a **velocity**, too? The state of rest is a case of **uniform linear motion** with a value of zero velocity. The ULM is applied in absence of external forces, such as **friction**, which you can see in the picture.

FIG. 2.1 Boxes resist movement.

Glossary

Impulse. A force carried by a moving or growing body.

Exploring Knowledge

1. If you throw a notebook on the floor and it slides, why does it travel less distance than if you throw a ball with the same velocity?
2. What does a body need to stop being in a state of rest?
3. When does a moving body stop? In other words, when does a ball or a car stop?

FIG. 2.2 A spaceship.

Newton's first law states that a body will keep its state of rest or uniform linear motion until an external force acts upon that state. If the body is at rest on an ice rink, its velocity is zero and it will remain so unless somebody or something pushes it. However, if the body has a uniform linear motion on the ice rink and it moves onto a rubber surface, a friction force will stop the body from moving.

A ship in space, as the one shown in the picture, is not subject to meaningful friction forces. Its initial movement comes from its engines. When the engines are turned off, the ship will maintain its uniform linear motion indefinitely without the need of something to impulse it, therefore, saving fuel.

SKILLS DEVELOPMENT

Critical thinking skills: Remembering, comparing and contrasting, analyzing, imagining.

EVALUATION OF CONTENT

Students should be able to explain the first law of motion in other situations.

Activity

Watch the following clip from a Mexican movie:
http://www.youtube.com/watch?v=GfKkugEl7iU
Do you think the actors are moving all the time?
How was the effect of motion achieved?
Thinking about what you have read regarding motion and the state of rest on the previous pages, how does a person feel when traveling on a plane?

Inertia is the tendency of bodies to maintain their state of rest or uniform linear motion. **Inertia** is in direct relation with the mass and velocity of an object. The bigger an object is, and the higher the velocity it has, the more inertia it possesses and the more difficult it will be to modify its state of rest or uniform linear motion. For example, at rest, a truck's inertia is greater than a sports car's inertia. However, if the sports car moves at a higher velocity than the truck, its inertia could be greater. Which one would be more difficult to stop? Why?

Closing

How much did I learn?

Answer the questions with your teammates. Share your answers with the class.

1. Explain Newton's first law in your own words.
2. Why is it that sooner or later all objects on Earth stop if no one is applying a force upon them?
3. What is inertia?
4. Which is easier to move, a body with little or much inertia? Why?

Newton's Second Law: Relationship between Force, Mass and Acceleration. The Newton, as a Unit of Force

Expected Learning

Interpret and apply Newton's laws as a group of rules to describe and predict the effect of forces in experiments and everyday situations.

Unlike Newton's first law, which deals with the objects' state of motion, Newton's second law, deals with the **force** acting upon bodies in order to change their velocity, that is, their acceleration.

Acceleration is the change in a body's velocity. It can increase or decrease.

Acceleration happens in the following conditions:

a) If two bodies receive the same force each, the body with less **mass** will accelerate more.
b) If two bodies with the same amount of mass receive different forces each, the body receiving the greater force will accelerate more.

FIG. 2.3 Change of velocity is called acceleration.

SESSION INFORMATION

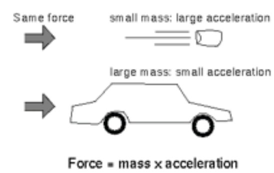
Week: 9

Sessions: 53, 54

Expected learning outcome: Interpret and apply Newton's laws as a group of rules to describe and predict the effect of forces in experiments and everyday situations.

CONTENT DELIVERY

Start: Show students the example of Newton's Second law of motion. Have them analyze it and help them say what happens:



Development: Students should go on to page 46, and analyze the formula. Help them with 10 examples at least. Then, have them do the problems in the section *Team Work*. You might want to check for more problems. Look for: Newton's Second Law problems in an internet browser to find further practices.

Closing: Students should do the experiment on page 46. Help them in the process. Finally, they should respond to the questions in the section *How much did I learn?* on page 47.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Analyzing, problem solving, imagining.

EVALUATION OF CONTENT

Students should be able to solve problems using Newton's Second Law of Motion.

SESSION INFORMATION

Week: 10

Sessions: 55, 56

Expected learning outcome: Interpret and apply Newton's laws as a group of rules to describe and predict the effect of forces in experiments and everyday situations.

CONTENT DELIVERY

Start: Show students the example of Newton's Second law of motion. Have them analyze it and help them say what happens:

Development: Students should go on to page 46, and analyze the formula. Help them with 10 examples at least. Then, have them do the problems in the section *Team Work*. You might want to check for more problems. Look for: Newton's Second Law problems in an internet browser to find practices.

Closing: Students should do the experiment on page 46. Help them in the process. Finally, they should respond to the questions in the section *How much did I learn?* on page 47.

This is expressed in the following equation:

$$F = m \cdot a$$

In which:

F= force applied upon a body.
m= mass of the body.
a= acceleration experimented by the body.

Curious Facts

A Newton is the result of multiplying the mass by acceleration.

$N = (kg)\left(\frac{m}{s^2}\right)$

Here is a classic problem:
What is the force acting upon an 8kg body if it accelerates at $2\,\frac{m}{s^2}$?

m= 8 kg

$a= 2\,\frac{m}{s^2}$

As the equation shows, we multiply both terms: mass per acceleration. Let's solve it:

$$F=(8\text{ kg})\left(2\,\frac{m}{s^2}\right) = 16\text{ N}$$

➔ Team Work

With your teammates, answer the following problems. Share your answers with the class.

1. What is the acceleration force of a body with a mass of 3.4 kg if it goes from rest to motion at $10\,\frac{m}{s}$ in 5s?
2. What is the acceleration of a 55 kg body, if you apply a force of 200 N upon it?
3. What is the mass of a body, which accelerates at $3\,\frac{m}{s^2}$ when you apply a force of 10 N upon it?
4. If you have two bodies, one is 5 kg and the other is 10 kg, and you apply a force of 30 N to each one, how are their accelerations different?

Glossary

Inclined plane. A flat surface that forms an angle with the horizontal and facilitates the rising or lowering of bodies.

Experiment

In teams, do the following experiment:

Use an **inclined plane** of 1 m to roll a pellet. Make marks every 20 cm. Set up the inclined plane for the pellet to take 10 seconds to travel the entire length. Measure the time it takes the pellet to cross each of the 20 cm marks. Obtain the mass of the pellet using a balance. For each distance and time, obtain the acceleration and force used by gravity to attract the pellet.

Fill in the table below and repeat the same procedure increasing the inclination 6°. Compare your results.

FIG. 2.4 Example of an inclined plane to use in the experiment.

Distance	Time	Acceleration	Force
20 cm			
40 cm			
60 cm			
80 cm			
100 cm			

SKILLS DEVELOPMENT

Logical/Mathematical skills: Analyzing, problem solving, imagining.

EVALUATION OF CONTENT

Students should be able to solve problems using Newton's Second Law of Motion.

Closing

How much did I learn?

1. Discuss the following questions with your teammates. Share your answers with the class.. What does Newton's second law state?
2. Does Newton's second law state that the greater the mass of a body, the more you need to move it?
3. If the same force is applied to different bodies, which one accelerates more? Why?
4. If we apply two different forces to bodies with an equal mass, which one accelerates more?
5. Answer the following problems using Newton's second law:
   a) What is the force applied to a body accelerating at $4\frac{m}{s^2}$ if it has a mass of 12 kg?
   b) What is the acceleration of a race car with a mass of 1,340 kg and an engine force of 10,000 N?
   c) What is the mass of a body with gravity's acceleration value and with an applied force of 870 N?

Newton's Third Law: Action and Reaction; Magnitude and Direction of Forces

Expected Learning

Interpret and apply Newton's laws as a group of rules to describe and predict the effect of forces in experiments and everyday situations.

We have studied addition of forces, their origin and what happens to a body when forces are present and absent. However, we must never forget that whenever there is a force, another will be present. This is fundamental in Newton's third law.

Exploring Knowledge

- Push the wall with your body. What happens to your body? Did the wall push you?

Newton's third law states:

For every action, there is an equal and opposite reaction.

This means that every applied force, either of attraction or repulsion, will have an associated counterpart in the opposite direction (180°).

There are many extreme cases where it is very easy to appreciate the two forces, or their consequences, involved in Newton's third law. For example, when a space rocket takes off, it is launched upwards by the fuel, which is burnt and expelled in the opposite direction, downwards. This is a clear example of the action and the reaction.

FIG. 2.5 The reaction of burnt fuel impulses the rocket.

A number of situations in our daily life are also explained with Newton's third law. For example:

a) When we are standing on the floor, our weight exerts a downward force on the floor. The floor also exerts a force with the same magnitude but in the opposite direction, which is an upward force; therefore we neither fall nor rise. The action is our weight, the reaction is the floor's upward force.
b) When we walk forward (the action), we push the floor backwards; therefore the floor pushes us forward (the reaction).
c) If we place a cup of coffee on a table, it exerts a downward force with its weight. At the same time, the table exerts an upward force of the same magnitude and the cup remains stable.

Kells

SESSION INFORMATION

Week: 10

Sessions: 57 - 60

Expected learning outcome: Interpret and apply Newton's laws as a group of rules to describe and predict the effect of forces in experiments and everyday situations.

CONTENT DELIVERY

Start: Students should read the information about Newton's Third Law of Motion. Help them with examples and guide them to clearly understand it.

Development: Have them do the section *Activity* on page 48 and help them find more examples in which the law is clearly seen.

Closing: Students should respond to the questions in the section *How much did I learn?* Help accordingly.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Solving problems.

Critical thinking skills: Analyzing, solving problems, finding relations.

EVALUATION OF CONTENT

Students should find examples of Newton's Third Law of Motion.

Kells

SESSION INFORMATION

Week: 11

Sessions: 61, 62

Expected learning outcome: Establish the relationship between gravitation, free fall and weight of objects based upon every day situations.

Describe the relationship distance - gravitational force and represent it on a force vs. distance graph.

CONTENT DELIVERY

Start: Students should read the information about the "Effects of forces on Earth and the Universe" (pages 48, 49). Guide them to analyze the explanation.

Development: Help students to name other examples of the effects of gravity.

Closing: Students should be able to explain how gravity acts upon objects on Earth.

Homework: In teams, students should take a scale.

Activity

In teams of four, explain where action and reaction take place in the following cases. Discuss the answers with another team and share them with the class.

1. Kick a football.
2. Row a boat.

Closing

How much did I learn?

Answer the questions with your teammates. Share them with the class..

1. What does Newton's third law state?
2. What important implication does this law have?
3. Is it possible to find a force that is the only one applied in a given case?
4. For each of the following cases, explain where action and reaction take place. Represent both forces with vectors.
   a) A child running.
   b) A sphere hanging from a Christmas tree.
   c) Blowing air hard.

Expected Learning

Establish the relationship between gravitation, free-fall and weight of objects based on everyday situations.

Describe the relationship between distance and gravitational force and represent it on a force vs. distance graph.

Effects of Forces on Earth and the Universe

Gravitation. Graphical Representation of Gravitational Attraction. Relationship between Free-Fall and Weight

We have seen the effects of applying one or several forces on a body. According to Newton's second law, bodies accelerate by the action of a force.

We are always subjected to the **force** of gravity because our planet and everything on it are attracted to one another for the simple reason of having **mass**.

Earth attracts all the bodies: meteorites, people, animals, plants and everything around us, including air. If air were not attracted, it would escape Earth and there would be no atmosphere.

The **attraction** Earth exerts on a body will be greater depending on its mass, that is the **force of gravity**. What do you think is harder to lift 1 m high, an ant or an elephant? Why?

FIG. 2.6 A meteorite is attracted to Earth by gravity and catches fire due to its friction with the atmosphere.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, comparing, deducing information.

EVALUATION OF CONTENT

Students should be able to name three examples of the force of gravity.

All the objects around us are attracted in a greater or lesser intensity towards the Earth. It depends on the object's mass; the greater the mass, the more it is attracted by the gravitational force. The force by which objects are attracted is called **weight** and it is measured in Newtons (N).

➔ **Activity**

Weigh a pencil, a notebook and a full school bag separately on a balance. Write down the weight of each one.

Object	Weight

As you can see, in general, balances measure the mass of bodies, not the weight, so it is incorrect to say that we are going to weigh something if what we are actually obtaining is the mass.

In order to know the weight of a body, we have to multiply the mass value, in kilograms, by $9.81 \frac{m}{s^2}$, which is the acceleration created by Earth's gravitational force. Write the weight you obtained and complete the table.

Object	Weight

The Earth also exerts a gravitational attraction on both the moon and the Sun, as shown in figure 2.7, and they also exert a force on Earth, as well as on each other, and pon everything that conforms our solar system, because everything has mass. This attraction gets weaker with **distance** in a quadratic way. These

FIG. 2.7 The Sun also exerts an attraction force on Earth.

SESSION INFORMATION

Week: 11

Sessions: 63 - 65

Expected learning outcome: Establish the relationship between gravitation, free fall and weight of objects based upon every day situations.

Describe the relationship distance - gravitational force and represent it on a force vs. distance graph.

CONTENT DELIVERY

Start: Students should say the definition of force of gravity.

Development: Students should do the activity using the scale they took.

Closing: Help them to get not only the mass but also the weight of each object.

SKILLS DEVELOPMENT

Critical thinking skills: Observing, problem-solving.

EVALUATION OF CONTENT

Students should get the weight of the objects by multiplying the mass by 9.81 m/s2.

SESSION INFORMATION

Week: 11, 12

Sessions: 66 - 69

Expected learning outcome: Establish the relationship between gravitation, free fall and weight of objects based upon every day situations.

Describe the relationship distance - gravitational force and represent it on a force vs. distance graph.

CONTENT DELIVERY

Start: Students should read the information starting at the bottom of page 49 and beginning of page 50. Guide them step-by-step to understand how the formula works.

Development: Students should answer the exercises in the section *Team Work*.

Closing: Students should answer the questions in the section *How much did I learn?* Guide them as they need it.

GLOSSARY

Gravitational constant. A physical constant that sets the size of the gravitational force.

relationships can be expressed in what we know as the Law of Universal Gravitation, where: *F* is the force between the masses; *G* is the gravitational **constant**; m_1 and m_2 are the masses of two bodies and *r* is the distance between them.

$$F = G\frac{m_1 m_2}{r^2}$$

Let's find the force of gravitational attraction in a real situation, for example, between Earth and the moon. We need to know the distance between them and their mass.

Earth's mass = 5.9×10^{24} kg

The moon's mass = 7.2×10^{22} kg

Approximate distance of separation = 380,000 km

$$G = \frac{6.67384 \times 10^{-11}\ N \times m^2}{kg^2}$$

Although these numbers seem huge or very small, since it is for the constant, we only have to do basic multiplication and division operations. Look:

$$F = (6.67384 \times 10^{-11}\ \frac{N{\cdot}m^2}{kg^2})\ (5.9 \times 10^{24}\ kg)\ \frac{(7.2 \times 10^{22}\ kg)}{(380{,}000\ km)^2}$$

$$F = \frac{283.34 \times 10^{35}}{14.44 \times 10^{10}}$$

$$F = 19.62 \times 10^{25}\ N$$

This is the force of gravitational attraction between Earth and the moon.

Team Work

What would the force of gravitational attraction be between these bodies (Earth and the moon) if the distance of separation were:

a) The third part.
b) Twice as much.
c) Three times as much.

Closing

How much did I learn?

Answer the questions with your teammates. Share your answers with the class.

1. What is the force of gravity?
2. What is the weight of bodies?
3. What does the weight of bodies depend on?
4. When you step on a balance, what does the measurement show?
5. What does the force of gravitational attraction between two bodies depend on?
6. If the distance between two bodies doubles up, what happens with the force of attraction between them?

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing data, problem-solving.

EVALUATION OF CONTENT

Students should be able to do the exercises with the teacher's help at first and then by themselves.

Newton's Contribution to Science: Explanation of Movement on Earth and within the Universe

Exploring Knowledge

In teams of five, answer the following questions. Discuss your points of view to reach one answer per team. Share your answers with the class.

1. Why doesn't the moon crash against **the Earth**, or the Earth against the Sun?

Expected Learning

Identify the movement of objects in the Solar System as a result of the gravitational force of attraction.

Discuss the importance of Newton's contribution to the development of science.

Only a few people in the history of science have contributed as much as Isaac **Newton** (England, 1642-1727). He established not only the three laws that carry his name about movement of bodies and the law of universal gravitation, but he also invented what we know as differential and integral calculus and carried out optical studies, among many other topics. Regarding his law of universal gravitation, a specific question must be made: why doesn't the moon crash against the Earth? The following sequence of figures shows us that if we throw an object with great acceleration at various degrees of inclination, it will fall further every time we throw it, forming several curved **trajectories** (parabolic). But, if we throw it with a very strong force making its trajectory follow the Earth's **curvature**, the object will start orbiting the Earth and will not collide against the surface, it will only follow its orbit around the Earth.

FIG. 2.8 Bodies thrown with a certain degree of inclination.

FIG. 2.9 Object thrown in a direction that follows the Earth's curvature.

FIG. 2.10 Trajectory of the same object after a certain period of time.

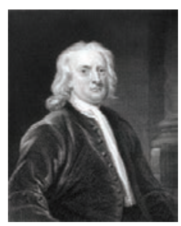


FIG. 2.11 Isaac Newton.

SESSION INFORMATION

Week: 12

Sessions: 70 - 72

Expected learning outcome: Identify the movement of objects in the solar system as a result of the gravitational force of attraction.

Discuss the importance of Newton's contribution to science development.

CONTENT DELIVERY

Start: Students should predict the answer to the introductory question.

Development: Students should read the information on the page and see the three images. Help them understand what happens in each case.

Closing: Students should do the activity (on page 52) and answer the questions in the section *How much did I learn?*

Homework: Students should take two objects to class, a heavy one and a light one.

SKILLS DEVELOPMENT

Critical thinking skills: Predicting, observing, imagining.

EVALUATION OF CONTENT

Students should be able to explain how the gravitational force acts.

SESSION INFORMATION

Week: 13

Session: 73

Expected learning outcome: Describe mechanical energy based upon the relation between motion, position and velocity.

CONTENT DELIVERY

Start: Show students a small ball rolling, an apple and you standing on a chair and help them say what you have in common with the ball and the apple. (Answer: energy). Have them analyze what kind of energy each object has. Then, help them say what kinetic and potential energy means. Help them accordingly.

Development: Students should say the definitions of kinetic and potential energy helping themselves with the information they can find on the page.

Closing: Students should give at least three examples.

Activity

As we have mentioned before, Newton was one of the most important scientists that ever existed. He made fundamental contributions to physics and mathematics and wrote one of the most important books in science, which changes the way to present scientific contributions: ***Philosophiae Naturalis Principia Mathematica,*** or The Mathematical Principles of Natural Philosophy.

Carry out a bibliographic research about the life and work of Isaac Newton and point out his contributions in the following four areas:

- Science
- Technology
- Alchemy (chemistry)
- Relationship with other people and scientists

Closing

How much did I learn?

Answer the questions with your teammates. Share your answers with the class.

1. Why is it that the moon and the Earth don't collide against each other, if both bodies are attracted according to the law of universal gravitation?
2. Likewise, why doesn't the Earth fall into the Sun, if it is attracting the Earth?
3. Which are Newton's greatest contributions to science?

Expected Learning

Describe mechanical energy based on the relationship between motion, position and velocity.

Energy and Movement

Mechanical Energy: Kinetic and Potential

Energy is how we measure the ability to perform a job; this means applying force to a body and moving it to a certain distance. When a body is moving, it is said that it has **kinetic energy** (motion energy), but if it is in a state of rest, its energy will depend on the altitude at which the body is positioned according to a frame of reference. This is called **potential energy**. Both concepts are related to the object's **mass**.

FIG. 2.12 Dams take advantage of potential energy.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, imagining, deducing meaning.

EVALUATION OF CONTENT

Students should be able to say three examples of kinetic and potential energy.

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach an answer per team. Share your answers with the class.

1. What is energy?
2. Do you think a body at a height of 10 m possesses more energy than one at a ground level?
3. How can we know that bodies hold energy by having a certain **velocity**?

Intuitively, you can know how much potential or kinetic energy an object may have in regards to its environment. For example, if an object is located at a considerable height, or if it makes a big noise when crashing against the floor, it is said that it has a lot of potential energy. But if the object moves at high speed, like when a ball moves on a pool table during a game, it is said that it has a lot of kinetic energy.

As mentioned before, both concepts of energy are proportional to the mass of the object. If two objects are at the same height or have the same speed, the one with a larger mass has more potential or kinetic energy.

Reflect, Explain and Share

What do you think has more potential energy, hurricane-force wind or a needle lying at the top of a skyscraper?

Activity

Work in teams of five. Four team members will stand facing the classroom wall as the fifth member drops a marble from three different heights: 10 cm, 50 cm and 1.5 m high. By the sound of the crash (conversion of potential energy into sound), the students facing the wall will have to guess the height from which the marble was dropped. Repeat the activity five times and make a table to record if they guessed the marble's height (potential energy) categorizing the height as: low, middle and high.

- What was the percentage of correct guesses?
- What else can you think of to figure out the height from which the marble is thrown without looking at it?

Discuss with your teammates first and then with the class.

FIG. 2.13 A pool table is a fun and practical application of kinetic energy.

SESSION INFORMATION

Week: 13

Sessions: 74 – 76

Expected learning outcome: Describe mechanical energy based upon the relation between motion, position and velocity.

CONTENT DELIVERY

Start: Have students say examples of potential and kinetic energy. Then, they should answer the questions in the section *Exploring knowledge*.

Development: Students should read the information on the page and answer the question in the section *Reflect, Explain and Share.*

Closing: Students should do the activity on page 53, in order to analyze the difference between kinetic and potential energy.

SKILLS DEVELOPMENT

Critical thinking skills: Imagining, analyzing.

Logical/Mathematical skills: Experimenting.

EVALUATION OF CONTENT

Students should describe how mechanical energy depends on motion, position and velocity.

SESSION INFORMATION

Week: 13

Sessions: 77, 78

Expected learning outcome: Interpret diagrams about the transformation of kinetic and potential energy into free-fall movements in the surrounding environment.

CONTENT DELIVERY

Start: Students should say what the meaning of kinetic and potential energy is.

Development: Students should read the information about mechanical energy. Help them as necessary so they can tell it is the addition of kinetic and potential energy. Then, have them do the activity on page 54.

Closing: Students should do the analysis questions in the section *How much did I learn?* Help them if they need it.

Homework: Students should get the meaning of the Law of Conservation of Energy.

FIG. 2.14 The skateboard has potential energy due to its height and kinetic energy, because of its movement.

Mechanical Energy

An object's mechanical energy is the addition of its potential and kinetic energies. In the picture, a young man is riding his skateboard. His displacement shows the combination of both energies given the height he reaches and his displacement velocity. If he were just in a state of rest in the lowest part of the ramp, the addition of these energies would be zero.

➔ **Activity**

In teams of five, find three real situations of a body:

1. without **mechanical energy**;
2. with a given mechanical energy due to the increase of its kinetic or potential energy (not both) under certain circumstances; and
3. with more mechanical energy due to the increase of both, kinetic and potential energies.

Discuss the situations with the class.

Closing

How much did I learn?

Answer the questions with your teammates. Share your answers with the class.

1. What does the potential energy of bodies depend on?
2. What does the kinetic energy of bodies depend on?
3. What is mechanical energy?
4. Mention a situation in which a body could have mechanical energy equal to zero, then a certain value of kinetic or potential energy (not both) and finally a certain amount of kinetic and potential energies.

➔ **Expected Learning**

Interpret diagrams about the transformation of kinetic and potential energy into free-fall movements in the surrounding environment.

Transformations of Kinetic and Potential Energies

Exploring Knowledge

In teams of five, answer the following questions. Discuss to reach an answer per team. Share your answers with the class.

1. What does the Law of the Conservation of Energy state?
2. Mention some of the energy transformations you have observed or know about.
3. When a body is falling, what happens to its speed?

When a body falls in a straight line or is thrown upwards vertically it loses or gains height, so it loses or gains potential energy. This change in **potential energy** brings about the change in **kinetic energy**. In this topic, you will learn how a body during free fall changes its potential energy into kinetic energy, and vice versa.

If we throw an object upwards, as shown the picture, it will have a maximum kinetic energy at the beginning of its rise, but it will decrease as it slows down (due to the force of gravity). At some point, the object will reach its maximum height and be at rest. At this point, potential energy is at the maximum and kinetic energy is zero. When it begins to fall, kinetic energy increases and potential energy comes down to zero when the body touches the floor, as shown in the graph (fig 2.15) Therefore, this way, mechanical energy meets the principle of energy conservation when transforming from potential to kinetic and vice versa.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Finding relations, experimenting.

Critical thinking skills: Analyzing information.

EVALUATION OF CONTENT

Students should be able to notice how kinetic and potential energy can transform into free-fall movements.

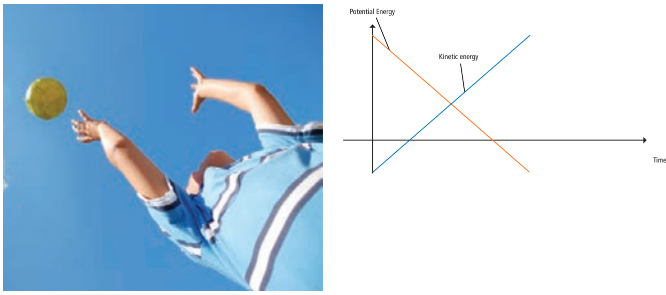


FIG. 2.15 Throwing an object up high is represented by the graph of potential energy vs time.

Closing

How much did I learn?

Answer the following questions with your teammates. Share your answers with the class.

Let's suppose that the kinetic energy of a body during free-fall is determined in the following graph.

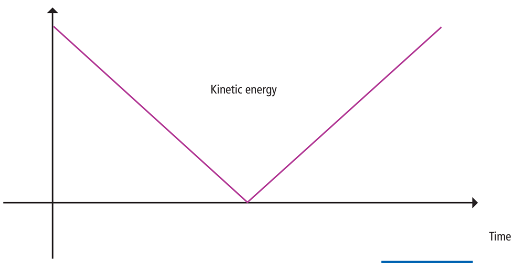


FIG. 2.16 Energy vs time graph.

1. What would the graph for potential energy be like in this case?
2. What kind of movement does the body have?

Principle of Conservation of Energy

Potential energy, as we know, depends on the height and **mass** of a body. The following formula shows it:

$$PE = m \cdot g \cdot h$$

In which:

PE = potential energy.

m = mass of the body.

g = gravitational acceleration $\left(9.81 \frac{m}{s^2}\right)$

h = height, from the floor or in accordance to another frame of reference.

Expected Learning

Use algebraic expressions of potential and kinetic energy to describe movements in the surrounding environment and/or in experimental situations.

SESSION INFORMATION

Week: 14

Sessions: 79, 80

Expected learning outcome: Interpret diagrams about the transformation of kinetic and potential energy into free-fall movements in the surrounding environment.

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring Knowledge* on page 54 with your help and the research they did.

Development: Students should read the information on page 54 and see the image and graph. Help them as necessary.

Closing: Students should answer the problem in the closing section *How much did I learn?* Help them as needed.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting, observing.

EVALUATION OF CONTENT

Students should interpret the diagram.

SESSION INFORMATION

Week: 14

Sessions: 81, 82

Expected learning outcome: Use algebraic expressions of potential and kinetic energy to describe movements in the surrounding environment and/or in experimental situations.

CONTENT DELIVERY

Start: Students should read the formula of the principle of conservation of energy on page 55. Help them with at least 10 examples.

Development: Students should read page 56 and do the activity.

Closing: Students should be able to interpret diagrams about the transformation of energy.

Homework: In teams of four, they should choose an airplane they like and investigate the mass it has.

FIG. 2.17 James Joule.

The standard measurement unit for kinetic energy is the joule (J), honoring James Joule for his studies in mechanical and thermic energy equivalences:

$$1 \text{ Joule} = (1\text{kg}) \left(\frac{m}{s^2}\right)$$

If we want to know, for example, the potential energy of a 50 kg body which is positioned at 12 meters above the floor, we will have the following:

$$PE = (50 \text{ kg}) \left(9.81 \frac{m}{s^2}\right) (12 \text{ m}) = 5{,}886 \text{ J}$$

Kinetic energy depends on mass and velocity. It is equal to the constant $\frac{1}{2}$ multiplied by the mass multiplied by the square of the speed, as shown in the formula:

$$KE = \frac{1}{2} m \cdot v^2$$

In which:

KE = Kinetic Energy.

m = mass.

v = velocity of the body.

Notice that the body's velocity is squared. If we want to find out the kinetic energy of a car which has a mass of 1,200 kg and moves at $10 \frac{m}{s}$, we have the following:

$$KE = \frac{1}{2} (1{,}200 \text{ kg}) \left(10 \frac{m}{s}\right)^2 = 6{,}000 \text{ J}$$

➔ **Activity**

Answer the following problems individually. Then, work in teams and check your answers with your teammates. Share the results with the class.

1. A 0.6 kg bird flies at an altitude of 24 meters at a velocity of $14 \frac{m}{s}$. What is its **mechanical energy**?
2. A body thrown upwards vertically carries a **kinetic energy** of 2,000 J and its mass is 6 kg. How high does it go?

FIG. 2.18 How much energy do we spend when climbing 10 stories?

How can we find out the energy a person spends in climbing the stairs of a 10-story building?

Let's say the building is 30 m tall and the person's mass is 70 kg. The potential energy he gains is calculated as follows:

$$PE = (70 \text{ kg}) (30 \text{ m}) \left(9.81 \frac{m}{s^2}\right) = 20{,}601 \text{ J}$$

This is the minimum amount of energy the person spent climbing up the stairs of the building.

If a person is standing on the floor, he/she also possesses potential energy because most of his/her body is above floor level. In order to know the potential energy, the height must be considered at half its value, which gives us a good approximation.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting.

Critical thinking skills: Problem-solving.

EVALUATION OF CONTENT

Students should be able to do the activity on page 56 and get an accurate result.

Therefore, if we want to find out the potential energy of someone who is 1.56 m tall and has a mass of 60 kg, we must do the following operation:

$$PE = (60kg)\ (9.81\ \frac{m}{s^2})\ (0.78m) = 459.1\ J$$

➔ Team Work

- Obtain the potential energy of a building 40 m high, with a total mass of 45,000 ton.
- Discuss the procedure and the answer you obtained with your teammates and share your results with the class.

Curious Facts

Remember that to know the potential energy we need to use the following formula:

PE = m • g • h

Closing

How much did I learn?

Answer the following questions with your teammates. Share your answers with the class

1. Calculate the potential energy of an airplane flying 200 m high. Be specific about the type of plane to know its mass.
2. Calculate the kinetic energy of this same airplane when its velocity is 600 $\frac{Km}{h}$ while flying.
3. What is the mechanical energy in this case?

FIG. 2.19 What would the potential energy of an airplane be?

SESSION INFORMATION

Week: 14

Sessions: 83, 84

Expected learning outcome: Use algebraic expressions of potential and kinetic energy to describe movements in the surrounding environment and/or in experimental situations.

CONTENT DELIVERY

Start: Students should read the information on top of the page, and check the example. (Help them with more examples following the formula of Potential Energy (described at the bottom of page 55).

Development: Students should do the section *Team Work*. Help accordingly.

Closing: Students should do the experiment in the section *How much did I learn?* Using the information on the airplane they chose.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting.

Critical thinking skills: Problem-solving.

EVALUATION OF CONTENT

Students should actively participate in the experiment procedure.

SESSION INFORMATION

Week: 15

Sessions: 85 - 90

Expected learning outcome: State questions or hypothesis to solve a situation of interest related to movement, forces or energy.

Select and organize relevant information from research, to outline a project.

Design technical objects or conduct experiments that help to describe explain or predict physical phenomena related to movement, forces or energy.

Organize and share the information and results from the project with the group or community through media: oral presentations, written works, graphs or by using the Information and Communication Technologies (ICT).

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the parameters described in the rubrics.

Project: A Safe and Responsible Society in Motion

→ Expected Learning

State questions or hypothesis to solve a situation of interest related to movement, forces or energy.

Select and organize relevant information obtained from research, to outline a project.

Design technical objects or conduct experiments that allow the description, explanation or prediction of physical phenomena related to movement, forces or energy.

Organize and share the information and results obtained from the project with the group or community through various media: : oral presentations, written works, graphs or by using the Information and Communication Technologies (ICT).

→ Proposed problems to define the project:

1. How are movement and force related to the importance of using the seat belt when traveling by some means of transportation?
2. How do forces affect the construction of a hanging bridge? Are there any safety standards to meet when a bridge is being built?

We have learned a lot about movements, causes, consequences, applications and relationships with mechanical energy and we have seen how all this information is used in our daily life, especially in modern societies.

Remember that if you or your team have another question or problem you want to research and solve, you are free to do so. Do not lose your enthusiasm, since these are only proposals. Try to choose something you find useful for you and your community.

→ Developing the Project

With your team, answer the following questions.

1. Have we defined the main idea or problem of the project? Why is it relevant? What is it?

____
____
____
____
____

2. What is the plan to carry out? What resources do we need?

____
____
____
____
____

3. How and when will we carry it out? What impact are we expecting for this project to have?

____
____
____
____

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

4. How will you communicate the outcome of this project to the rest of the group? And to the school body? And to the community?

With the help of your teacher, go over the project in general. Start an outline for the project in order to make decisions about the information you need. Make sure the information you are using is correct and comes from reliable sources.

➔ Communicating the results of the project

With your team, propose several kinds of communication media to help you present the project to the class and school body, as well as to the community, if you find it necessary.

Take into account that Information and Communication Technologies (ICT) may help you in communicating the results of the project, although you may consider more traditional media, such as billboards, handouts, school newspapers or any other more educational media, such as lectures, workshops with the participation of the school community, among others.

Do not forget to share everything you have carried out in the project. It may be useful to have a preliminary outline in writing, which you can support with physical models at the moment of communicating results.

➔ Evaluating the Project

Once the project is finished and has been shared at school, meet with your team and reflect on what you did during this time to carry the project out. Consider the following questions:

1. Were the objectives of the project met? Why?
2. How did you evaluate results? Are they positive or negative? What grade would you give your project?
3. What obstacles did you face? How did you work them out? In case one of the obstacles was not overcome, why did it happen?
4. What could you have done better?
5. How was the participation of each team member in the project? Did all the members accomplish their responsibilities?

In your notebook, write down a personal thought about what you have learned regarding the topic while working on this project. Also include, your personal experiences while doing this project. Think about how you carried out the search for answers, faced obstacles and made decisions throughout the project.

SESSION INFORMATION

Week: 15

Sessions: 85 - 90

Expected learning outcome: State questions or hypothesis to solve a situation of interest related to movement, forces or energy.

Select and organize relevant information from research, to outline a project.

Design technical objects or conduct experiments that help to describe explain or predict physical phenomena related to movement, forces or energy.

Organize and share the information and results from the project with the group or community through media: oral presentations, written works, graphs or by using the Information and Communication Technologies (ICT).

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the parameters described in the rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

SESSION INFORMATION

Week: 16

Sessions: 91 - 96

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 60 and 61 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages 148 to 151 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

Evaluation

Look carefully at the pictures and answer the questions.

Picture 1

Picture 2

Picture 3

1. In picture 1, a parachutist jumps from an airplane. Point out why we say Newton's first law is in action.

- **a.** Because he was at rest and now he is in movement due to the effect of an external force.
- **b.** Because every action has a corresponding reaction of the same intensity and in opposite direction.
- **c.** Because when he jumped out of the airplane, his horizontal velocity was the same as the one on the airplane due to inertia.
- **d.** Because he is subjected to the force of gravity.

5. In picture 2, the following statements are true, except:
   a. When the parachute opens up, more friction is produced with air.
   b. With bigger resistance to air, the parachutist decelerates.
   c. When a final velocity is reached, it will be lower than the starting one.
   d. Acceleration is always 9.8 $\frac{m}{s}$ because it is the standard gravitational acceleration.

5. In picture 3, the parachutist reaches the ground. If Newton's third law states that when body A exerts a force on body B, body B exerts an equal force in the opposite direction on body A. This means that if Earth pulls the parachutists, they pull Earth with a force that is equal and opposite. Why can't we see this? Perhaps the law is not met?

   It is not visible because force cannot be seen, but its effects can be perceived and in this case, the effect is that the parachuter stays on the ground and feels the force in his feet as a hit.

6. What did you like the most in this unit?

SESSION INFORMATION

Week: 16

Sessions: 91 - 96

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 60 and 61 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages148 to 151 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

SESSION INFORMATION

Week: 16

Sessions: 91 - 96

SELF EVALUATION

Evaluation

Self-Evaluation

Evaluate your own way of working; check in the boxes what you are able to do with the themes in this unit.

SKILLS	YES	NO
I can apply physics to solve problems in my community, country and around the world.		
I can relate the knowldege of physics with the surrounding environment and with the ethical, economic, sociopolitical and cultural matters of my country and the world.		
I can use technical physics terms to communicate information.		
I use graphs, tables and models in my reports, homework and projects.		
I can search for information in the correct sources and organize it according to the report, project or assignment I'm working on, mentioning the sources of information.		
I establish mathematical models and solve problems related to physics.		
I analyze physics problems and can break up a whole in its parts, finding the relationship among the parts as well as identify cause and effect of the problem.		
Organize and analyze data, represent it in graphs and tables, evaluate the validity of ideas and the quality of work.		
Come to conclusions based on scientific reasoning.		
Make decisions related to my health and that of others, as I promote the culture of prevention.		
I am responsible and committed, work well with others and respect their point of view.		
I apply my knowledge and skills to solve problems in my community.		

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

SESSION INFORMATION

Week: 16

Sessions: 91 - 96

SELF EVALUATION

Peer Evaluation

Rubric

POINTS	VALUE	MEANING
10	Excellent	Perfect collaboration without mistakes.
8	Very good	Little, involuntary or justified mistakes.
6	Good	Has shown mistakes and lack of a helping attitude.
4	Barely accomplishes	Total lack of helping attitude, mistakes and excuses constantly present.
2	Not accomplished	Has not accomplished the task and shows irresponsibility.

Characteristics To Evaluate

	CHARACTERISTICS
A	Prepares his share of the work in a responsible way.
B	Makes his best effort at sharing his learning.
C	Handles conflicts constructively.
D	Shows trust, respect, acceptance, listens and support towards others.
E	Points out strengths and areas of opportunity during group processing.
F	Gives feedback to the group to improve on assignments and responsibilities.

Peer Evaluation

Write the name of each your teammates and check the box for each trait your partner has.

TEAM TO BE EVALUATED						
NAME OF STUDENT	A	B	C	D	E	F
	2-10	2-10	2-10	2-10	2-10	2-10
1						
2						
3						
4						
5						

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

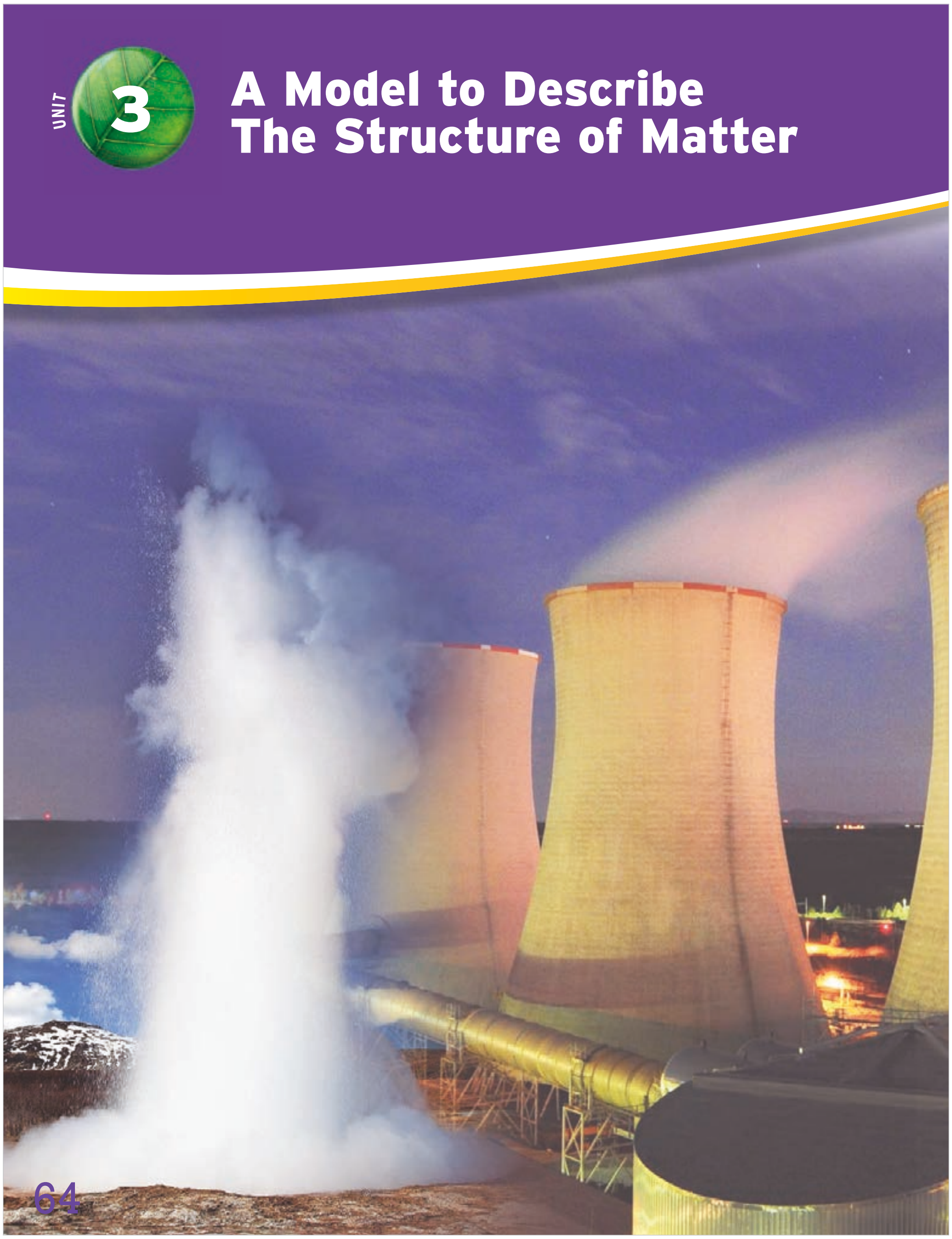
Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

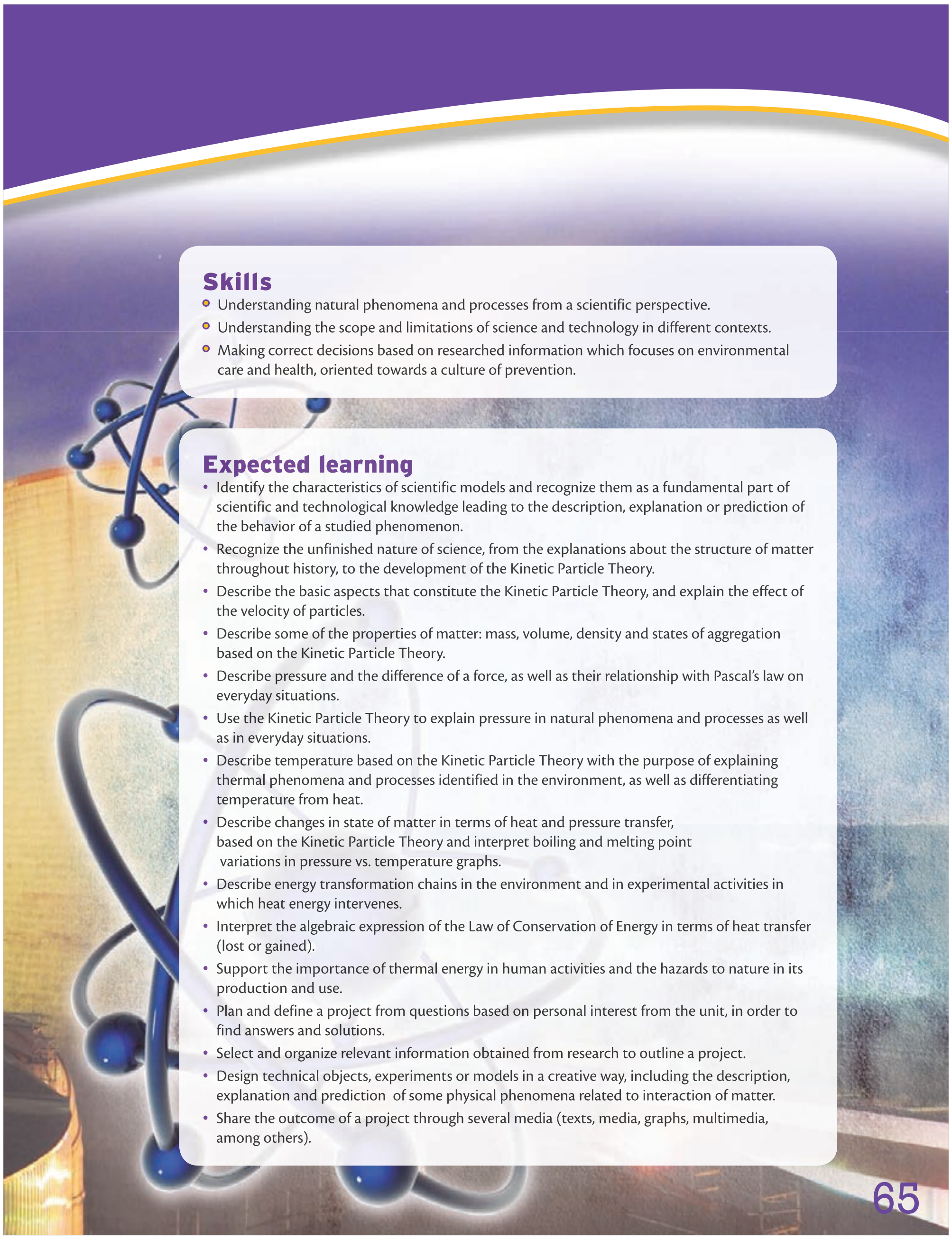
EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.


UNIT 3

A Model to Describe The Structure of Matter

64



Skills

- Understanding natural phenomena and processes from a scientific perspective.
- Understanding the scope and limitations of science and technology in different contexts.
- Making correct decisions based on researched information which focuses on environmental care and health, oriented towards a culture of prevention.

Expected learning

- Identify the characteristics of scientific models and recognize them as a fundamental part of scientific and technological knowledge leading to the description, explanation or prediction of the behavior of a studied phenomenon.
- Recognize the unfinished nature of science, from the explanations about the structure of matter throughout history, to the development of the Kinetic Particle Theory.
- Describe the basic aspects that constitute the Kinetic Particle Theory, and explain the effect of the velocity of particles.
- Describe some of the properties of matter: mass, volume, density and states of aggregation based on the Kinetic Particle Theory.
- Describe pressure and the difference of a force, as well as their relationship with Pascal's law on everyday situations.
- Use the Kinetic Particle Theory to explain pressure in natural phenomena and processes as well as in everyday situations.
- Describe temperature based on the Kinetic Particle Theory with the purpose of explaining thermal phenomena and processes identified in the environment, as well as differentiating temperature from heat.
- Describe changes in state of matter in terms of heat and pressure transfer, based on the Kinetic Particle Theory and interpret boiling and melting point variations in pressure vs. temperature graphs.
- Describe energy transformation chains in the environment and in experimental activities in which heat energy intervenes.
- Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (lost or gained).
- Support the importance of thermal energy in human activities and the hazards to nature in its production and use.
- Plan and define a project from questions based on personal interest from the unit, in order to find answers and solutions.
- Select and organize relevant information obtained from research to outline a project.
- Design technical objects, experiments or models in a creative way, including the description, explanation and prediction of some physical phenomena related to interaction of matter.
- Share the outcome of a project through several media (texts, media, graphs, multimedia, among others).

65

SKILLS DEVELOPMENT

Metacognitive skills: Planning, organizing studies content.

EVALUATION OF CONTENT

Students should get their study plan checked by the teacher.

SESSION INFORMATION

Week: 17

Session: 97

Expected learning outcome: Identify topics in the unit students consider will be hard to understand in order to make a studies plan.

CONTENT DELIVERY

Start: Have students and identify what they could do well in units 1 and 2, as well as what they should improve in unit 3. Ask them, for instance: What topics were easy? Did your previous study plan work? Didn't it work? Why? Did you really follow your study plan?

Development: Have students check the skills, learning outcomes and key concepts in unit 3. Ask them to identify the topics they consider the hardest ones. To plan how to study them and do better than the previous unit. If a strategy didn't work, then they should find another one. Help them with ideas.

Closing: Students should write down their study plan and have it checked.

Homework: Organize teams of four people to present with visuals one of the following models: Lattice model, graphs, representation of phenomena to scale, statistical models, and dynamical systems.

SESSION INFORMATION

Week: 17

Sessions: 98, 99

Expected learning outcome: Identify the characteristics of scientific models and recognize them as a fundamental part of scientific and technological knowledge leading to the description, explanation or prediction of behavior of a studied phenomenon.

CONTENT DELIVERY

Start: Students should present the models they found, briefly. Then, have them do the section *Exploring Knowledge*.

Development: Students should read the information on page 66.

Closing: Students should make a model about a previous topic they find interesting.

Homework: Organize four teams. Each team will be presenting one of the suggested videos on page 67. Students should prepare the video and a small questionnaire about it.

→ Expected Learning

Identify the characteristics of scientific models and recognize them as a fundamental part of scientific and technological knowledge leading to the description, explanation or prediction of the behavior of a studied phenomenon.

Models in Science

Characteristics and Relevance of Models in Science

Exploring Knowledge

1. Write the names of three models used in one of the following sciences: physics, chemistry, biology or math.
2. In teams, choose one of the models and explain if it represents something real or not and why.

In physics, we use **models** to understand physical phenomena, such as the solar system and submicroscopic objects that we cannot see, such as the atom.

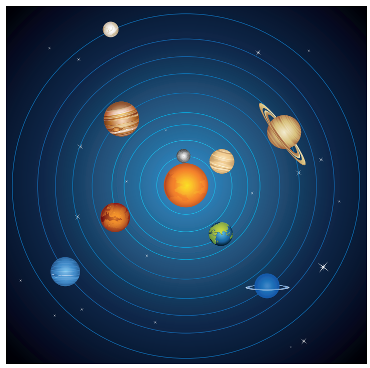


FIG. 3.1 Models of the Solar System

Models represent natural phenomena in a way that can be understood by everyone. In ancient times, it was believed the stars traveled in circles around the Earth such as in the Ptolemaic model (2nd century BC). This accurately described the position of the stars, but failed to describe the position of Mars, creating the need for a better model. Today, models of our solar system establish that planets travel in elliptical orbits around the sun.

Every scientific model requires experimental testing to determine if it is valid or not. The great achievement of many scientists has been the creation of the right model to explain how our world works.

Several research institutions have developed planetary models which need to be tested and proven to be useful; therefore, these models are sent as space probes to perform research on planets and their satellites.

Today, specialized institutes are testing models for a spaceship to be sent to Europa, one of Jupiter's largest moons. The probe's mission to drill into one of Europa's ice layers, which is 10 km thick, because according to models that have been built in the past, this new probe may find some kind of life.

Curious Facts

The first artificial satellite was Sputnik 1, which was sent to space in 1957 by the Soviet Union. This satellite started the spatial era and at the same time, had the two most powerful countries in those days – The United States and the Soviet Union, join efforts to send the first human being into space; this person was Yuri Gagarin, a Russian cosmonaut who went on a space mission on April 12th, 1961.

FIG. 3.2 Sputnik 1.

SKILLS DEVELOPMENT

Critical thinking skills: Summarizing.

Visual/Spatial skills: Graphing, building models.

EVALUATION OF CONTENT

Students should be able to make a model about the topic they find interesting.

To Learn More

On the Jet Propulsion Laboratory website, http://www.jpl.nasa.gov/index.php, you will find more detailed information about the two vehicles that are currently present on the surface of Mars, and about future projects for space exploration.

Several ancient civilizations studied the position of the celestial bodies, then based on their descriptions they built constructions that reflect seasonal behaviors; an example of these buildings is the temple of Kukulcan in Chichen Itza.

FIG. 3.4 Kukulcan Pyramid in Chichen Itza.

Curious Facts

Watch the documentary Aliens of the Deep (2005), by the Canadian director James Cameron, in which he explores the deep end of the ocean and recreates the launch, arrival and drilling of Europa, Jupiter's moon, to test if the theory about life on other planets is true.

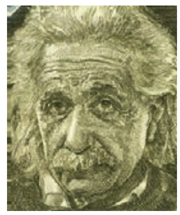


FIG. 3.3 Albert Einstein made elaborate models, since it was impossible for him to conduct many of his experiments.

ICT

Visit http://www.youtube.com/watch?v=RSyZHzyaDsg to see a series of photos that show the famous effect of Kukulcan's shadow going down the pyramid.

Closing

How much did I learn?

You have learned about models in science and the role they play in the description of phenomena. Answer the following questions. Discuss the answers with your classmates to reach a consensus.

- What are models and what are they used for?
- Which model could you use to describe the Solar System?
- Do you think all phenomena can be understood by using a model?

Curious Facts

If you want to know more about the pyramid of Kukulcan, please visit this website:

http://www.exploratorium.edu/ancientobs/chichen/HTML/castillo.html

SESSION INFORMATION

Week: 17

Sessions: 100 - 102

Expected learning outcome: Identify the characteristics of scientific models and recognize them as a fundamental part of scientific and technological knowledge leading to the description, explanation or prediction of behavior of a studied phenomenon.

CONTENT DELIVERY

Start: Students will be presenting the video they previously watched. Then, they should ask the group 5 to 7 questions about it. (They should have the answers ready).

Development: Help them discuss the content of the video and how models are used in each case.

Closing: Students should discuss the questions in the section *How much did I learn?*

Project preparation: Divide the group into seven teams. The following four lessons, students will be presenting the information on pages 68 and 69. The complete instructions are explained on page 69, in the section *How much did I learn?* Just make sure one of them will dress up like the author whose theory or contribution will be explained.

SKILLS DEVELOPMENT

Interpersonal skills: Working as a team member.

Verbal/Linguistic skills: Discussing.

Critical thinking skills: Analyzing relations.

EVALUATION OF CONTENT

Students should be able to recognize characteristics of scientific models.

SESSION INFORMATION

Week: 18

Sessions: 103, 104

Expected learning outcome: Recognize the unfinished nature of science, from the explanations about the structure of matter throughout history, to the development of the Kinetic Particle Theory.

CONTENT DELIVERY

Start: Introduce students' presentations by saying that science is a never-ending process and that it has had actors along human history. Explain that you will be examining some of them.

Development: Each team will be presenting one of the theories or contributions explained in the section *How much did I learn?* On page 69. The rest of the group should mind map what classmates present.

Closing: Check students' mind maps about the theories and contributions that were presented.

→ Expected Learning

Recognize the unfinished nature of science, from the explanations about the structure of matter throughout history, to the development of the Kinetic Particle Theory.

Ideas in History about The Continuous and Discontinuous Nature of Matter: Democritus, Aristotle and Newton; Contributions Made by Clausius, Maxwell and Boltzmann

Exploring Knowledge

In this activity you will analyze the characteristics of matter around you. Answer the following questions in your notebook.

1. Do you think that the particles in water are different from those in ice?
2. How do you picture the layout of particles in a solid, a liquid and a gas?

Curious Facts

Aristotle was a philosopher in Ancient Greece whose ideas had a great influence over the intellectual history in the Western world for over twenty centuries. His model resembling the Universe was sustained until the 16th century and it stated that the Earth was the center of the universe and all celestial bodies orbited around it.

Democritus of Abdera (460–370 BCE) was a Greek philosopher who thought the Universe could be explained through the description of **matter**. He advocated a school of thought called Atomism, which assumed that matter was formed by small indivisible particles called a**toms** (which in Greek means indivisible or indestructible).

Aristotle believed there were four elements: earth, air, water and fire, and that the gods had used a combination of those to form matter. Among Greek contemporaries, it was believed that there was a fifth element called **ether**, that was associated with stars, and this idea prevailed until the end of the 19th century.

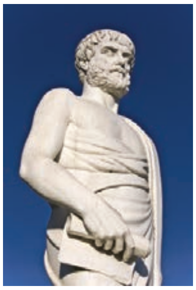


FIG. 3.5 Aristotle.

FIG. 3.6 René Descartes, French physicists and philosopher.

Several scientists accepted the Particle Model, even though there was controversy about what light was composed of. Isaac Newton (1642–1727) carried out experiments with **prisms** and noticed that **white light** would decompose into the colors of the rainbow, so he explained this phenomenon stating that white light was a mix of different **corpuscles**.

FIG. 3.7 Newton in his lab watching white light decomposing through a prism.

Glossary

Ether. Light, invisible, imponderable and elastic fluid that according to an obsolete hypothesis fills the whole space and its vibrating movement, transfers light, heat and other energy forms.

Prism. Triangular crystal object used to produce reflection, refraction and decomposition of white light.

Corpuscle. A very small body, cell, molecule, particle or element.

SKILLS DEVELOPMENT

Bodily/Kinesthetic skills: Acting.

Critical thinking skills: Mind mapping information.

EVALUATION OF CONTENT

Students should get their mind map checked by the teacher.

Ludwig Boltzmann, James Clerk Maxwell and Rudolf Clausius were advocates of atomism, and contributed to the understanding of matter during the 19th century.

FIG. 3.8 Ludwig Eduard Boltzmann.

Austrian physicist Ludwig Eduard Boltzmann (1844–1906) was the creator of statistical **mechanics**, which helped understand and predict properties of atoms like mass, electric charge and structure. He also defined some of the visible properties of matter: viscosity, thermal conductivity and diffusion.

FIG. 3.9 James Clerk Maxwell.

Scottish physicist and mathematician James Clerk Maxwell's work on **electromagnetism** and electromagnetic radiation led him to discover the interaction between electricity and matter.

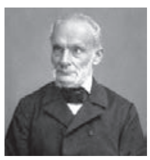


FIG. 3.10 Rudolf Clausius.

Almost simultaneously, German physicist Rudolf Clausius (1822–1888) formulated what is known today as the 2nd law of thermodynamics, which establishes that "heat never flows from a cold body to a hot one". For a machine to transfer heat from a cold to a hot body, external mechanic energy is necessary.

Curious Facts

Isaac Newton's mother, Hanna Ayscough, believed her son was anything but intelligent. The Newton family lived on a farm in the city of Woolsthorpe and when Isaac took the sheep out he would sit under a tree to think about math and astronomy without minding the flock. On more than one occasion, a neighbor would charge Hanna for the damages the sheep would cause to their garden. When in college, Isaac Barrow – a professor who recognized Newton's talent – visited Hanna and let her know about her son's skills, but she reacted saying her son was unintelligent and lazy. Who would have thought she raised one of the greatest geniuses of all time?

Closing

How much did I learn?

In teams of five, research one of the following topics and present it to your class. Your teacher will assign a topic to each team.

1. The contributions of Leucippus and Democritus to the understanding of matter.
2. Aristotle and his conception of the world.
3. Boyle's experiments.
4. Newton, his life and his contributions to the understanding of matter.
5. What is statistical mechanics and what was Boltzmann's work?
6. Maxwell and the relevance of his work to the study of electromagnetic theory.
7. The laws of thermodynamics and the contribution of Clausius's ideas.

Curious Facts

Maxwell was one of the greatest physicists and mathematicians of the 19th century. His work covered mainly electromagnetism and found that the work of his predecessors could be summarized in four major equations that describe every known electromagnetic phenomenon. Without his work, most of the technology we have today would not exist.

SESSION INFORMATION

Week: 18

Sessions: 105 - 107

Expected learning outcome: Recognize the unfinished nature of science, from the explanations about the structure of matter throughout history, to the development of the Kinetic Particle Theory.

CONTENT DELIVERY

Start: Introduce students' presentations by saying that science is a never-ending process and that it has had actors along human history. Explain that you will be examining some of them.

Development: Each team will be presenting one of the theories or contributions explained in the section *How much did I learn?* On page 69. The rest of the group should mind map what classmates present.

Closing: Check students' mind maps about the theories and contributions that were presented.

SKILLS DEVELOPMENT

Bodily/Kinesthetic skills: Acting.

Critical thinking skills: Mind mapping information.

EVALUATION OF CONTENT

Students should get their mind map checked by the teacher.

Kells

SESSION INFORMATION

Week: 18

Session: 108

Expected learning outcome: Describe the basic aspects that constitute the Kinetic Particle Theory and explain the effect of velocity of particles.

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring Knowledge* in their notebooks. Elicit answers.

Development: Students should read the information. Help accordingly with terms so that students clearly understand the behavior of gasses. Show them the models below.

Closing: Students should discuss the states of aggregation of matter stated in the instructions in the section *How much did I learn?*.

Expected Learning

Describe the basic aspects that constitute the Kinetic Particle Theory, and explain the effect of the velocity of particles.

KEY CONCEPT

Particle, mass, model, microscope.

FIG. 3.11 With this small device, scientists could observe a world which at simple sight, was invisible.

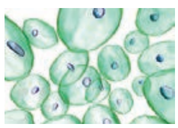


FIG. 3.12 Cells under a microscope.

Curious Facts

In 1590, Hans Janssen, his son Zacharias and Hans Lippershey, invented the **microscope**, which allowed scientists to analyze the small things in the world. Englishman Robert Hooke, for instance, was able to observe insects thoroughly, and coined the term *cell* that is used in biology. However, even though the microscope opens up a whole new world towards the small, it does not reveal the nature of matter.

Basic Aspects of the Kinetic Particle Theory. Indivisible Microscopic Particles with Mass, Movement, Interactions and Space between Them

Exploring Knowledge

In your notebook, answer the following questions individually. Share your answers with the class.

1. How do you think matter is formed?
2. What do you think matter is made of?
3. Do you think any important discoveries have helped to better understand how and what matter is made of?

Experiences around the Structure of Matter

For centuries, scientists tried to understand what matter was composed of and establish why some objects were different from others. Scientist needed to build **models**, in order to describe the behavior of matter at a microscopic scale.

Throughout history, there were many ideas about the structure of matter, and the conception of the atom. But, the many experiments with gases and contributions of Boltzmann and Maxwell led to the development of the Kinetic Particle Theory. It establishes the following about the behavior of gases:

1. There is a large number of molecules.
2. Every molecule is identical.
3. The distance between molecules is large in comparison to their size.
4. Molecules have a constant average velocity.
5. The collision between molecules doesn't represent energy loss.

Today, we know that matter can be found in solid, liquid and gas states and that as temperatures rise, the movement of the particles that compose matter increases.

Closing

How much did I learn?

Work in teams of five. Research the Kinetic Particle Theory and discuss what the assumptions made about the behavior of particles stand for.

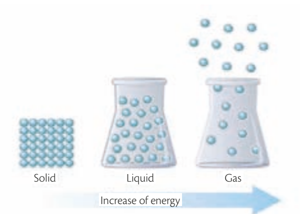


FIG. 3.13 States of aggregation of matter in the model of particles.

SKILLS DEVELOPMENT

Intrapersonal skills: Developing points of view.

Critical thinking skills: Analyzing, imagining.

EVALUATION OF CONTENT

Students should describe basic aspects of the Kinetic Particle Theory.

The Structure of Matter according to the Kinetic Particle Theory

Properties of Matter: Mass, Volume, Density and States of Aggregation

Matter has five states (solid, liquid, gas, plasma and Bose-Einstein condensate), although it is common to talk about the first three.

Exploring Knowledge

Read the next questions and answer them individually in your notebook.

1. Why do you think different states of matter exist?
2. Do you think there are changes in particles when materials change from one state to another?
3. Draw models that represent the different states of matter.

All matter, regardless of its state, has common properties and sometimes it is difficult to distinguish one substance from another. For example, extensive properties depend on the amount of matter available: **mass**, volume and weight. Mass is the amount of matter in a body, volume is the place the body occupies in space and weight is the mass multiplied by the gravity. In the International System of Units, these properties are measured in cubic meters (m^3), kilograms (kg) and newtons (N), respectively..

On the other hand, matter has intensive properties which do not depend on the mass or size of objects. These properties are: porosity, elasticity, impenetrability and compressibility. Porosity depends on the number of holes present in matter (sponges are said to be porous, for instance); elasticity is the ability of matter to keep its shape after the application of force; impenetrability is the inability of two portions of matter to occupy the same space at the same time. **Compressibility** measures how much the volume of a body can be reduced when it is subject to pressure (this property is also attributable to fluids).

Density is another property found in matter, which is defined as the quantity of matter contained per unit of volume, or in mathematical terms:

In which, the Greek letter ρ (rho) represents density, m is the object's mass and V is the object's volume.

$$\rho = \frac{m}{V}$$

In the International System of Units, density, as the result of this equation, is expressed in $\frac{kg}{m^3}$

FIG. 3.14 These meteorites were found in the desert and their origin was determined through their high density.

→ Expected Learning

Describe some of the properties of matter: mass, volume, density and states of aggregation based on the Kinetic Particle Theory.

Curious Facts

Satyendra Nath Bose (1894 – 1974) was a Hindi physicist who specialized in mathematical physics. He is very well known for his work in quantum mechanics in the 1920s, in which he laid the foundation for Bose-Einstein statistics and, of course, the theory of the Bose-Einstein condensate. Despite being very famous in India, he was not well-known in the West. When he finished developing the theory on the condensate, he sent it to Einstein for revision; Einstein was pleasantly surprised and proposed publishing it. This was the first of many articles that would give Bose respect and admiration around the world.

Glossary

Compressibility. The change in volume due to the stress applied to a body.

Kells

SESSION INFORMATION

Week: 19

Sessions: 109, 110

Expected learning outcome: Describe some of the properties of matter: mass, volume, density and states of aggregation based on the Kinetic Particle Theory.

CONTENT DELIVERY

Start: Students should read the introduction and individually answer the questions in the section *Exploring Knowledge*. Elicit answers in whole class.

Development: Students will read the information on the page. Guide them to understand the density equation. Show them at least 10 examples.

Closing: Students should solve problems in which they use the density equation: p = m/v.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Discovering relations.

EVALUATION OF CONTENT

Students should successfully solve problems regarding the density equation.

SESSION INFORMATION

Week: 19

Session: 111

Expected learning outcome: Describe some of the properties of matter: mass, volume, density and states of aggregation based on the Kinetic Particle Theory.

CONTENT DELIVERY

Start: Have students tell the density equation.

Development: Students should look at the chart showing the density of different substances. Show them different images that show either extensive or intensive properties. They should tell them apart easily.

Closing: Students should work in teams to answer the questions in the section *How much did I learn?*

Curious Facts

Fluids receive that name because they can flow, that is to say, they can be transported from one point to another through pipes, although each fluid has different properties.

This chart shows the density of some common substances:

Substance	Density $\frac{Kg}{m^3}$	Substance	Density $\frac{Kg}{m^3}$
Ice	0.917×10^3	Water	1.00×10^3
Aluminum	2.70×10^3	Glycerin	1.26×10^3
Iron	7.86×10^3	Ethyl alcohol	0.806×10^3
Copper	8.92×10^3	Benzene	0.879×10^3
Silver	10.5×10^3	Mercury	13.6×10^3
Lead	11.3×10^3	Air	1.09
Gold	19.3×10^3	Oxygen	1.43
Platinum	21.4×10^3	Hydrogen	0.089
Concrete	2×10^3	Helium	0.17

All the values are given at room temperature and at normal atmospheric pressure, except gases at 0 degrees Celsius (° C) and water at 4° C.

Curious Facts

Density is a very important property since it allows scientists to determine the origin of objects, as in the case of the meteorites in the *Palacio de Minería* in Mexico City.

Closing

How much did I learn?

Work in teams of five to answer the questions. Share your answers with the class.

1. What kind of property is density, extensive or intensive? Explain your answer.
2. Make a list of five different materials or substances around you and write three extensive and three intensive properties for each one.

Now, follow the next instructions and do the activities as a group.

1. Classify the materials of every team according to common extensive properties.
2. From the classification you made, choose the longest list of objects and differentiate each material in the list according to their intensive properties.

Expected Learning

Describe pressure and force, as well as their relationship with Pascal's law in everyday situations.

Use the Kinetic Particle Theory to explain pressure in natural phenomena and processes as well as in everyday situations.

Pressure, Its Relationship with Force and Area. Pressure in Fluids. Pascal's Law

Exploring Knowledge

Establish the relationship between **area**, **force** and **pressure**.

Answer the following questions in your notebook.

1. If a woman has a mass of 55 kg and is standing barefoot on the ground, what is the force she is exerting over it?
2. Will the force over the ground change if she wears high heel shoes? Why?
3. Why do you think it is forbidden to wear high heel shoes in some places?

The Particle Model and Pressure

Pressure is the force that an object exerts over a certain area, in mathematical terms: $P = \frac{F}{A}$

In which:

P= represents pressure. A= area.

F= force. If F is measured in N and A in cm^2, pressure is measured in Pascals (Pa).

SKILLS DEVELOPMENT

Critical thinking skills: Observing, remembering, problem-solving.

Logical/Mathematical skills: Experimenting.

EVALUATION OF CONTENT

Students should be able to describe some of the properties of matter.

Force and pressure are **directly proportional**, while pressure and area are **inversely proportional**. This is why more pressure is exerted on the floor if we are standing on our heels or toes than if we are standing on our soles.

FIG. 3.15 The floor in the observation deck at the CN Tower in Toronto has been designed to support a lot of weight but only if you wear flat shoes.

Curious Facts

The CN Tower in Toronto, Canada has an observation deck from where you can see the entire city. One of its main attractions is the "glass floor", which has a 342 meter view straight down! It is strictly forbidden to walk on this area wearing high heeled shoes. What do you think might happen if someone broke that rule?

Reflect, Explain and Share

In India, fakirs perform a fearless act – or at least, this what those who do not understand physics think. Fakirs lie on a bed of nails with no problems or injuries. How can they possibly lie on nails without getting hurt? Is is true that fakirs have magical powers?

What really happens is that, by exerting a force that equals the weight of the fakir over a large area (even if the area is covered in nails), the force spreads evenly on each nail and so none of those nails will hurt the fakir. On the contrary, if the bed had only one nail and the fakir laid on it, all his weight (that is, the force) would be exerted on a small area and the nail would hurt him. So, fakirs do not have any magical powers, they just know physics!

Curious Facts

The units in which pressure is measured are Pascals (Pa), named after Blaise Pascal (1623 – 1662), a French physicist, mathematician and philosopher who conducted extensive studies about pressure on matter and its states.

Pressure and force: two different concepts.

Through the equation for pressure, we can see that force and pressure are two different concepts. Force is what makes bodies change their state of rest or motion, while pressure is the quantity of force exerted over a given area.

Pressure in liquids and gases.

In thermodynamics, we refer to liquids and gases as **fluids**, since they have the ability to flow, while solids do not. Since matter is made up of particles, pressure exerted by liquids over the walls of a container that holds them can be very great. For example, if we pour water into a glass until it's half full, there are a number of particles that exert a force over the walls and bottom of the glass. Whereas, if we fill the glass to the top, the pressure exerted will increase considerably, since now there are twice the amount of particles exerting twice as much force over the same area.

With gases, something similar occurs. If we fill a container with a gas, for example, oxygen, we know it will spread evenly and the particles will exert pressure over its walls; however, if we continue to add oxygen, the number of particles will increase and so will the exerted force – therefore, the pressure will also increase.

FIG. 3.16 Fakirs amaze people for their bravery, but anybody could lie on a bed of nails without getting hurt.

FIG. 3.17 A mini-submarine is prepared to withstand great pressure.

SESSION INFORMATION

Week: 19

Sessions: 112, 113

Expected learning outcome: Describe pressure and force, as well as their relationship with Pascal's law in everyday situations.

Use the Kinetic Particle Theory to explain pressure in natural phenomena and processes as well as in every day situations.

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring Knowledge* on page 72. Elicit answers.

Development: Then, students should read about the Pascal Model and pressure along with the rest of page 73 (including the curious facts). Ask comprehension-check questions. Students should be able to understand the Particle model, pressure and force.

Closing: Students should say at least two similar examples to the fakir's nail beds and the glass floor without high heels.

Project preparation: In teams, students should take to the next class the materials for the experiments explained on page 74 sections *Experiment and How much did I learn?*

SKILLS DEVELOPMENT

Critical thinking skills: Comparing, analyzing, and imagining.

EVALUATION OF CONTENT

Students should be able to name two examples about pressure in natural phenomena.

SESSION INFORMATION

Week: 19

Session: 114

Expected learning outcome: Describe pressure and force, as well as their relationship with Pascal's law in everyday situations.

Use the Kinetic Particle Theory to explain pressure in natural phenomena and processes as well as in every day situations.

CONTENT DELIVERY

Start: Check that each team has all the materials they need for the experiment.

Development: Students should do the experiment. Help them in the process. Then, they should read the rest of page 74. Help as necessary.

Closing: Then, in teams again, they should answer the questions in the section *How much did I learn?* After doing the other two experiments, described in the same chart.

Curious Facts

In 1985, the mini-submarine Alvin was used to observe the ruins of the Titanic at about four thousand meters below sea level. Alvin withstood the enormous pressure of the water thanks to its titanium walls, which are 2.9 inches thick.

Experiment

PURPOSE

Appreciate what the pressure of gas on a container can generate.

MATERIAL

- A clean can of soda.
- 20 mL of water.
- Pliers to hold the can.
- A bowl, full of cold or room-temperature water.
- A heat source (a stove, a Bunsen burner or an electric burner).

PROCEDURE

1. Pour the 20 mL of water in the can and set it on the fire, with the opening facing up. Be careful not to get burned, since you must wait until the water begins evaporating.
2. Place the bowl near the can.
3. Very carefully, take the can with the pliers and place it upside down in the bowl in one quick movement.
4. What happens? How can you explain the phenomenon? Write your conclusions in your notebook.

FIG. 3.18 Hydraulic press or Pascal press.

Pascal's Law

As we mentioned before, Blaise Pascal conducted extensive studies on how the pressure of a fluid acts upon the container that holds it. He noticed that the fluid does not only exert pressure over the walls of the container, but also over itself. Therefore, any change in pressure would also be manifested throughout the fluid.

One of the most common applications of Pascal's law is what is called the hydraulic press or simply, Pascal press. It consists of two pistons of different size joined by a hose or pipe in a u-shape.

The equation for the Pascal press is quite simple. It involves the area of both pistons, as well as the force exerted in each one of them.

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

In which:

F_1 = force over the small piston F_2 = force over the large piston
A_1 = area of the small piston A_2 = area of the large piston

We must remember that for the measurement units to be correct, areas must be expressed in square meters (m^2) and forces in Newtons (N).

Curious Facts

One of the most common uses of the hydraulic press is in car shops, where it is necessary to lift cars in order to clean the engine, change oil and so on. The great advantage is that with a smaller effort on the small piston, we obtain a large force over the large piston.

»» Closing

How much did I learn?

In teams of five, do the following:

1. Get a brush with metal bristles and a balloon. Inflate the balloon and press it against the brush. Explain what happens in terms of pressure.
2. Find out why some people get earaches when they swim or travel by plane.
3. Using two syringes (without needles), a regular one and a turkey syringe, joined by a flexible hose, build an artifact that simulates a Pascal press. Using water as the fluid of the press, verify that Pascal's law takes place.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Discovering relations, experimenting.

EVALUATION OF CONTENT

Students should be able to describe the relation Pascal's law and pressure.

SESSION INFORMATION

Week: 20

Session: 115

Expected learning outcome: Describe temperature based on the Kinetic Particle Theory with the purpose of explaining thermal phenomena and processes identified in the environment, as well as differentiating temperature from heat.

Temperature and Scales of Measurement

Exploring Knowledge

Reflect and answer.

1. When you get sick, and have a sore throat or a stomachache, you get a little fever. How can you be sure that you have a fever, that is, that your body is over 36°C?
2. Can your hands work as **thermometers**? How?
3. The sensation of extreme heat or cold is very similar: in both cases we suffer from burns. Why do you think this happens?

Expected Learning

Describe temperature based on the Kinetic Particle Theory with the purpose of explaining thermal phenomena and processes identified in the environment, as well as differentiating temperature from heat.

What Happens to Solids, Liquids and Gases When Their Temperature and The Pressure Exerted on Them Changes?

We know that if an ice cube is warmed up, it turns into water and if we continue heating it up, it turns to vapor until it has evaporates completely. What are we doing to the ice to turn it to water?

If we apply energy in the form of heat, particles absorb it and vibrate more, which will cause the **temperature** to rise, the more they vibrate the more space they use separating among them. Moving on to the next stage: liquid. If we continue to add heat, particles will continue to absorb that energy and will vibrate occupying greater spaces in its movement. Then matter goes to the next state: gas.

Then, if we want to change the state of matter from solid to liquid, we must add heat (increase temperature) and the same goes if we want to go from solid state to gas state. The reverse process implies removing heat, or decreasing temperature.

Changes of state can be generated not only by increasing or decreasing temperature, but also by changing the pressure that we exert over the particles of matter.

Glossary

Calibrate. To adjust, with the greatest possible precision, the indications of an instrument of measurement with the standards of the magnitude it measures.

Thermometers and Their Scales

Thermometers measure the temperature using materials that change their volume when they are heated or cooled. In an alcohol or mercury thermometer, the liquid expands when it is warmed up and contracts when it is cooled, making the length of the liquid column greater or smaller depending on the temperature they read. Modern thermometers are **calibrated** in standard temperature units: Celsius, Fahrenheit and Kelvin.

The first scale was established by Anders Celsius (1701–1744), a Swedish astronomer that situated the freezing point of water at 0° C and its boiling point at 100 °C. The term "centigrade" refers to the fact that between the melting point and the boiling point there is a division of 100 equal parts.

The Fahrenheit scale was created by the German physicist Daniel Gabriel Fahrenheit (1686–1736). He stablished that temperature at which a mix of sodium and salt, water and ice stabilize would be cero in his scale, while human body temperature would be 100 degrees (though later this was adjusted to 98.6 degrees).

William Thomson, better known as Lord Kelvin (1824–1907), invented the absolute or Kelvin scale based on the idea of absolute temperature described in the 2nd law of thermodynamics , and established the **Dynamical Theory of Heat**.

In the 19th century, scientists tried to find which was the lowest possible temperature. The Kelvin scale uses the same units as the Celsius scale, but begins at an absolute zero that is, the temperature at which everything, stops vibrating. Absolute zero begins at -273.15 degrees Celsius.

FIG. 3.19 Galileo's **thermometer**, which is in fact a **thermoscope**,"measures" the temperature in the environment.

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring Knowledge*. Elicit answers.

Development: Students should read page 75. Segment the information, ask them comprehension-check questions and illustrate with examples.

Closing: Students should be able to describe temperature in terms of the Kinetic Particle Theory.

SKILLS DEVELOPMENT

Reading skills: Reading for detail, scanning.

EVALUATION OF CONTENT

Students should describe temperature in terms of the Kinetic Particle Theory.

SESSION INFORMATION

Week: 20

Sessions: 116, 117

Expected learning outcome: Describe temperature based on the Kinetic Particle Theory with the purpose of explaining thermal phenomena and processes identified in the environment, as well as differentiating temperature from heat.

CONTENT DELIVERY

Start: Students should read the formulas. Show them as many examples they need as necessary in order to have them understand the formulas. First, in the basic form, once they can follow you easily, modify the formula to get another value.

Development: Have students solve problems; as many as they need to clearly use the formulas.

Closing: Have students answer the section *How much did I learn?*

Curious Facts

Before thermometers existed, there was an instrument called thermoscope, which was like a thermometer, but without a scale. In 1593, Galileo Galilei invented a quite rudimentary water thermoscope, which allowed analyzing the variations of temperature in the environment. In 1612, Italian inventor Santorio Santorio was the first to include a numerical scale on the thermoscope. It can be considered as the first clinical thermometer since it was designed to be put inside the patient's mouth to measure the body temperature. In 1654, the Grand Duke of Tuscany, Ferdinand II, invented the first thermometer with a liquid in a sealed glass. The Duke used alcohol because it is very sensitive to changes in temperature; however, it was still inexact and did not use any scale.

To convert **measurements** from one scale to another, we can use the following equations or the corresponding variable isolation where °C, °F and K refer to degrees Celsius, Fahrenheit and Kelvin.

From Fahrenheit to Celsius use the following equation: $^{\circ}C = \frac{5}{9}(^{\circ}F - 32)$

From Celsius to Fahrenheit use the following equation: $^{\circ}F = \frac{9}{5}(C + 32)$

From Celsius to Kelvin, we simply add: $K = {^{\circ}C} + 273.15$

From Kelvin to Celsius, we subtract: $^{\circ}C = K - 273.15$

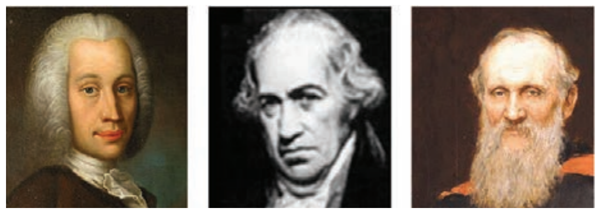


FIG. 3.20 Thanks to the work of Celsius, Fahrenheit and Lord Kelvin. Today, we have very accurate thermometers for a variety of uses.

Closing

How much did I learn?

In teams of five people, do the following:

1. Do some research on how a mercury thermometer works.
2. Write the six mathematical expressions that help convert measurements from degrees Celsius to Fahrenheit and Kelvin.
3. Explain temperature in terms of the Kinetic Particle Theory.

Expected Learning

Describe temperature from the kinetic particle theory with the purpose of explaining thermal phenomena and processes identified in the environment, as well as differentiating temperature from heat.

Heat, Heat Transfer and Thermal Processes: Dilation and Ways of Propagation

Exploring Knowledge

Answer the questions in your notebook.

1. If you are outside on a sunny day, with your eyes closed, how do you know in which direction the Sun is?
2. Does your body feel the same when you're very hot as when you have a fever? Describe what you feel in each situation.
3. Is it necessary for food to be directly over a flame to be cooked?
4. Why are most pots and pans in the kitchen made of metal?

SKILLS DEVELOPMENT

Critical thinking skills: Problem solving.

EVALUATION OF CONTENT

Students should be able to use temperature to describe thermal phenomena.

Heat and Temperature, Are They The Same?

Everyday language makes us confuse terms that represent different physical measurements, even though they are related. This is the case with **heat** and temperature.

Heat is energy transferred from one body to another with different temperature, while temperature is a measurement of the average **kinetic energy** of particles. When we say, "it's very hot" we must understand that the Sun is emitting heat that is absorbed by the air and the particles in it start vibrating faster. This causes the temperature to rise. It is not that it "is" hotter; rather, it is a greater amount of energy in the form of heat that has been absorbed by the air around us.

FIG. 3.21 Heat and temperature represent different but closely related measurements.

Reflect, Explain and Share

When we have a fever, the thermometer registers that the particles in our body are vibrating with greater speed. Fever is a natural reaction of the body when it detects strange agents inside it and, therefore, increases its temperature to kill them.

Curious Facts

The lowest recorded temperature in a laboratory was produced for the first time in 1995. Two scientists, Eric Cornell and Carl Wieman managed to cool atoms at their lowest level of energy, which corresponded to 1.9°K or -271.1°C.

Explanation of Temperature and Heat in Terms of The Kinetic Model

When most scientists accepted the kinetic particle model, many of them began searching for answers to questions like "What is temperature?". Chemists and physicists began to understand that temperature is a measurement of the kinetic energy in the particles that form matter.

Kinetic energy is the energy that objects have in terms of their movement, and particles are in constant **vibratory movement**. For many years, it was believed that heat was a substance that flowed from a warm body to a cool one and very strange properties were attributed to it, but scientists weren't completely satisfied.

A known fact is that if two bodies, a cool one and a warm one, are in contact with each other, as time passes one will cool down, the other one will warm up and the temperature in both will be the same. This is known as the Zeroth law of thermodynamics.

If temperature is a measurement of the kinetic energy of vibration of molecules in a body, then the greater the vibration motion is, the greater its temperature will be. So, when a body starts to cool down, it starts losing energy, that is, losing heat.

Dilation or Thermal Expansion

We know that when the temperature of matter is increases, it suffers **dilation** or increase in dimensions. Linear dilation of an object, that is, the increase or decrease of its length, no matter what material it is made of, can be expressed with the following formula:

$$\Delta L = \square L_0 \Delta t$$

In which:

ΔL = change in length.
$\square$ = dilation (expansion) quotient.
L_0 = is the initial length.
Δt = change in temperature.

SESSION INFORMATION

Week: 20

Session: 118

Expected learning outcome: Describe temperature from the Kinetic Particle Theory with the purpose of explaining thermal phenomena and processes identified in the environment as well as differentiating temperature from heat.

CONTENT DELIVERY

Start: In teams of four people, students should answer the questions in the section *Exploring knowledge*, on page 76. Elicit answers and guide a small discussion.

Development: Students should read the information on page 77. Segment the information, and ask them comprehension-check questions. Explain one by one with examples so students can see how the formula is applied in real life.

Closing: Students should see the formula of thermal expansion. Explain it and show them examples of how to use it.

SKILLS DEVELOPMENT

Reading skills: Reading for detail, scanning.

EVALUATION OF CONTENT

Students should be able to do problems regarding temperature.

SESSION INFORMATION

Week: 20

Session: 119

Expected learning outcome: Describe the changes of the state of matter in terms of heat and pressure transfer based on the Kinetic Particle Theory and interpret boiling and melting point variations in pressure vs. temperature graphs.

CONTENT DELIVERY

Start: Students should see the table with the dilatation quotient of some materials. Help them get the result with the dilatation expansion formula. Guide them little by little with two examples; later have them do the rest.

Development: In teams, students should answer the questions in the section *How much did I learn?* Elicit answers.

Closing: Wrap the topic up with the answers they gave in the previous activity.

This table shows the linear dilation quotient of some materials.

Material	Dilation of 10 meters of material at a temperature increase of 100° C	Dilation quotient
Steel	12 mm	0.000012
Aluminum	25 mm	0.000025
Cement	14 mm	0.000014
Copper	16 mm	0.000016
Diamond	1 mm	0.000001
Iron	10 mm	0.00001
Brick	10 mm	0.00001
Gold	13 mm	0.000013

Closing

How much did I learn?

Answer the questions.

1. Using the Kinetic Particle Theory, what would you say temperature is?
2. Using the Kinetic Particle Theory, what would you say heat is?
3. What's the difference between temperature and heat?
4. Using an everyday example, explain the difference between temperature and heat.

In groups of three, find out what problems the change in temperature causes in the following objects: train rails, electrical wiring and pipes in countries with snow.

Changes of State. Interpretation of Pressure vs. Temperature Graph

Expected Learning

Describe the changes of the state of matter in terms of heat and pressure transfer, based on the Kinetic Particle Theory and interpret boiling and melting point variations in pressure vs. temperature graphs.

Exploring Knowledge

Work in pairs. Share your answers with the class.

1. Make a chart with four columns: solid, liquid, gas and plasma in your notebooks.
2. Under each heading, write the characteristics of each state of matter, such as volume, appearance, temperature, odor, color.

Changes of the Aggregation State of Matter

Changes of state, phase or **aggregation** are identified with specific names.

- **Condensation or liquefaction**: changes from the gas state to the liquid state. Gas loses energy and the particles vibrate less, which makes them regroup in a liquid.
- **Evaporation**: is the reverse process of condensation. Matter goes from a liquid state to a gas state through an increase in temperature.
- **Melting**: is the change from the solid to the liquid state and it is caused by an increase in the energy of particles, which absorb it and vibrate more.

SKILLS DEVELOPMENT

Critical thinking skills: Problem solving, analyzing.

EVALUATION OF CONTENT

Students should be able to describe changes of the state of matter regarding heat and pressure.

- **Solidification or freezing**: is the reverse process of melting. Matter goes from a liquid to a solid state by losing energy in its particles.
- **Sublimation**: is the change of state from solid to gas without going through the liquid stage. This is caused by an abrupt change in the amount of energy that particles absorb. But also, when we talk about sublimation, we can refer to the change of the gas state to solid without going through the liquid state. To avoid confusion, this last process is referred to as **reverse sublimation**.

FIG. 3.22 Aurora Borealis.

Curious Facts

The states of matter: solid, liquid and gas are very common because we can see them around us. The plasma state, even though it is not commonly found, is easily observed in phenomena related to electrification of a gas, such as in neon lamps or the Aurora Borealis. On the other hand, the Bose-Einstein condensate is not easy to observe as it is achieved by cooling a fluid at extremely low temperatures.

Closing

How much did I learn?

In the following picture you can see three states of matter: solid, liquid and gas.

1. Write the names of the changes of state that correspond to each arrow.
2. In groups, interpret the changes of state in terms of the Kinetic Particle Model.

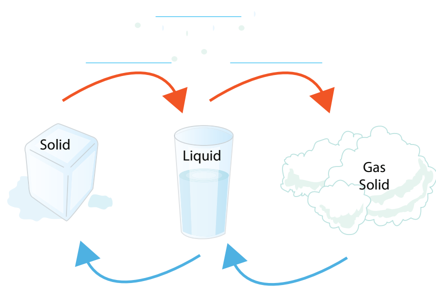


FIG. 3.23 Change processes of the aggregation state of matter.

SESSION INFORMATION

Week: 20

Session: 120

Expected learning outcome: Describe the changes of the state of matter in terms of heat and pressure transfer based on the Kinetic Particle Theory and interpret boiling and melting point variations in pressure vs. temperature graphs.

CONTENT DELIVERY

Start: In pairs, students should answer the questions in the section *Exploring Knowledge* on page 78. Elicit answers.

Development: Students should continue reading page 78 and 79. Segment the information; help them as necessary to clarify concepts.

Closing: Students should answer the questions in the section *How much did I learn?* Once they finish, elicit answers.

SKILLS DEVELOPMENT

Interpersonal skills: Pair work.

Critical thinking skills: Analyzing, remembering, applying information.

Visual/Spatial skills: Building a chart.

EVALUATION OF CONTENT

Students should describe changes of matter in terms of heat and pressure.

SESSION INFORMATION

Week: 21

Session: 121

Expected learning outcome: Describe energy transformation chains in the environment and in experimental activities in which heat energy intervenes.

CONTENT DELIVERY

Start: In pairs, students should answer the questions in the section *Exploring knowledge*. Elicit answers. Help them as necessary and get a student to write on the board the definition of energy.

Development: Students should read page 80. Help them with examples of real life problems in which work, force or distance should be calculated. Then, help them calculate kinetic or potential energy in different real life problems. Segment the formulas. Once they can do problems move on to the following one.

Closing: Have students solve problems by themselves. Guide the procedure at first, then let them try.

Project preparation: In teams, students should take to the following class: A scale, measuring tape, a stopwatch, five objects of different masses, which can fit in the scale.

→ Expected Learning

Describe energy transformation chains in the environment and in experimental activities in which heat energy intervenes.

Caloric Energy and its Transformations

Transformation of Caloric Energy

Exploring Knowledge

Purpose: To know and identify the different kinds of energy and its transformations.

Answer the questions in your notebook.

1. What is energy?
2. How many energy forms do you know?
3. How do you use energy in your everyday life?
4. Do all objects have energy? Why?

Curious Facts

The particles of the Sun are in constant movement and this generates an immense amount of **thermal energy** spread in every direction; from which our planet only gets a small amount in the form of heat and light.

Even though energy is a core concept in every science, not just in physics, for centuries its definition and description remained unclear. Newton and his predecessors did not know the concept, and until 1850, it was the subject of debate at science meetings.

Energy, its Manifestations and its Transformations

Energy is defined as the capacity to carry out work. A force carries out work when it displaces an object to a certain distance. In the simplest of cases, in which the force applied upon an object and its displacement is in the same direction, we have the following formula to calculate work:

$$W = F \cdot d$$

In which:

W = work

F = force

d = distance

If force is measured in Newtons (N) and distance in meters (m), then the units of work are measured in Joules (J).

In mechanics, two kinds of energy can be distinguished: kinetic energy, associated to bodies in motion, and potential energy which is the one a body has, due to the presence of a force, such as gravity. In math terms, a body's kinetic energy is calculated as:

$$KE = \frac{1}{2} m \cdot v^2$$

In which, **KE** is kinetic energy, v^2 is the body's velocity and **m** is mass.

At the same time, the potential energy is calculated as:

$$PE = m \cdot g \cdot h$$

In which, **PE** is the potential energy; **m** is the mass of a body; **g** is the gravitational acceleration and **h** is the height at which an object is placed at a given point.

It is easily perceived that the faster an object moves or the larger its mass is, the greater the kinetic energy will be; therefore, the higher an object is in reference to a given point, the greater its potential energy will be each time.

FIG. 3.24 Machines take advantage of the transformation of matter and energy.

SKILLS DEVELOPMENT

Critical thinking skills: Imagining, remembering, problem solving.

EVALUATION OF CONTENT

Students should be able to solve problems by themselves.

Experiment

PURPOSE

Identify the quantity and type of energy in an object depending on its position or velocity.

Objects can have kinetic energy if they are in motion and potential energy if they are at rest. We have seen that the potential energy of an object is transformed into kinetic energy as soon as motion begins. Let's make some calculations to determine the energy of several objects.

MATERIAL

- A scale
- Measuring tape
- A stopwatch
- Five objects of different masses and sizes that can fit on the scale.

PROCEDURE

1. Measure the mass of each object.
2. With the measuring tape, mark different heights from the floor up, 30 cm apart each, until you reach 150 cm.
3. Drop each object from each mark. Record how long it takes for each object to hit the ground and answer the following questions in your notebook.
   a) Is there an object that will take longer to hit the ground from the same height as the others?
   b) Does each object's mass make a difference in the time it takes it to hit the ground?
   c) Using the equation for kinetic energy, calculate the energy for each object before you drop it. Remember the only variable is height.
   d) Calculate velocity of each object and write it down.
   e) How much kinetic energy does each body have right before it hits the ground?

As you know, the particles that form matter vibrate and, thus, have **kinetic energy** that gives way to the body's internal energy. We have established that the greater the kinetic energy is, the higher the body's temperature will be and we have differentiated heat from temperature, understanding heat as the energy that must be given to a body to raise its temperature – but that's not all, it is necessary to add heat to a body to provoke a change state, like from liquid to gas.

Mechanical energy can be defined as total energy and it is obtained by adding the kinetic energy and the **potential energy**. This addition is constant when friction is absent; however, if friction is factored in, mechanical energy is not only transformed into kinetic and potential energy, but also into caloric energy. Regardless of which manifestations of energy intervene in a physical phenomenon, the **law of conservation of energy** always takes place: ***Energy cannot be created or destroyed, just transformed from one form to another.***

FIG. 3.25 A weight lifter does not carry out any work while maintaining the weights above his head.

Reflect, Explain and Share

A pendulum does not always oscillate, but rather it gradually ceases to do so due to the existence of dissipative forces, which affect motion. An example of that kind of force is friction, which in this case is manifested in air.

In addition to mechanical energy and heat, we can also find other manifestations of energy such as luminous energy, electric energy and magnetic energy. If we understand energy as a resource that is used in our world, we can include solar energy, wind energy, geothermal energy and nuclear energy, among others.

SESSION INFORMATION

Week: 21

Sessions: 122, 123

Expected learning outcome: Describe energy transformation chains in the environment and in experimental activities in which heat energy intervenes.

CONTENT DELIVERY

Start: Remind students of the formulas they studied the previous session. Have them solve some problems. You might want to use some of the exercises in the Teacher's Guide on page 169.

Development: Students should do the experiment. Guide them in the process. Then, they should read the rest of page 81. Guide them and help them with examples.

Closing: Students should read and answer the questions in the section *How much did I learn?* On page 82.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting.

Critical thinking skills: Analyzing.

EVALUATION OF CONTENT

Students should actively participate in the experiment and research.

SESSION INFORMATION

Week: 21

Sessions: 124, 125

Expected learning outcome: Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (given or gained).

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring knowledge*. Elicit answers.

Development: Students should read the information on page 82. Guide them with examples so that it is clear how the laws of thermodynamics work.

Closing: Students should answer the questions in the section *How much did I learn?* In their notebooks. Elicit answers.

FIG. 3.26 Joule devoted a large part of his work to studying energy and its diverse manifestations.

Closing

How much did I learn?

In teams of five, answer the following questions.

1. In physics, what is energy and what is work?
2. You and your teammates are standing on a surface, which is 3 meters above the ground; what is the potential energy each one of you has in relation to the ground?
3. What is the kinetic energy of a 60 kg person that runs at a speed of $5\frac{m}{s}$?
4. What is the internal energy of matter?
5. Do some research on the generation of energy in hydroelectric industries and describe the transformation processes that take place there.
6. Explain in your own words the law of conservation of energy.

Thermal Equilibrium

Expected Learning

Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (given or gained).

Exploring Knowledge

Answer the questions in your notebook.

1. If you put together two objects with different temperature, do you think the cooler object will decrease its temperature even more and the warmer object will increase it? Why?
2. How is thermal equilibrium reached?

It is said that two objects, A and B, have reached thermal equilibrium if no heat flows between them. The Zeroth law of thermodynamics establishes that if a third object, C, is in thermal equilibrium with both objects (A and B) then, A and B will also be in thermal equilibrium with each other. Historically, this law was established as the need to define the concept of temperature that was part of the remaining laws of thermodynamics without having been defined. The Zeroth law provides such a definition and establishes the possibility to build thermometers.

Thermodynamics is the branch of physics that studies matter in its states of equilibrium. Besides the Zeroth law, there are three other laws or principles in which thermodynamics rests.

The **first law of thermodynamics** is the thermodynamic version of the law of conservation of energy, establishing that if work is carried out over a system or if the system exchanges heat with another system, the system's inner energy will change.

The **second law of thermodynamics** establishes the direction in which processes take place and, consequently, it is the basis of the operation of thermal machines, such as engines.

Closing

How much did I learn?

Answer the questions in your notebook..

1. According to what we read in this subtopic, what do you think would happen, if one day an object's temperature reached absolute zero?
2. How do you apply the laws of thermodynamics in your everyday life? Why?
3. What does thermodynamics study?
4. How does a coffee thermos work? Why does it have inner glass walls that reflect exterior light?

SKILLS DEVELOPMENT

Critical thinking skills: Imagining, analyzing.

EVALUATION OF CONTENT

Students should be able to interpret the algebraic expression of the Law of Conservation of Energy.

Heat Transfer: from The Body with The Highest Temperature to The One with The Least Temperature

Exploring Knowledge

Answer the questions in your notebook.

1. How does a mercury or alcohol thermometer work?
2. How do manufacturers know how much mercury or alcohol to put inside a thermometer?
3. When we touch something, how do we know whether it is hot or cold?
4. How is heat transferred from one body to another?

Expected Learning

Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (lost or gained).

There are three ways to **transfer** heat: conduction, convection and radiation.

In conduction, two bodies are in contact, like when we touch something with our hand. Convection is when heat is transferred through the movement of mass like water in a pot over a flame. In radiation, heat is transferred without contact between bodies, such as the heat coming from the Sun.

FIG. 3.27 Heated particles go up while cooler particles descend. After a while, all the particles of the water will have the same temperature.

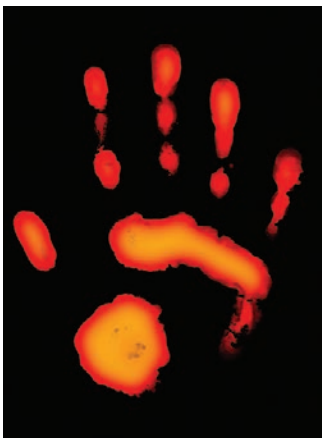


FIG. 3.28 A thermal camera takes advantage of radiation transfer, so we can observe the zones of higher and lower temperatures in a body.

FIG. 3.29 Heat transfer through conduction: a metal bar placed directly over the flame.

Closing

How much did I learn?

Answer the questions.

1. Imagine you place 1 L of water for some time over an open flame and its temperature rises 2°C. If you place 2 L of water over the same flame for the same time, will the rise in temperature be the same? Why?
2. Write five examples for each kind of heat transfer: conduction, convection and radiation.

Curious Facts

One of the most common manifestations of convection is rain: the planet's hot surface plus solar radiation cause the water in seas, rivers and lakes to be evaporated and to form clouds, that when containing too many particles get cooler again and fall to the ground as water drops.

SESSION INFORMATION

Week: 21, 22

Sessions: 126, 127

Expected learning outcome: Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (lost or gained).

CONTENT DELIVERY

Start: In teams, students should answer the questions in the section *Exploring knowledge*. Elicit answers.

Development: Students should read the information on the page. Show them further examples.

Closing: Students should answer the questions in the section *How much did I learn?* Elicit answers.

SKILLS DEVELOPMENT

Critical thinking skills: Imagining, analyzing.

EVALUATION OF CONTENT

Students should be able to understand the algebraic expression of the Law of Conservation of Energy.

SESSION INFORMATION

Week: 22

Session: 128

Expected learning outcome: Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (lost or gained).

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring knowledge*. Elicit answers.

Development: Students should read the definition of The Law of Conservation of Energy and say as many examples as they can about it. Help them to find examples.

Closing: Students should be able to say examples of the law of conservation of energy.

Project preparation: In teams, students should get the following material for next sessions: A universal support, a clean and empty can of soda, a straw cut in halves, an alcohol lamp, a 7 cm diameter pinwheel, a 15 cm long wooden stick, modeling clay, adhesive tape, water.

Expected Learning

Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (lost or gained).

Law of Conservation of Energy

Exploring Knowledge

Answer the questions in your notebook.

1. How many of your everyday activities are related to the term "energy"?
2. If you could measure the energy you get from food and the energy that you spend in your everyday activities, what would the result be? Do you spend more energy than what you ingest or is it the other way around?

Let's remember that the law of Conservation of Energy establishes that:

Energy cannot be created or destroyed, it is just transformed from one form to another.

Reflect, Explain and Share

Let's imagine for a moment that the law of Conservation of Energy does not apply in a certain region on our planet, what do you think would happen? It may sound exaggerated or unlikely, but the universe has worked in the same way ever since its creation and for about 13.7 billion years.

FIG. 3.30 A part of our universe.

SKILLS DEVELOPMENT

Critical thinking skills: Imagining.

EVALUATION OF CONTENT

Students should be able to say examples of the law of conservation of energy.

The law of Conservation of Energy is stated through the first law of thermodynamics that in mathematical terms establishes the following:

$$\Delta U = Q - W$$

In which:

ΔU = the change in internal energy.
Q = the heat added to the system.
W = the work done by the system.

Closing

How much did I learn?

Building a thermal machine.

1. Work in small teams and bring the following material:
   - A universal support
   - A clean and empty soda or juice can.
   - A straw cut into 2 halves.
   - An alcohol lamp.
   - A 7 cm diameter pinwheel.
   - A 15 cm long wooden stick.
   - Some modeling clay
   - Adhesive tape
   - Water
2. Fill the can halfway with water. Put one half of the straw inside the can, leaving 2 cm out. Secure the straw with the modeling clay and make sure you cover the hole on the can entirely.
3. Secure the pinwheel to one end of the wooden stick. Using the tape, secure the other end to the can, making sure the pinwheel is near the straw. Secure the can with the universal support as as shown in figure 3.31.
4. Light the alcohol lamp and place it under the can. Wait a few minutes for the water inside the can to start evaporating.
5. Answer the question.
   a) What happens to the pinwheel after several minutes and what makes this happen?
6. Take the lamp away from the alcohol lamp while vapor is still coming out of the straw, and carefully place your hand near the can.
   a) With what you already know about heat, describe what you are feeling and the reason this happens.
   b) Based on what you just saw in the experiment, could all the heat applied to the can be completely transformed into a force to make a machine work? Discuss with your teammates. Do some research on how the first law of thermodynamics is applied to the thermal machines.

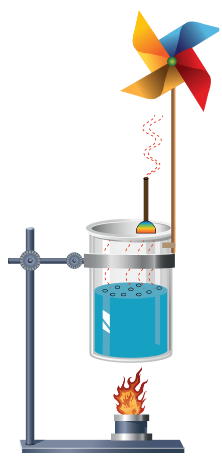


FIG. 3.31 Diagram to build the experiment.

SESSION INFORMATION

Week: 22

Sessions: 129, 130

Expected learning outcome: Interpret the algebraic expression of the Law of Conservation of Energy in terms of heat transfer (lost or gained).

CONTENT DELIVERY

Start: Students should say the law of conservation of energy and some examples. Ask at random.

Development: In teams, they will do the experiment. Guide them in the process.

Closing: They should answer the questions in the experiment.

Homework: In teams of four, students should do research on how humans get energy from food and calories in common food. They should also take to class: cardboard, markers, and ruler.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting.

EVALUATION OF CONTENT

Students should actively participate in the experiment.

SESSION INFORMATION

Week: 22

Session: 131

Expected learning outcome: Support the importance of thermal energy in human activities and the hazards to nature in its production and use.

CONTENT DELIVERY

Start: Have students answer a couple of questions about the previous presentations.

Development: Students should give their presentations (help accordingly); ask their questions, self-monitor and self evaluate their performance.

Closing: Students should ask their questions to their partners.

Students who listen to the presentations, should mind map the information they give.

→ Expected Learning

Support the importance of thermal energy in human activities and the hazards to nature in its production and use.

Implications of The Production and Use of Energy in Human Activities

Experiment

PURPOSE

Identify the sources of energy in everyday life.

MATERIAL

- 12 or more food wrappers of any kind.

PROCEDURE

It's always mentioned that to maintain our weight at an acceptable level we must have a consumption of 2,000 Calories or 2 Kcal (notice that **Calories** and **kilocalories** are different by a factor of 1,000). Create a chart with all the food items you chose and write the total amount of calories each one provides.

Answer the following questions in your notebook.

1. How does the body get energy from food?
2. Do you think certain food items provide more energy than others?
3. From the list you made about food and their calories, which provide the most energy? Which provides the least? What is the difference between them?

The human body works like a machine that transforms everything we eat into energy; some of that energy is used to carry out mechanical work like: walking, blinking, lifting our arms, and running. so on. Food provides us with the essential nutrients and energy to carry out every reaction required by the body. Carbohydrates, fats and proteins are a source of energy. It is normal to express energy that comes from food in calories or kilocalories instead of using Joules (1 Joule = 0.2388 calories).

FIG. 3.32 In everyday life we associate energy with having good attitude and happiness.

Not only does out body require energy, but energy is a part of our lives. Consider, for instance, how many electric appliances you use every day, so that you can picture how much energy you consume. Then, multiply that amount by 7,000 million (the approximate number of people on the planet) and you will understand the average of how much energy is consumed daily on Earth. It is evident that we need to make the process of production and use of energy much more efficient.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

Critical thinking skills: Summarizing, formulating questions.

Interpersonal skills: Working as a team member.

EVALUATION OF CONTENT

Follow the projects rubrics on page 164.

FIG. 3.33 Marathon runners consume a great quantity of calories.

The search for energy to meet the needs of human consumption is associated with several problems in our world. Most power plants give energy to cities by burning hydrocarbons, which have a great impact polluting the environment. Moreover, hydrocarbons or petroleum products are running out, which makes an energy crisis a very real possibility in the near future. There are, however, "clean energies" which are associated with energy production that cause less harm to the environment. Some examples are: solar energy, wind energy and nuclear energy, although each one of them comes with its own set of problems. Solar and wind energy cannot produce the same amount of energy as traditional power plants, and nuclear plants are associated with latent risks that in some cases, have caused severe consequences to the cities located near the plant.

FIG. 3.34 Chernobyl before and after the catastrophe.

Closing

How much did I learn?

Answer the questions in your notebook.

1. Where does electric energy in Mexico come from?
2. Do you know how a hydroelectric power plant works?
3. How many hydroelectric power plants are there in Mexico and where are they located?
4. What alternate energy sources do you think we will need to use in the future?

SESSION INFORMATION

Week: 22

Session: 132

Expected learning outcome: Support the importance of thermal energy in human activities and the hazards to nature in its production and use.

CONTENT DELIVERY

Start: Ask students to explain in their own words how humans get energy from food.

Development: Students should present the research they did on one of the questions in the section *How much did I learn?* Students who listen, should mind map what their classmates present. Guide them in the process and help as needed.

Closing: Students should get their mind map checked by the teacher.

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Critical thinking skills: Mind mapping.

Verbal/Linguistic skills: Presenting information.

EVALUATION OF CONTENT

All students should actively participate in the presentations and get their mind maps checked by the teacher.

SESSION INFORMATION

Week: 23

Sessions: 133- 138

Expected learning outcome: Plan and define a project from questions based on personal interest from the unit, find answers and solutions.

Select and organize relevant information obtained from research to outline a project.

Design technical objects, experiments or models in a creative way, including the description, explanation and prediction of physical phenomena related to interactions of matter.

Share the outcome of a project through several media texts, graphs, videos.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

Project: Use and Application of Hydraulic and Caloric Machines in The Community

➔ Expected Learning

Plan and define a project from questions based on personal interest from the unit, find answers and solutions.

Select and organize relevant information obtained from research to outline a project.

Design technical objects, experiments or models in a creative way, including the description, explanation and prediction of physical phenomena related to interactions of matter.

Share the outcome of a project through several media texts, graphs, video.

➔ Proposed problems to define the project:

- How do steam engines work?
- How do hydraulic jacks work?

Remember that if you or your team have another question or problem you want to research and solve, you are free to do so. Do not lose your enthusiasm since these are only proposals. Try to choose something you find useful for yourself and your community.

➔ Developing the Project

1. Have we defined the main idea or problem of the project? What is it? Why is it relevant?
2. What is the plan to carry out? What resources do we need? What have we accomplished up to now? What are we missing and still need to achieve?
3. How and when will we carry it out? What impact are we expecting for this project to have? What will do if this doesn't work? Do we have a B plan to follow? Which one?
4. How will you communicate the outcome of the project to the rest of the group? And to the rest of the school body? And to the community?

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

With the help of your teacher, go over the project in general. Start an outline for the project and the steps to follow during the next couple of weeks to develop it and achieve your goals. Make sure your sources of information are reliable, and when your research is done, include diagrams, charts or graphs to show results and analysis. Don't forget to include your conclusions and possible solutions.

➔ Communicating the results of the project

With your team, propose several kinds of communication media to help you present the project to the rest of the class and school body, as well as to your community, if you find it necessary.

Take into account that Information and Communication Technologies (ICT) help us in communicating the results of the project, although you may consider more traditional media, such as billboards, handouts, school newspapers or any other more educational media, such as lectures, workshops with the participation of the school community, among others.

Do not forget to share everything you have carried out in the project. It may be useful to have a preliminary outline in writing, which you can support with physical models at the moment of communicating results.

➔ Evaluating the Project

Once the project is finished and has been shared at school, meet with your team and reflect on what you did during this time to carry the project out. Consider the following questions:

1. Were the objectives of the project met? Why?
2. How did you evaluate results? Are they positive or negative? What grade would you give your project?
3. What obstacles did you face? How did you work them out? In case one of the obstacles was not overcome, why did it happen?
4. What could you have done better?
5. How was the participation of each team member in the project? Did all the members accomplish their responsibilities?

In your notebook, write down a personal thought about what you have learned regarding the topic while working on this project. Also include, your personal experiences while doing this project. Think about how you carried out the search for answers, faced obstacles and made decisions throughout the project.

SESSION INFORMATION

Week: 23

Sessions: 133- 138

Expected learning outcome: Plan and define a project from questions based on personal interest from the unit, find answers and solutions.

Select and organize relevant information obtained from research to outline a project.

Design technical objects, experiments or models in a creative way, including the description, explanation and prediction of physical phenomena related to interactions of matter.

Share the outcome of a project through several media texts, graphs, videos.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

SESSION INFORMATION

Week: 24

Sessions: 139, 140

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 90 and 91 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages152 to 155 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

Evaluation

1. What is the Kinetic Particle Theory?

   It is a Theory that describes and explains the properties of the different states of matter.

2. Why are heat and temperature different?

   Because heat is the energy that manifests and temperature is a measurement of the average kinetic energy of particles.

3. In order to maintain liquids at a given temperature, we can use a thermos, which consists of two cylindrical containers, one smaller than the other and placed inside the larger one, separated by a space, which holds a layer of air. Is the air between the containers, a heat conductor or an insulator? What ways of heat transfer does it favor or avoid?

   a) It is a conductor and it favors heat conduction.
   b) It is a conductor and it favors heat convection.
   c) It is an insulator and it avoids heat conduction.
   d) It is an insulator and it avoids heat convection.

5. Why are water heaters painted white?

a) To avoid heat flowing out by conduction.
b) To avoid heat flowing out by convection.
c) To make it look clean and nice.
d) To avoid heat flowing out by radiation.

5. What is the more ecological and cost-efficient way to use a water heater?

In order to have a more efficient use of a water heater and save energy and costs, it is advisable to use the water heater in a specific time.

6. What did you like the most in this unit?

Students' own answers.

Kells

SESSION INFORMATION

Week: 24

Session: 141, 142

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 90 and 91 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages152 to 155 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

SESSION INFORMATION

Week: 24

Session: 143

SELF EVALUATION

Evaluation

Self-Evaluation

Evaluate your own way of working; check what you are able to do with the themes in this unit.

SKILLS	YES	NO
I can apply physics to solve problems in my community, country and around the world.		
I can relate the knowldege of physics with the surrounding environment and with the ethical, economic, sociopolitical and cultural matters of my country and the world.		
I can use technical physics terms to communicate information.		
I use graphs, tables and models in my reports, homework and projects.		
I can search for information in the correct sources and organize it according to the report, project or assignment I'm working on, mentioning the sources of information.		
I establish mathematical models and solve problems related to physics.		
I analyze physics problems and can break up a whole in its parts, finding the relationship among the parts as well as identify cause and effect of the problem.		
Organize and analyze data, represent it in graphs and tables, evaluate the validity of ideas and the quality of work.		
Come to conclusions based on scientific reasoning.		
Make decisions related to my health and that of others, as I promote the culture of prevention.		
I am responsible and committed, work well with others and respect their point of view.		
I apply my knowledge and skills to solve problems in my community.		

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

Peer-Evaluation

Rubric

POINTS	VALUE	MEANING
10	Excellent	Perfect collaboration without mistakes.
8	Very good	Little, involuntary or justified mistakes.
6	Good	Has shown mistakes and lack of a helping attitude.
4	Barely accomplishes	Total lack of helping attitude, mistakes and excuses constantly present.
2	Not accomplished	Has not accomplished the task and shows irresponsibility.

Characteristics To Evaluate

	CHARACTERISTICS
A	Prepares his share of the work in a responsible way.
B	Makes his best effort at sharing his learning.
C	Handles conflicts constructively.
D	Shows trust, respect, acceptance, listens and support towards others.
E	Points out strengths and areas of opportunity during group processing.
F	Gives feedback to the group to improve on assignments and responsibilities.

Peer-Evaluation

Write the name of each of your teammates and check the box for each trait your partner has.

TEAM TO BE EVALUATED						
NAME OF STUDENT	A	B	C	D	E	F
	2-10	2-10	2-10	2-10	2-10	2-10
1						
2						
3						
4						
5						

SESSION INFORMATION

Week: 24

Session: 144

SELF EVALUATION

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

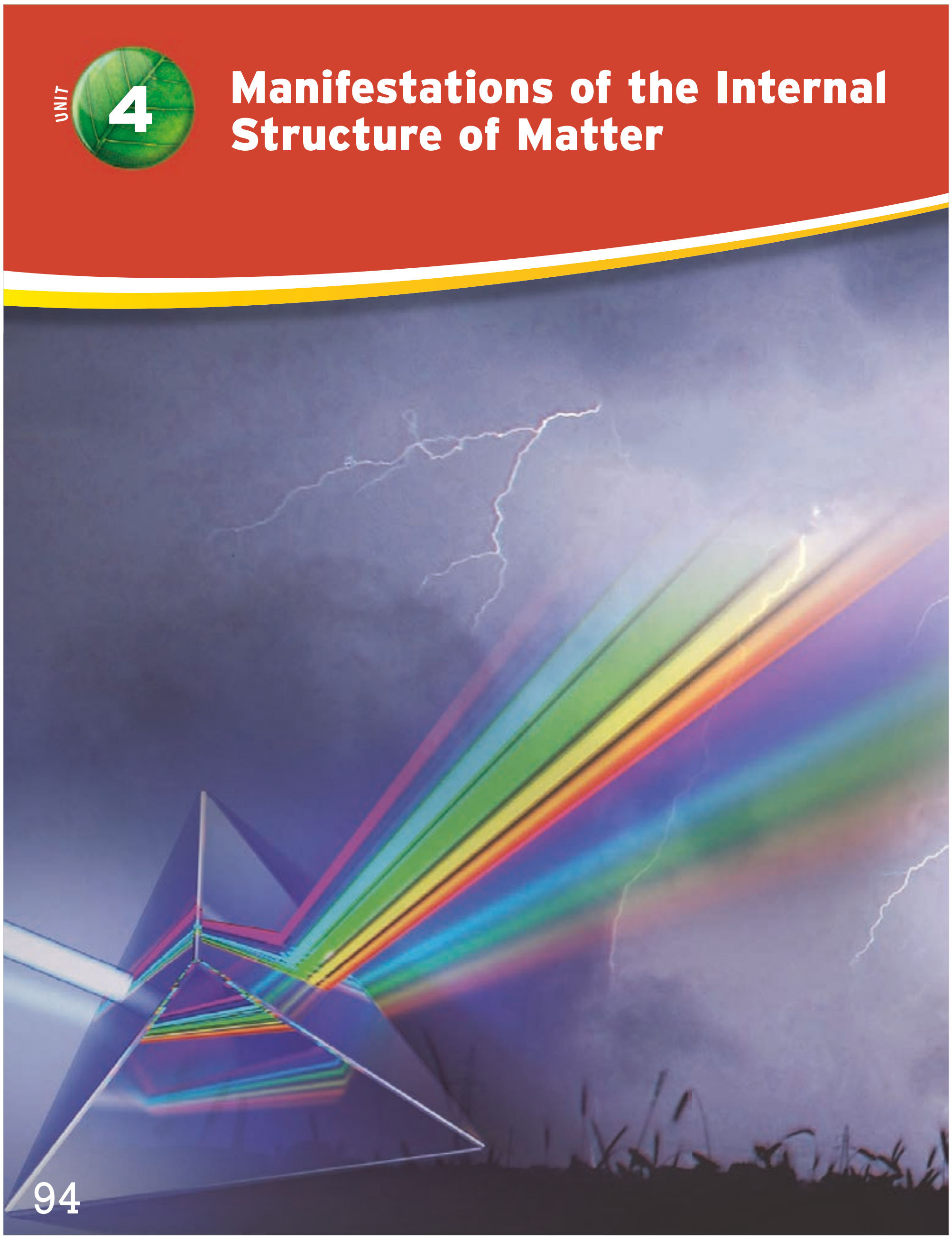
Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

SESSION INFORMATION

Project preparation for sessions 146 to 148: Divide the group into 7 teams. Each team should read one of the following topics: Leucippus atomic theory, Democritus atomic theory, John Dalton atomic theory, Mendeleyev periodic table, Discovery of electrons, Thompson atomic model, Rutherford Atomic Theory and Bohr atomic model briefly explained on pages 96 to 98. They should prepare visuals, do further research and prepare a seven-question quiz to ask questions to their classmates. Remind students what you will evaluate in the presentation. Check the projects' rubrics on page 164.



UNIT 4

Manifestations of the Internal Structure of Matter

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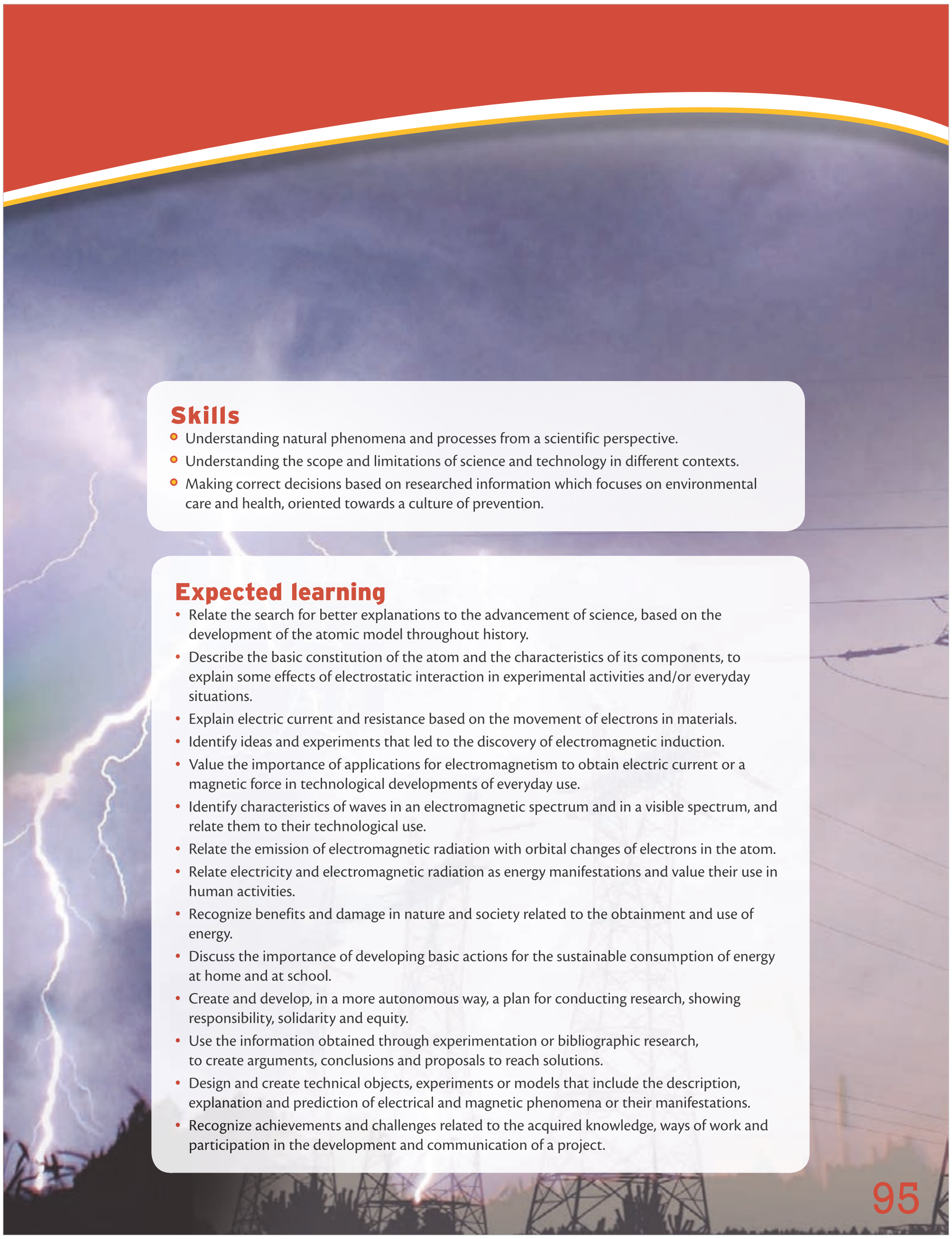

Skills

- Understanding natural phenomena and processes from a scientific perspective.
- Understanding the scope and limitations of science and technology in different contexts.
- Making correct decisions based on researched information which focuses on environmental care and health, oriented towards a culture of prevention.

Expected learning

- Relate the search for better explanations to the advancement of science, based on the development of the atomic model throughout history.
- Describe the basic constitution of the atom and the characteristics of its components, to explain some effects of electrostatic interaction in experimental activities and/or everyday situations.
- Explain electric current and resistance based on the movement of electrons in materials.
- Identify ideas and experiments that led to the discovery of electromagnetic induction.
- Value the importance of applications for electromagnetism to obtain electric current or a magnetic force in technological developments of everyday use.
- Identify characteristics of waves in an electromagnetic spectrum and in a visible spectrum, and relate them to their technological use.
- Relate the emission of electromagnetic radiation with orbital changes of electrons in the atom.
- Relate electricity and electromagnetic radiation as energy manifestations and value their use in human activities.
- Recognize benefits and damage in nature and society related to the obtainment and use of energy.
- Discuss the importance of developing basic actions for the sustainable consumption of energy at home and at school.
- Create and develop, in a more autonomous way, a plan for conducting research, showing responsibility, solidarity and equity.
- Use the information obtained through experimentation or bibliographic research, to create arguments, conclusions and proposals to reach solutions.
- Design and create technical objects, experiments or models that include the description, explanation and prediction of electrical and magnetic phenomena or their manifestations.
- Recognize achievements and challenges related to the acquired knowledge, ways of work and participation in the development and communication of a project.

95

SKILLS DEVELOPMENT

Metacognitive skills: Planning, organizing studies content.

EVALUATION OF CONTENT

Students should get their study plan checked by the teacher.

SESSION INFORMATION

Week: 25

Session: 145

Expected learning outcome: Identify topics in the unit students consider will be hard to understand in order to make a studies plan.

CONTENT DELIVERY

Start: Have students analyze and identify what they could do well in units 1 through 3; as well as what they should improve in unit 4. Ask them, for instance: What topics were easy? Did your previous study plan work? Didn't it work? Why? Did you really follow your study plan? Students should write down their reflections.

Development: Have students check the skills, learning outcomes and key concepts in unit 3. Ask them to identify the topics they consider the hardest ones. Then, they should plan how to study them and do better than the previous unit. If a strategy didn't work, then they should find another one. Help them with ideas. (Drawing mind maps, discussing with partners, making their own exams, making timelines, making associations, etc.)

Closing: Students should write down their study plan and have it checked.

SESSION INFORMATION

Week: 25

Session: 146

Expected learning outcome: Relate the search for better explanations to the advancement of science, based on the development of the atomic model throughout history.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

➔ **Expected Learning**

Relate the search for better explanations to the advancement of science, based on the development of the atomic model throughout history.

Explanation of Electric Phenomena: The Atomic Model

Historical Process of The Development of The Atomic Model: Contributions by Thomson, Rutherford and Bohr; Reach and Limitations of The Models

➔ Reflect, Explain and Share

Work in teams of three. Answer the questions. Share your answers with the class.

1. Have you ever wondered what matter is made of? In other words, everything living or inert that surrounds us.
2. Have you heard the word atom? What do you think it means?
3. If you had a very powerful microscope that allowed you to see what matter is made of, what do you think it would look like? Draw and explain your model.

FIG. 4.1 Leucippus of Miletus.

FIG. 4.2 Democritus of Abdera.

In Classic Greece, the wise men of the time started to wonder about the composition of **matter**. Leucippus and his disciple Democritus stated that matter was made of elementary **particles** they called **atoms**. Atoms were considered indivisible, **immutable** and different according to the matter they belonged to. These ideas were forgotten for over two millennia and it was not until the eighteenth century that they were retaken again.

In 1808, English physicist and chemist John Dalton published a **postulate** stating that matter was made of atoms. He said that they formed the elements (atoms of a same type) of matter and that they were mixed by simple fractions to form compounds, which when re-combined, formed more complex products. His atomic model was a simple sphere.

GLOSSARY

Postulate. Proposition admitted as true without proof.

Immutable. That can't change or can't be changed.

➔ **Activity**

1. Answer the following questions and discuss the answers with your teammates.
   a) What characteristics do Democritus' and Dalton's atomic theories have in common?
   b) What fundamental differences can you find?

Dalton's and Democritus's Atomic Theories Comparison	
Similarities	Differences

FIG. 4.3 John Dalton.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

In 1869, Russian chemist Dimitri Ivanovich Mendeleyev published the **periodic table** of elements in which he emphasized that elements could be classified by their corresponding atomic weight. For example, hydrogen 1, helium 4, carbon 12, oxygen 16 and so on. He also predicted that the blank spaces in the table belonged to elements not yet discovered in his time. This shed light on how atomic elements could be combined in a reaction.

FIG. 4.4 Dimitri Mendeleyev.

FIG. 4.5 Mendeleyev's periodic table.

Discovery of Electrons

The electric phenomena of nature gave birth to ideas questioning the theories of an indivisible atom. While these ideas were developed, Irish physicist and mathematician George Johnstone Stoney proposed that electricity was created from elemental particles he called electrons (1891), present in the atoms of all elements. In 1897, English physicist Joseph John Thomson (1856 – 1940) discovered in his experiments with cathode rays that the atom had small particles called **corpuscles** which had an electric negative charge.

FIG. 4.6 George Johnstone Stoney.

FIG. 4.7 John Thomson.

Thomson's Atomic Model

In 1898, John Thomson discovered that the corpuscles were electrons, which were charged negatively. In 1904, he established his atomic model stating the atom was a sphere charged positively with electrons fit in its body. This model was known as "Thomson's plum pudding model", with this model he suggested the atom could be divided, unlike Dalton's unitary model. In 1909, Robert Millikan confirmed the existence of the electron and described its properties.

Kells

ICT

Watch this video about the cathode rays experiment:

http://www.youtube.com/watch?v=1dPv5WKBz9k

Glossary

Corpuscle. Generic name for very small bodies: cell, molecule. Old denomination of proton, neutron and electron.

Curious Facts

In the mid-nineteenth century, scientists started to study electrical charges through some tubes from which almost all air had been extracted. Electric charges produced radiation, this is, fluorescent light rays called cathode rays because they originated in the negative electrode or cathode.

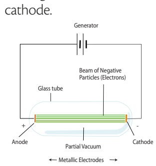

FIG. 4.8 Tube of cathode rays.

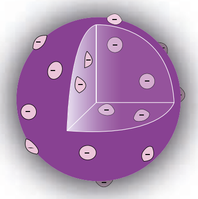

FIG. 4.9 Thomson's atomic mode.

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SESSION INFORMATION

Week: 25

Session: 147

Expected learning outcome: Relate the search for better explanations to the advancement of science, based on the development of the atomic model throughout history.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

Kells

SESSION INFORMATION

Week: 25

Session: 148

Expected learning outcome: Relate the search for better explanations to the advancement of science, based on the development of the atomic model throughout history.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

Curious Facts

Thomson was awarded the Nobel Prize in 1906 for his work on electricity conductivity through gases.

Rutherford's Atomic Theory

Thomson's model was unable to explain the atom structure with a positively charged **nucleus**. In 1911, New Zealand physicist Ernest Rutherford (1871 – 1937) created a new atomic model consisting of an atom in which the electrons go around a nucleus formed by particles with a positive charge called **protons** that makes up the largest part of the atom's mass. However, this model did not match the atomic mass measurements predicted by Mendeleyev and other scientists, so Rutherford included **neutrons** at the nucleus of his model, with a mass similar to that of protons. English physicist James Chadwick confirmed the existence of neutrons in 1932, when he discovered this particle and proved it did not have an electric charge.

How big are atoms? In 1865, German chemist Joseph Loschmidt used the particle theory to calculate how many atoms there were in a given volume of gas in order to find the size of each one and he found that this number was 6×10^{23} atoms. Since Loschmidt knew the total volume of the gas, he just had to divide it by the number of atoms and found that an atom's diameter was 1×10^{-9} cm, that is, 0.000000001 cm.

ICT

Watch the video of Rutherford's atomic model.

http://www.youtube.com/watch?v=PcOLWkUWPI8

FIG. 4.10 Ernest Rutherford.

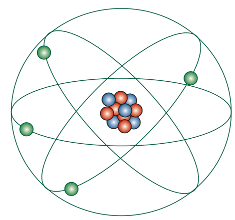


FIG. 4.11 Rutherford-Chadwick's atomic model.

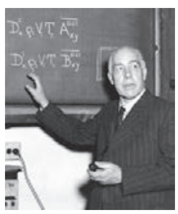


FIG. 4.12 Niels Bohr.

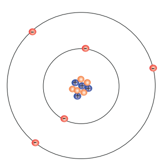


FIG. 4.13 Bohr's atomic model.

Bohr's Atomic Model

A definite model of the atom, still in use today, was developed by Danish physicist Neils Bohr (1885 – 1962). In 1913, he used a very innovative theory called quantum theory, which solved many of the problems presented by Rutherford's atomic model.

Bohr's model is very simple and is similar to Copernicus's planetary model. Bohr's postulates are:

1. Electrons revolve around the nucleus in circular paths, which are known as **orbits** or **energy level**.
2. Electrons orbit stably at a discrete distance from the nucleus. This postulate determines the "allowed" orbits in which an electron can rotate around the nucleus.
3. Electrons can only gain or lose energy by jumping form one allowed orbit to another.

Bohr's model states that in the atom, electrons are organized in **layers** and that they will have a given energy in each one, always filling the inner layers first and the outer ones later. The distribution of electrons in the layers is called **electronic configuration** and is carried out as follows:

- The first layer may have a maximum of two electrons.
- The second layer may have a maximum of eight electrons. It starts to get filled after the first one is complete.
- The third layer may have a maximum of 18 electrons. It starts to get filled after the second one is complete.

This model is represented with numbers in parenthesis separated by commas. For example, the atom of sodium has eleven electrons: two fill the first layer, eight are in the second layer and one last electron is left for the third layer; this is represented (2, 8, 1).

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

Closing

How much did I learn?

Work in teams to answer the questions. Share your answers with the class.

1. Is the concept of atom clear for you now?
2. Compare your answers, then discuss the similarities and differences between the different theories and complete the following table:

Model	Differences	Similarities
Leucippus		
Democritus		
Dalton		
Thomson		
Rutherford		
Bohr		

Basic Characteristics of The Atomic Model: Nucleus with Protons and Neutrons and Electrons in Orbits. Electron's Electric Charge

As seen in the previous topic, the atom is formed by three fundamental or **subatomic particles**; **protons** and **neutrons** found in the nucleus (also called nuclear particles), and **electrons**, which rotate around the nucleus with much less **mass** than the other two.

Expected Learning

Describe the basic constitution of the atom and the characteristics of its components and explain some effects of electrostatic interaction in experimental activities and/or everyday situations.

Exploring Knowledge

Now that you understand the atom, what do you think matter would look like under a very powerful microscope? Make a drawing and explain your model.

Atomic Structure

The atomic nucleus is approximately 100,000 times smaller than the entire atom, and subatomic particles cannot exist isolated, except in very special conditions. Protons have a **positive electric charge** and are noted ***p+***; electrons have a **negative electric charge** of the same magnitude as the proton's, and are noted ***e-***, and finally, neutrons do not possess electric charge and are noted ***n***.

The proton's and electron's electric charge is the same with opposite signs and a value of 1.60217733 x 10^{-19} **Coulomb**.

Millikan´s Experiment: Fundamental Unit of Electric Charge

When you learned about Thomson's atomic model, it was stated that the existence of electrons was confirmed by an experiment. Millikan used a sprayer to drop tiny oil drops from a certain height inside a box to confirm it. He set up two metal plates wired to a battery to charge them with electricity: the upper plate had a perforation in the center to allow the oil drops to pass. Inside the box, between the two plates, he set up a microscope lens to see inside. The lower plate had a negative charge and the upper one had a positive charge. The drops fell inside the box, and he also connected a source of X-rays to produce a negative charge that would join the oil drops. Whatever happened to the drops would depend on the amount of charge in them:

Glossary

Coulomb. Unit of electric charge in the International System. It equals the amount of electricity carried by a current of 1 ampere in 1 second (unit symbol: C).

SESSION INFORMATION

Week: 25

Session: 149

Expected learning outcome: Describe the basic constitution of the atom and the characteristics of its components and explain some effects of electrostatic interaction in experimental activities and/or every day situations.

CONTENT DELIVERY

Start: With information from everyone's presentations about the atomic model, students should complete the section *How much did I learn?* On top of the page. Students should get their chart checked by the teacher.

Development: Students should draw a model of the atom according to their own vision, as stated in the section *Exploring Knowledge*. Elicit two or three examples.

Closing: Students should read the Atomic Structure and Millikan's Experiment. Ask comprehension check questions to verify they understand both paragraphs.

Homework: On page 100 there is the link to watch a video about Millikan's experiment. Students should watch it and explain it the following class.

SKILLS DEVELOPMENT

Critical thinking skills: Remembering.

Visual/Spatial skills: Building a model.

Reading skills: Scanning, reading for detail.

EVALUATION OF CONTENT

Students should get their chart and atom model checked by the teacher. Later, they should be able to accurately respond to the comprehension-check questions.

SESSION INFORMATION

Week: 25

Session: 150

Expected learning outcome: Describe the basic constitution of the atom and the characteristics of its components and explain some effects of electrostatic interaction in experimental activities and/or every day situations.

CONTENT DELIVERY

Start: Remind students of the information they read the previous session. Use the same comprehension-check questions you used the previous session.

Development: Students should read page 100 and the top of page 101. Then, they should name the differences they notice between the information and the video they watched for homework. Guide them to understand how Millikan's experiment works.

Closing: Students should answer the questions in the chart *How much did I learn?* On page 101.

Homework: Students should take a balloon the following session.

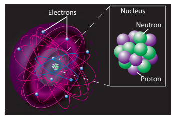


FIG. 4.14 Diagrams of the atom.

FIG. 4.15 Robert Millikan.

- If the Earth's attraction (the weight) of the drop were larger than the force of electric repulsion, the drop would continue falling, slowly.
- If the force of electric repulsion were larger than the weight, the oil drop would invert its movement and would go up.
- If both forces were equal, the drop would remain in the air.

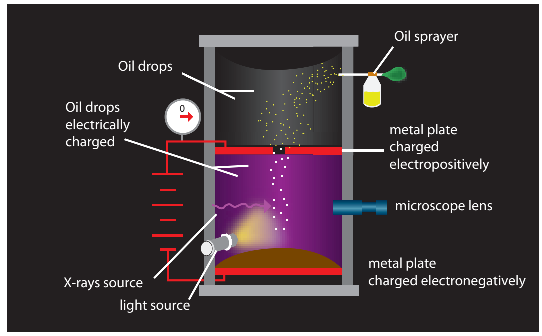


FIG. 4.16 Millikan's experiment.

He repeated the experiment hundreds of times to measure the charge of the drops and made sure they could only acquire values that were multiples of a fundamental value. Millikan calculated the electron charge: -1.602 x 10^{-19} C. As you learned, the proton's electric charge is the same as the one of the electron but with positive sign, that is why the minus sign is used in the electron to differentiate the charge.

Atoms, through chemical or physical processes, can gain or lose electrons. This turns an electrically neutral atom into an **ion**. If it gains an electron, it is called an **anion** (more electronegative), and if it loses an electron, it is called **cation** (more electropositive). This process is called ionization. Look at figure 4.17 where the process is shown.

ICT

Take a look at this website:

http://www.deciencias.net/simulaciones/quimica/atomo/millikan.htm

to see a simulation of Millikan's experiment of the oil droplet.

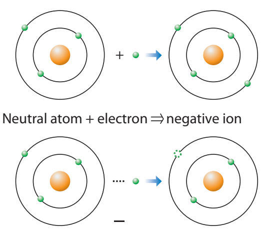


FIG. 4.17 Neutral atoms.

Electrons have a mass of 9.109382 x 10^{-31} kg, approximately 1,836 times less than that of protons and neutrons. A proton's mass is 1.672621 x 10^{-27} kg and a neutron's is 1.00137 times that of the proton– 1.674927 x 10^{-27} kg.

SKILLS DEVELOPMENT

Critical thinking skills: Remembering, comparing and contrasting.

EVALUATION OF CONTENT

Students should be able to answer the questions in the last activity correctly.

Scientific curiosity has led to the discovery of **quarks**, which are what particles of protons and neutrons are made of. There are six different types of quarks, and since several nomenclatures, of physical and chemical parameters were already taken, scientists decided to call the quarks *up, down, strange, charm, bottom* and *top*.

Quarks are classified by flavor. Not that one can taste them, but the tiny differences that distinguish them are called flavors. .

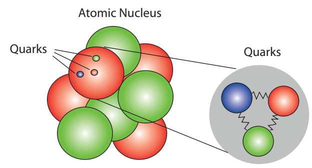


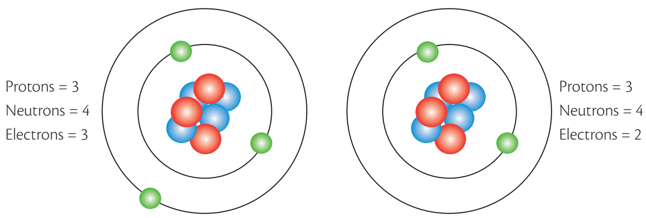
FIG. 4.18 Quarks making a proton: 2 up and 1 down.

Closing

How much did I learn?

Work in teams to answer the questions. Share your answers with the class.

1. According to fig. 4.19.
   a) What is the total charge of the atom on the left? Explain your answer.
   b) What is the total charge of the atom on the right? Explain your answer.



2. What must happen for an atom to have a total negative charge?
3. In your own words, explain what an ion is.

FIG. 4.19 Total charge of the atom.

Effects of Electrostatic Attraction and Repulsion

In unit 2 you studied the **force** of gravitational attraction, which depends on the attraction between masses. Now, you will study the force between charges, which can be of attraction or repulsion.

In Greece, during the fifth century BC, Thales of Miletus studied the electrification of materials. They learned that by rubbing materials, such as **amber** or wool, they would attract light bodies like papyrus or hair. They were said to be electrified, which meant they were "bewitched".

Scientists and philosophers studied this phenomena over time, helping to understand it. Among the most notable researchers was English physicist William Gilbert, who in 1600 published a book about the characteristics of electrification. German physicist Otto von Guericke, who studied electric machines and electrical processes on the atmosphere, such as rays; French physicist Rancois de Cisternay du Fay, who published in 1733 that electric charges could be differentiated in positive and negative; Dutch physicist Petrus van Musschenbroeck, who in 1746 created "Leyden's bottle", the precedent of the first condensers; American scientist Benjamin Franklin, who published an article about the conservation of electricity in 1747; French physicist Charles Coulomb, who in 1785 established the laws of **attraction** and **repulsion** of charged bodies, which helped **electromagnetic** studies become an exact science, not only a contemplative one; and Scottish physicist James Clerk Maxwell, who in 1873 published his works on classic electromagnetic theory, stating that electricity, magnetism and light are manifestations of the same phenomenon and had great influence on early twentieth century scientists.

Expected Learning

Describe the basic constitution of the atom and the characteristics of its components and explain some effects of electrostatic interaction in experimental activities and/or everyday situations.

SESSION INFORMATION

Week: 26

Session: 151

Expected learning outcome: Describe the basic constitution of the atom and the characteristics of its components and explain some effects of electrostatic interaction in experimental activities and/or every day situations.

CONTENT DELIVERY

Start: Students should rub the balloon on their head and then "stick" it on the wall. Then, they should try to explain why the balloon "sticks" to the wall. Elicit answers. Tell them they will study effects of electrostatic.

Development: Students should read the paragraph. Help with vocabulary. Ask students to write five questions about the information they read.

Closing: In pairs, they should exchange questions and answer each other's work.

SKILLS DEVELOPMENT

Logical/Mathematical skills: Experimenting.

Critical thinking skills: Creating questions.

Interpersonal skills: Exchanging information.

EVALUATION OF CONTENT

Students should get their questions checked by the teacher.

SESSION INFORMATION

Week: 26

Session: 152

Expected learning outcome: Describe the basic constitution of the atom and the characteristics of its components and explain some effects of electrostatic interaction in experimental activities and/or every day situations.

CONTENT DELIVERY

Start: Prepare the video mentioned in the ICT chart, page 102. Ask some comprehension-check questions.

Development: Then, have students read the page. Guide them little by little and explain how the law is applied in the end of the page.

Closing: Give students similar problems to the one at the bottom of the page. Guide them little by little so that they can solve problems using Coulomb's law by themselves.

Project preparation: In teams, students should get these materials the following session: a small glass jar (like a mayonnaise jar), a small sheet of Styrofoam or cork to use as a lid, aluminum foil of 10 cm, 15 cm of thick wire, insulating tape, a plastic comb, long nose pliers.

Curious Facts

The word electron comes from the Greek *elektron,* which means amber.

Glossary

Amber. Fossil resin of dark yellow color, opaque or semitransparent, very light, hard and brittle, of easy combustion.

Electromagnetism. Area of physics that studies the interaction of electric and magnetic fields.

ICT

Watch this video about Coulomb and his torsion balance.

http://www.youtube.com/watch?v=sM6n9-Ggd6k

Coulomb's Law

French physicist and engineer Charles-Augustin de Coulomb (1736 – 1806) was the first scientist to establish the quantitative laws of **electrostatic**, this is, he described in mathematical terms the electric forces between static charges. Coulomb invented the **balance of torsion**, between 1777 and 1785, to measure the force of attraction or repulsion that two electric charges exert on each other, and established the function that relates this force with **distance**. In his honor, the unit of electric charges is called Coulomb.

In his experiment, Coulomb measured the force between two electrically charged spheres and observed the angle in which a bar turned. His measurements allowed him to obtain the following conclusions where he established that:

1. The force of attraction or repulsion between two charges ***q1*** and ***q2*** is directly proportional to the product of both charges. Graph a) shows how the force increases linearly with the increase of one of the forces, ***q***.

$$F \propto q1\ q2$$

2. The increase or decrease of the force of attraction is inversely proportional to the square of the distance of separation, ***r***. If 3 units separate the bodies, then the force decreases one ninth, $\frac{1}{3^2} = \frac{1}{9}$. Graph b) shows how the force decreases quadratically with distance.

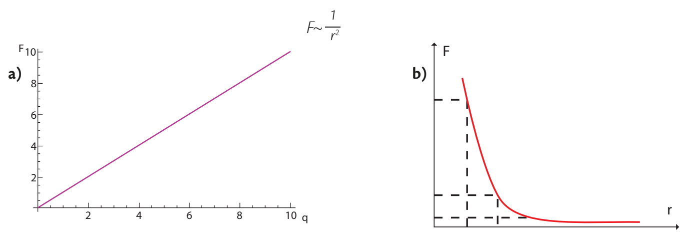


FIG. 4.20 a) Electric force is proportional to the product of the charges.
b) This force is inversely proportional to their squared distance

3. The electric force repels charges of the same sign, and attracts charges of different signs.

Finally, Coulomb's law states that:

The force is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.

The mathematical expression of this statement is as follows:

$$F = K\frac{q_1 q_2}{r^2}$$

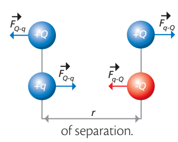


FIG. 4.21 Representation of Coulomb's Law of attraction and repulsion of charges.

In which, ***q1*** and ***q2*** are the electric charges, ***r²*** is the distance between them and ***K*** is Coulomb's constant. This constant value is ***K*** $= 9\times10^{9}\,\frac{Nm^2}{C^2}$

A coulomb is a unit of electric charge in the International Units System. It is equal to approximately 6.24×10^{18} electrons.

Now you will see how Coulomb's law is applied. Imagine there are two protons in a nucleus and they are separated by 5×10^{-15} m. Since the sign of the charges is the same, the electric force of repulsion between them is:

$$F = 9\times10^{9}\frac{Nm^2}{C^2}\ 1.60217733\times10^{-19}C\left(1.60217733\times10^{-19}C\right)\left(5\times10^{-15}m\right)^2 = 9.22N$$

102

Kells

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, problem solving.

EVALUATION OF CONTENT

Students should be able to solve problems using Coulomb's Law correctly.

Kells

Coulomb's law has limitations, because the mathematical expression is valid only for stationary charges (not moving). When the electric charges are moving, other much more complicated concepts have to be taken into account, especially if the particles' velocity is large, compared to the velocity of light.

Experiment

In teams of three, build an electroscope.
Construction of a homemade electroscope.
An electroscope is a simple instrument used to know if a body is electrically charged. It was created by William Gilbert. For your final project you will build a more complex one, similar to the one Gilbert built.

MATERIAL

- A small glass jar (like a jar of jam).
- A small sheet of Styrofoam or cork to use as a lid.
- Aluminum foil 1 cm x 10 cm.
- Thick wire 15 cm long.
- Electrical or insulating tape.
- One plastic comb.
- Electrician's pliers.

PROCEDURE

1. Cut the styrofoam or cork in a circle, a little larger than the top of the jar to make a lid.
2. Cover the wire with tape to insulate it, leaving 1 cm free at each end.
3. Stick the wire through the middle of the lid halfway down.
4. Use the pliers to bend the two ends of the wire and form a right angle.
5. Fold the aluminum foil and place it on the inside end of the wire.
6. Cover the jar with the lid and secure it with tape.
7. Rub the comb against your hair and bring it close to the outside end of the wire.

What happens to the aluminum foil? What charge do you obtain when you rub the comb against your hair?

ICT

Go to these sites to see two simulators of Coulomb's force:

http://www.educaplus.org/play-241-Fuerza-de-Coulomb.html

http://www.educaplus.org/play-240-Ley-de-Coulomb.html

Closing

How much did I learn?

Work as a team to answer the questions. Share your answers with the class.

Apply Coulomb's law to solve the following problems:

1. There are two spheres electrically charged with 4×10^{-8} y 2.3×10^{-7} C with a separation of 35 cm in air.
   a) Calculate the distance in meters.
   b) Calculate the electric force of both spheres.
   c) What is the force between them, attraction or repulsion? Explain your answer.
2. An electrically neutral object is given 2×10^{6} electrons. What is the value of its total charge after electrically charging it?
   a) Explain the reasoning you must use for the calculation.
   b) What is the value of its total charge?
   c) What is the force between them, attraction or repulsion? Explain your answer.
3. Calculate the distance between the electron and the proton in a hydrogen atom, if the force of attraction between them is 8.17×10^{-8} N.
4. What must be the distance between the charge $q1 = 26.3\ \mu C$ and the charge $q2 = 47.1\ \mu C$, for the force of attraction between them to be 5.66 N?
   a) Convert the charge to coulombs.
   b) Calculate the distance between the charges.

Curious Facts

A microcolumb is a measure of electric charge. Its symbol in the International System of Units is μC.

1C = 1'000,000 μC or
$1\mu C = 1 \times 10^{-6}$

SESSION INFORMATION

Week: 26

Session: 153

Expected learning outcome: Describe the basic constitution of the atom and the characteristics of its components and explain some effects of electrostatic interaction in experimental activities and/or every day situations.

CONTENT DELIVERY

Start: Check that each team has all the necessary materials they were asked to take to class.

Development: Students are going to build an electroscope. Guide them in the process. Monitor everyone is on task and actively participating.

Closing: Students should answer the questions in the section *How much did I learn?* (If there is not enough time, they can do the problems for homework).

SKILLS DEVELOPMENT

Visual/Spatial skills: Building models.

Critical thinking skills: Problem solving.

Logical/Mathematical skills: Problem solving.

EVALUATION OF CONTENT

Students should get their electroscope checked by the teacher. Everyone should actively participate in the building process.

SESSION INFORMATION

Week: 26

Session: 154

Expected learning outcome: Explain electric current and resistance based on the movement of electrons in materials.

CONTENT DELIVERY

Start: Check students' answers to the problems on page 103 in whole class.

Development: Divide the group in halves. One half will read the section *Electric current*. The second half will read the section *Direct Current and Alternate Current*. Once they finish, set opposites halves to share what they read. Then, check the page content in whole class. Ask them questions in order to get all of the information. Have students make diagrams if necessary.

Closing: Students should be able to tell apart direct and alternate current as well as say the definition of electric current.

Homework:

Students should do research on:

- Symbols for the elements of a circuit.
- Industrial uses of series and parallel circuits.
- Check if the electric connection in their house is in series or parallel.

→ **Expected Learning**

Explain electric current and resistance based on the movement of electrons in materials.

Electric and Resistant Current. Conductor and Isulating Materials

Electric Current

What we know as **electric current (I)** is the circulation or flow of electrons through a conductor material, for example, a piece of wire.

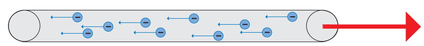


FIG. 4.22 An electroscope.

FIG. 4.23 Electric current.

An **electric circuit** is a group of elements set up in a way that allows the flow of electrons. These elements are: a generator or battery, conductor thread, a receiver like a lamp and a switch. The real orientation of current goes from a negative pole to a positive pole. However, because of the ignorance of the existence of electrons, the scientific community determined during the first studies, that electric current moved from the positive to the negative pole. In practice, this "historical error" does not affect the study of electric current.

The flow or movement of electron currents was determined by German physicist Georg Simon Ohm, who in 1827 formulated that the intensity of current, **I**, is directly proportional to voltage **V** (or differential of potential), and inversely proportional to resistance, **R**, of material, this is **I = V/R**. This means that if you apply force to the system or add energy, there is a larger flow of charges and if the material's resistance increases with the flow of charge in a poorly conductive material, this flow is reduced.

The units of measurements for these variables in the International System are:

I = intensity, in amperes (A)
V = voltage or differential of potential, in volts (V)
R = resistance, in ohms (Ω)

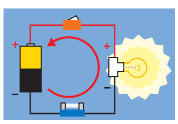


FIG. 4.24 In a closed electric circuit, current always flows from the negative to the positive pole of the generating source.

When electrons were discovered, it was also found that electric charges provided a source of **electromotive force**, and they moved from the negative sign (-) to the positive one (+) in a conductor, according to the law "different charges attract, equal charges repel".

Direct Current and Alternate Current

There are two types of electric current: direct (or continuous) and alternate. **Direct current** (DC) is the one in which electrons flow in a single orientation, while in **alternate current** (AC) electrons flow from one side to the other.

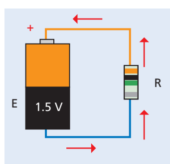


FIG. 4.25 Ohm's law diagram.

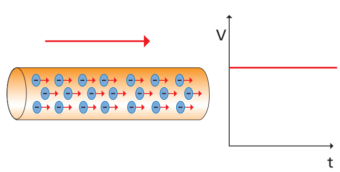


FIG. 4.26 All electrical devices must be tagged with their specifications.

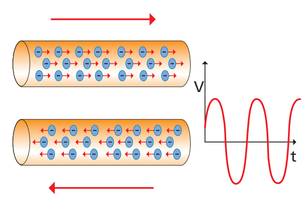


FIG. 4.27 Graphical representation of direct and alternate current.

According to the receiver we want to feed with energy, we must use one or the other. Most electrical devices use direct current, as they must control the flow of electrons selectively.

SKILLS DEVELOPMENT

Interpersonal skills: Sharing information.

Critical thinking skills: Paraphrasing.

Verbal/Linguistic skills: Teaching.

EVALUATION OF CONTENT

Students should actively teach a partner and they should name the definitions of electric current, alternate and direct current.

Circuits in Series and in Parallel

A circuit is an electric network where two or more components are connected, such as resistances, sources of electric energy, switches, etc., and has at least one closed trajectory. A node is a point of a circuit where several different components meet. Devices in a circuit can be connected in series, in parallel or mixed.

A **circuit in series** is a connection configuration in which the terminals of devices (generators, resistances, switches, etc.) are connected sequentially. The *out* terminal of device 1 is connected to the *in* terminal of device 2 and so on.

A **circuit in parallel** is a connection in which all the *in* terminal of devices are connected to each other, and so are their *out* terminals.

Curious Facts

The electric current phenomenon occurs because the electrons farthest from the nucleus of an atom can break apart from it and circulate among the atoms of the conductor material, as in metals.

➔ Activity

Read the following instructions and write the answers in your notebook.

1. Research and write down the symbols for the elements of a circuit.
2. Find out if the electric connection in your house is in series or parallel, and which one uses up more energy.
3. Research the industrial uses of series and parallel circuits.

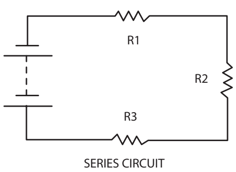


FIG. 4.28 Electric circuit connected in series.

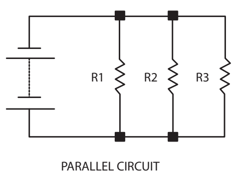


FIG. 4.29 Electric circuit connected in paralle.

The impediment of the flow of electrons through a material is known as **electric resistance**. In general, the electrons of the highest **valence band** in an atom tend to separate by physical or chemical processes. Then the electron flows freely through the **conductivity band**, but it constantly crashes on the electrons of other materials. Some materials facilitate the flow of electrons and are called conductors; others allow selectively the flow of current and are called **semiconductors**, while others do not allow the flow of current and are called **insulators**. A material with a large impediment to electric flow will tend to raise its temperature because of the continuous collision of electrons through the material. If the temperature is high enough, it can emit light. This principle was used in the creation of the first light bulbs, in which current flows through a tungsten resistance (which does not burn because of the vacuum inside the bulb), or applied in toasters, which raise their temperature when the electrons flow through the filaments.

FIG. 4.30 Heat caused by the resistance of a toaster warms the bread.

Many materials, including metals, change their conductivity conditions according to the temperature in the environment. For example, copper decreases 2% its conductivity capacity, if temperature rises 5°C. On the other hand, some semiconductors such as, carbon or germanium decrease their insulating capacity if their temperature rises.

The difference of energy between the valence band and the conductivity band is what produces good or bad conductors of electric current. A small breach is the cause of a better electric conductivity at low environmental temperatures. For example, at 20°C, the best electric conductor is silver (Ag), followed by copper (Cu), gold (Au), aluminum (Al) and seawater.

SESSION INFORMATION

Week: 26

Session: 155

Expected learning outcome: Explain electric current and resistance based on the movement of electrons in materials.

CONTENT DELIVERY

Start: Students should read the page introduction.

Development: They should get their research checked by the teacher. In whole class, ask for the symbols of the elements in a circuit and what the difference is between a series circuit and a parallel one. Get students to read the rest of the page. Help them with diagrams so they understand how each circuit works.

Closing: Ask students comprehension-check questions about the information in the rest of the page.

SKILLS DEVELOPMENT

Reading skills: Reading for detail, scanning.

EVALUATION OF CONTENT

Students should be able to respond to your comprehension-check questions correctly.

SESSION INFORMATION

Weeks: 26

Session: 156

Expected learning outcome: Explain electric current and resistance based on the movement of electrons in materials.

CONTENT DELIVERY

The end of the first objective

Start: Students should read the first part of the page.

Development: In teams, they should answer the questions in the section *How much did I learn?* Elicit answers in whole class.

Closing: Wrap the topic up verifying students can explain electric current and resistance based on the movement of electrons in materials.

Project preparation: In teams, students are going to build an electromagnet and perform some tests. They will need: a 10cm nail, 30 cm of insulated copper wire, a 1.5 volt and a 9 volt batteries, paper clips and other metal objects, insulating tape, a compass and a piece of flat, wooden surface.

Water is a good conductor of electricity, as long as it has many mineral salts. Pure water, without these salts, is a poor conductor.

One of the most worrying issues about electricity conductivity is the so-called "short circuit" that has caused many fires in houses and businesses. If the current flow is too strong, the wire will not be able to hold it and will start to get warm and in the best-case scenario, to melt, which will cause the current to stop flowing and start a fire.

That is why factories cover the wires with plastic, which is an insulating material. They also produce heavy-duty wires: if a device needs a lot of current in order to work, as in an iron or a microwave oven, the wire is made thicker to allow the flow of a larger number of electrons and avoid accidents.

Short circuits are also produced there is an overload of current; imagine you connect a microwave oven, a washing machine, a toaster, an iron, an electrical water heater and the TV to the same outlet, and you turn them on at the same time.

Closing

How much did I learn?

Work as a team to answer the questions. Share your answers with the class.

1. Research which materials are the best conductors of electricity and why.
2. Research what is the best insulating material and where it is used.
3. Find four examples of semiconductor materials and their applications in industry.
4. Write down a list of five electric devices that use resistances, besides the ones mentioned and explain their function inside them.

Electromagnetic Phenomena and Their Importance

Expected Learning

Identify ideas and experiments that led to the discovery of electromagnetic induction.

Discovery of Magnetic Induction: Experiments of Oersted and Faraday

A magnetic field is the space surrounding a magnetized object. Magnetic fields cannot be seen, so it is necessary to use iron dust and watch the shapes form around the magnets.

Exploring Knowledge

Do you think electricity and magnetism are related? How?

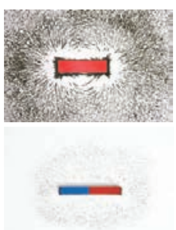


FIG. 4.31 A magnet allows us to see the effect of its magnetic field.

The lines formed by iron dust are called lines of magnetic field. For a magnet, it is said that these lines come in through the South Pole and go out through the North Pole.

If we run the above experiment several times, and watch what happens carefully, we will prove that the magnetic fields produced by the magnets create lines that go out from the North Pole to come in through the South Pole.

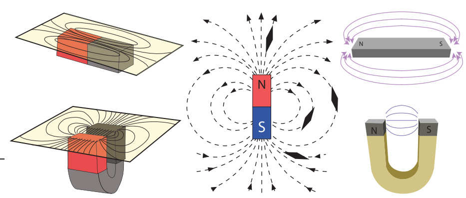


FIG. 4.32 Magnetic field lines.

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Critical thinking skills: Analyzing.

EVALUATION OF CONTENT

Students should answer the closing activity with appropriate answers.

In 1820, physicist-chemist Hans Christian Oersted discovered the relationship between the flow of electric currents and magnetism when he realized a compass changed orientation when close to an electric current. This discovery called the attention of French physicist André-Marie Ampere, who in 1825 validated Oesrted's discovery. He explained that electricity flow through a wire created a magnetic field, so the wire could behave as a magnet. His work founded the field of electromagnetism.

These advancements were the foundation for English physicist Michael Faraday, who before focusing on electromagnetism, was studying the works of Coratian scientist Roggero Boscovich. Boscovich said at the end of seventeenth century that atoms possessed positive and negative charges, inspiring Faraday in several ideas on molecule links. In 1831, Faraday presented his works on magnetic induction. He made a magnet rotate inside a bobbin to induce an electric current flow in wires, which would be the precedent of dynamo and electric engines.

FIG. 4.33 Hans Christian Oersted.

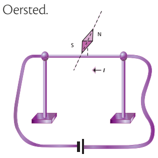


FIG. 4.34 Oersted's experiment.

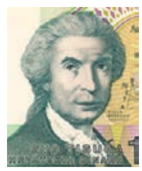


FIG. 4.35 Roggero Giuseppe Boscovich.

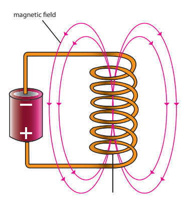


FIG. 4.38 Dynamo.

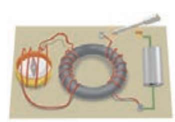


FIG. 4.39 Faraday's electrical engine.

FIG. 4.36 André-Marie Ampere.

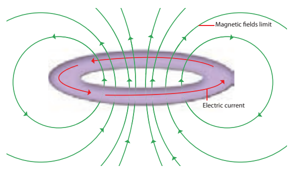


FIG. 4.37 Magnetic field of objects.

Closing

How much did I learn?

Build your own electromagnet. You will need one 10 cm nail, 30 cm of insulated copper wire, 1.5-volt and 9-volt batteries, paper clips and other metal objects, electrical or insulating tape and a compass. You must work on a flat, wooden surface.

1. Roll the wire on the nail leaving the ends loose. Peel the ends of the wire to connect them to the 1.5-volt battery with electric tape, as shown in the figure below.

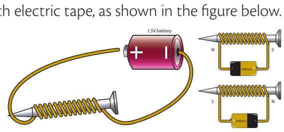


FIG. 4.40 How to build an electromagnet.

In the following website you will find a video showing how to build your electromagnet step by step: http://www.youtube.com/watch?v=8Ys0yubmE4

2. Connect one end of the wire to the negative pole of the battery and the other end to the positive pole.

- Leave the device on the table and bring the clip close. What happens?
- Now bring the compass close. What happens?
- Repeat the steps using the 9-volt battery. What differences can you find? Describe your observations in your notebook and explain why they happen.

Watch the following video and build a simple electric engine. Write the materials and the procedure in your notebook.
http://www.youtube.com/watch?v=Hwv4I0-Xx1M

107

SESSION INFORMATION

Week: 27

Sessions: 157 - 159

Expected learning outcome: Identify ideas and experiments that led to the discovery of electromagnetic induction.

CONTENT DELIVERY

Start: Students should start reading on page 106 *Discovery of Magnetic Induction: Experiments of Ørsted and Faraday.*

Development: They should go on to page 107. Ask them comprehension-check questions to verify they understand the experiments.

Closing: Students should make an electromagnet and try some tests.

Project preparation: Divide the group into three teams. Each team will present one of the three pieces of information described on page 108, in the section *How much did I learn?* Remind students what you will evaluate in their presentation: Relevant, clear information, visuals, five comprehension-check questions and further information.

SKILLS DEVELOPMENT

Visual/Spatial skills: Building a model.

Interpersonal skills: Working as team members.

Critical thinking skills: Summarizing data.

EVALUATION OF CONTENT

Students should actively participate in the electromagnet making and further tests.

SESSION INFORMATION

Week: 27

Sessions: 160, 161

Expected learning outcome: Value the importance of applications for electromagnetism to obtain electric current or a magnetic force in technological developments of every day use.

Identify the characteristics of waves in an electromagnetic spectrum and in a visible spectrum; as well as relate them to their technological use.

CONTENT DELIVERY

In session 160: students should give their presentations. Follow the projects rubrics on page 164.

Start: Students should answer the questions in the section *Exploring knowledge*. Elicit answers.

Development: Have students read the information in the section *Composition and Decomposition of White light*. Guide them in the process to understand how light can be decomposed. If possible, show them a video or the experiment with a crystal prism.

Closing: Students should tell the wavelengths which are visible to human eyes.

Expected Learning

Value the importance of applications for electromagnetism to obtain electric current or a magnetic force in technological developments of everyday use.

Curious Facts

Electric currents can be produced by the action of a magnetic field, as in electromagnets. When an electric current flows on a piece of wire or metal a magnetic force is produced. This is the principle of the electric engine.

The Electromagnet and Applications of Electromagnetism

Electric currents, which are nothing but the flow of electrons, produce friction and heat that dissipates. This loss of energy is proportional to the square of the flowing current's value. The measuring units of electric currents are amperes. An ampere is defined as the flow of a Coulomb, the unit of electric charge, per second, which equals the flow of 6.2×10^{18} electrons, this is, more than 3 thousand million electrons per second.

In buildings, the distributed electric current that makes appliances work is about 100 amperes; a light bulb recibesz about 1 ampere. You can check the consumption of each electrical appliance in the instructions manual.

Closing

How much did I learn?

Work as a team to answer the questions. Share your answers with the class.

1. Do some research about how electromagnetism is used in the following devices: a telephone, radio speakers, a compact disc and computers.
2. Draw diagrams on a piece of cardboard to explain what you found out.
3. Present your conclusion to the class.

Expected Learning

Identify the characteristics of waves in an electromagnetic spectrum and in a visible spectrum, and relate them to their technological use.

Composition and Decomposition of White Light

Exploring Knowledge

1. What is visible light?
2. What is white light?

Ever since the time of the Arabs, it was known that white light was composed of several colors, but it was not until Isaac Newton used prisms to decompose white light in colors that this phenomenon was clearly understood.

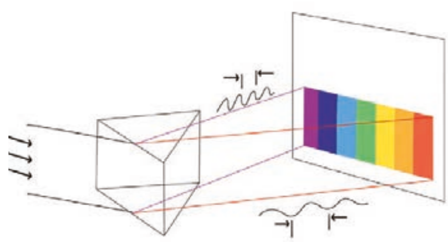


FIG. 4.41 Decomposition of white light into colors by a prism.

However, a doubt remained: why were there different colors and what caused this phenomenon? Several scientists tried for years to establish a theory of color. In 1900, German scientist Max Planck finally came up with an explanation: colors are different because each one has a different wavelength; the most intense red we can appreciate with sight has a wavelength of 780 nanometers, which is one billionth of a meter, while the darkest violet we can see has a wavelength of 400 nanometers.

Closing

The human eye cannot see wavelengths over 780 nanometers or under 400 nanometers; this range is called the visible spectrum. The electromagnetic spectrum is much larger than the visible one and comprises wavelengths from 10-13 meters to 108 meters.

SKILLS DEVELOPMENT

Critical thinking skills: Analyzing, summarizing.

Interpersonal skills: Working as team members.

EVALUATION OF CONTENT

Session 160: Everyone should actively participate in the presentations.

Session 161: Students should be able to identify wavelengths visible to human eyes.

Characteristics of Electromagnetic and Visible Spectrum: Velocity, Frequency, Wavelength and Their Relation with Energy

Exploring Knowledge

1. What is the electromagnetic spectrum?
2. What are UV rays and why are they dangerous to our skin?
3. Are radio waves and sound waves the same? Explain your answer.
4. Write the fundamental differences between sound and light waves.

Expected Learning

Identify some characteristics of waves in an electromagnetic spectrum and in a visible spectrum, and relate them to their technological use.

Electromagnetic radiation is a combination of electric and magnetic fields that oscillate and travel through space, carrying energy from one place to another.

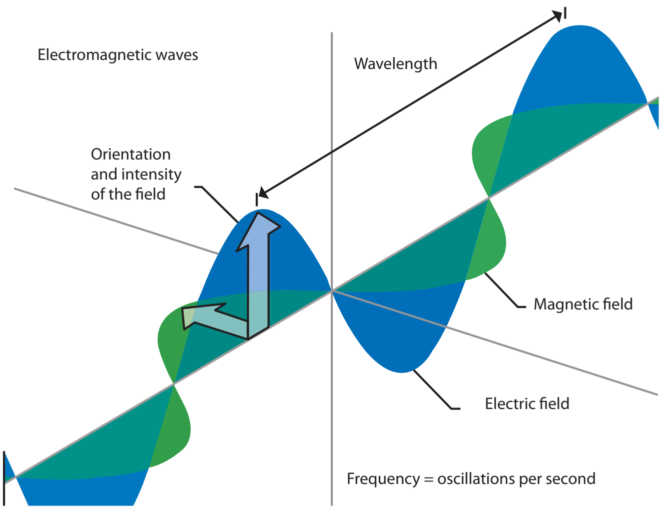


FIG. 4.42 Magnetic waves.

Electromagnetic radiation can be manifested in different way, such as, the heat radiating from a hot object, visible light or X-rays. As you learned in unit 1, light is a wave, but unlike sound, it does not need a material medium to propagate, it can travel in a vacuum.

In the nineteenth century, it was thought that there was an undetectable substance, called ether, which occupied vacuum and worked as a means of propagation for waves.

The range of all electromagnetic waves can be represented in a spectrum. In the spectrum, we can classify electromagnetic waves by length and frequency. In figure 4.43, you can see a spectrum divided by wavelength and frequency, the interval to which it belongs and an example of its source. For example, for microwave oven emissions, the wavelength is measured in centimeters, which places them in the infrared, with a frequency of 10^{12} Hertz (10^{12} waves or cycles per second) and in the section of non-ionizing energies. The higher the frequency, the more energy the wave possesses, as in the case of X-rays. Based on all this, what characteristics does visible light have in the spectrum?

SESSION INFORMATION

Weeks: 27, 28

Sessions: 162, 163

Expected learning outcome: Identify the characteristics of waves in an electromagnetic spectrum and in a visible spectrum; as well as relate them to their technological use.

CONTENT DELIVERY

Start: Students should answer the questions in the section *Exploring Knowledge* in pairs. They might look for the answers with the help of an internet browser. Elicit answers in whole class.

Development: Students should read the rest of the page. Ask comprehension-check questions. Elicit answers in whole class to verify students understand the model.

Closing: Students should identify characteristics of waves in an electromagnetic spectrum.

Homework: Divide students into three teams. Each team will present one of the following topics: topics in the section *Activity* on page 110. Remind students what you will evaluate, follow the Projects' Rubrics on page 164.

SKILLS DEVELOPMENT

Interpersonal skills: Working in pairs.

Critical thinking skills: Imagining.

Reading skills: Reading for detail.

EVALUATION OF CONTENT

Students should identify characteristics of waves in an electromagnetic spectrum.

SESSION INFORMATION

Week: 28

Sessions: 164, 165

Expected learning outcome: Identify the characteristics of waves in an electromagnetic spectrum and in a visible spectrum; as well as relate them to their technological use.

CONTENT DELIVERY

Start: Have students analyze the image on top of page 110. They should explain it. Elicit answers and guide them in the process.

Development: Students should read the information below figure 4.43. Ask comprehension-check questions about it.

Closing: Teams should present their research in whole class. Guide them and help them as necessary.

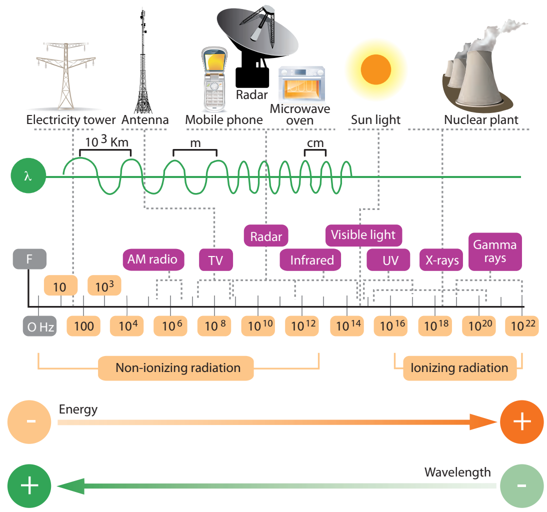


FIG. 4.43 Divisions of electromagnetic spectrum.

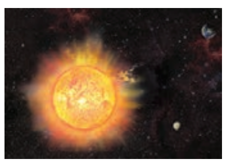


FIG. 4.44 The Sun emits UV rays.

Ultraviolet light can notably affect the life on the Earth. Ultraviolet radiation or UV rays have a shorter wavelength than the violet side of the visible spectrum. As it possesses a lot of energy, it can break chemical links, making the molecules exceptionally active, or ionizing them, which changes their behavior. Sunburns, for example, are caused by the harming effects of UV radiation on skin cells and can even cause skin cancer if the radiation reaches the complex DNA molecules in the cells. The sun emits a large amount of UV radiation, which could turn the Earth into a barren desert if it were not mostly absorbed by the ozone layer of the atmosphere before reaching the surface.

➔ Activity

1. Do some research about what electromagnetic pollution is and how it affects our daily life.
2. Why is light pollution a problem for astronomers watching the universe with optical telescopes?
3. Explain why, when you bring a mobile phone to a microwave oven, its signal gets distorted.

Using the frequency of electromagnetic radiation, we can calculate how much energy it carries when moving. We will use what you studied in Unit 1 to calculate the velocity of a wave:

$$c = \lambda \cdot v$$

In which **c** is the velocity of light in vacuum, **λ** is the wavelength and **v** is the wave frequency. The velocity of light is a constant we know, and if we also know the wavelength or the frequency of electromagnetic radiation whose energy we want to calculate, then we use the following equation:

$$E = h\nu \quad \text{or} \quad E = \frac{hc}{\lambda}$$

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Critical thinking skills: Describing pictures.

EVALUATION OF CONTENT

Students should be able to name characteristics of waves in the electromagnetic spectrum.

In which E is the energy and h is Planck's constant. Planck's constant is the relationship between the amount of energy and the frequency associated with an electromagnetic wave. Its value is 6.628×10^{-34} *J*•s. According to Planck, the bigger the wavelength, the shorter the frequency, therefore there is less energy. Analyze the next example.

We will use an average value for visible light of $\lambda = 750\ nm$ and an approximate value for the velocity of light of $3 \times 10^{8} \frac{m}{s}$. First, we must convert the nanometers to meters and then use Planck's equation:

$$1\ nm = 1 \times 10^{-9}\ m;\ 750\ nm : 7.5 \times 10^{-7}\ m$$

$$E_{light} = \frac{\left(6.628 \times 10^{-34} J \cdot s\right)\left(3 \times 10^{8} \frac{m}{s}\right)}{7.5 \times 10^{-7} m} = 2.6512 \times 10^{-19} \text{Joules}$$

Next, we will do the calculations for X-rays:

$$\lambda_{Xr} = 750\ nm = 7.5 \times 10^{-7}\ m$$

$$E_{Xr} = \frac{\left(6.628 \times 10^{-34} J \cdot s\right)\left(3 \times 10^{8} \frac{m}{s}\right)}{0.75 \times 10^{-8} m} = 1.988 \times 10^{-18}\ J \approx 2 \times 10^{-18}\ J$$

$$\frac{E_{Xr}}{E_{light}} = \frac{2 \text{ X } 10^{-18}}{2.65067 \text{ X } 10^{-19}} = 7.543754\ J$$

The result tells us that X-rays possess almost eight times as much energy, as the upper band of visible light.

Closing

How much did I learn?

Work with a team to answer the questions. Share your answers with the class to reach a final answer.

1. Do some research on the value of the wavelength or frequency of the colors comprising visible light.
2. Then, use Planck's equation to calculate their energy.
3. Finally, compare these values to microwaves ($\lambda \approx 30$ cm) and extreme UV rays ($\lambda \approx 200$ nm).
4. What can you say about UV rays' energy regarding visible light? And about microwave radiation? Write your conclusions in your notebook.

Light as Wave and Particle

Exploring Knowledge

Work in teams to research and answer the questions:

1. What is a photon?
2. What characteristics does a wave have?

Expected Learning

Relate the emission of electromagnetic radiation with orbital changes of electrons in the atom.

Research on the nature of light is ongoing, but experiments have shown that it sometimes behaves as particles and other times as waves.

SESSION INFORMATION

Week: 28

Sessions: 166, 167

Expected learning outcome: Identify the characteristics of waves in an electromagnetic spectrum and in a visible spectrum; as well as relate them to their technological use.

CONTENT DELIVERY

Start: Students should read the last part of page 110 and the equation solution on page 111. Guide them little by little and with more examples.

Development: Students should use the same equation in other problems. Do further research to get them more problems.

Closing: Students should do research to answer the questions in the section *How much did I learn?* It is advisable that they do it for homework.

SKILLS DEVELOPMENT

Critical thinking skills: Problem solving.

EVALUATION OF CONTENT

Students should be able to follow the procedure to use the equation to calculate how much energy a specific amount of radiation carries.

111

SESSION INFORMATION

Week: 28

Session: 168

Expected learning outcome: Relate the emission of electromagnetic radiation with orbital changes of electrons in the atom.

CONTENT DELIVERY

Start: In teams of four, students should look for the definition of photon and the characteristics of a wave. Elicit answers in whole class.

Development: Students should read page 112. Then, every team will write a seven-question quiz. Check every quiz.

Closing: Teams will exchange quizzes and answer each other's. Elicit answers in whole class.

Homework: Students should do research to answer the questions in the section *How much did I learn?* At the bottom of the page.

ICT

Watch this video on the duality of light:

http://www.youtube.com/watch?v=sDM6QE-wemU

Light as a Wave

The undulatory theory states that the energy of an electromagnetic wave is distributed in equal parts between electric (E) and magnetic (B) fields which are mutually perpendicular, and that both fields oscillate perpendicularly to the orientation of wave movement, as you learned in section 4.2.4.

In 1801, English physicist Thomas Young proved the undulatory nature of light when he passed a ray of light through two small holes, finding light and dark band patterns. Dark bands were the result of both waves cancelling each other.

FIG. 4.46 Thomas Young.

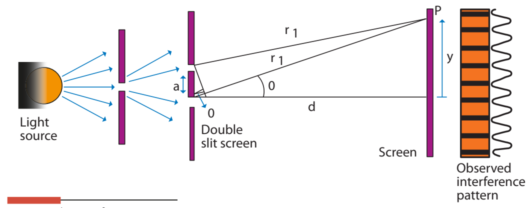


FIG. 4.45 Light interference.

The most important event related to the undulatory theory of light was the work of James Clerk Maxwell, who in 1873 proved that the light was a form of high-frequency electromagnetic wave. In 1887, German physicist Heinrich Rudolf Hertz experimentally confirmed Maxwell's theory by producing and detecting electromagnetic waves. He also proved that electromagnetic waves reflect, refract and possess all the characteristics of waves.

However, other works confirmed the corpuscular nature of light. In 1900, German physicist Max Planck established the quantic theory, which postulated that energy is not transmitted in a continuous manner, but by packets called quantum. Albert Einstein took Planck's works and in 1905 he wrote a paper about the photoelectric effect, in which he explains that light is carried in quantized packets he called photons. When these photons crash on the surface of any given material whose electrons are far away from the nucleus, they transmit their energy to the electrons on the valence band, which jump from the atom producing electric current.

FIG. 4.47 Max Planck.

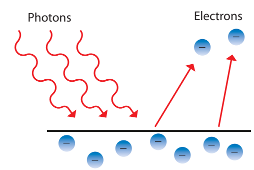


FIG. 4.49 Photoelectric effect.

FIG. 4.48 Albert Einstein.

Closing

How much did I learn?

Work in teams to answer the questions. Share your answers with the class.

1. Do some research on three applications of the photoelectric effect.
2. How was the velocity of light calculated?
3. Is the velocity of light always the same, no matter the medium it is traveling in? Why?
4. Do some research and explain what the effect of constructive interference is.

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Critical thinking skills: Formulating questions.

Reading skills: Scanning, reading for detail.

EVALUATION OF CONTENT

Students should get their quizzes checked by the teacher.

Energy and Its Use

Manifestations of Energy: Electricity and Electromagnetic Radiation

As you know, there are two complementary fields of study of electrical phenomena. One is the field

Exploring Knowledge

Answer the following question in your notebook.

1. What is light?
2. Why do we see colors?
3. What is an electromagnetic spectrum?

of electrostatics, which is when an electron is in a state of rest and the interaction of electrical forces (attraction and repulsion) between charges is studied, formalized by Coulomb's equation. The second field of study is electromagnetics, which is when the electron is in movement creating a magnetic field around its displacement trajectory and is explained by the works of Ampere and Faraday. Maxwell explained that electromagnetic waves could radiate (propagate) in a vacuum with a speed of almost 300,000 km/s. This was one of the main works to overthrow the theory of ether, which considered that light, because of its undulatory character, should propagate using some kind of material means. Finally, works by Planck and Einstein supported the property of particle of light and the existence of the photon as an energy transmitter. All of the above establishes that radiation can have two natures, an undulatory one and a corpuscular one. In 1924, French physicist Louis de Broglie wrote that both manifestations can be categorized in one single name: "ondicles". From the undulatory point of view, spectral ranges of radiation can be studied through an electromagnetic spectrum.

Another manifestation of energy is the gamma ray. Gamma rays possess the most energy and, therefore, are the most penetrating and dangerous. Their wavelength is extremely low, from 6 thousandths of a nanometer to 3 femtometers (1 femtometer is one quadrillionth of a meter). They are produced in nuclear reactions, which is what makes them so dangerous. These rays were responsible for the death of many people in the atomic explosions in the cities of Hiroshima and Nagasaki, Japan in 1945.

Expected Learning

Relate electricity and electromagnetic radiation as energy manifestations and value their use in human activities.

Closing

How much did I learn?

Answer the following questions in your notebook:

1. Is there any material gamma rays cannot penetrate? Think about the density of some materials.
2. What is radioactivity?
3. What are radioactive materials and what is their use?

SESSION INFORMATION

Week: 29

Sessions: 169 - 171

Expected learning outcome: Relate electricity and electromagnetic radiation as energy manifestations and value their use in human activities.

CONTENT DELIVERY

Start: Check students' research on Light as a wave. Then, they should answer the questions in the section *Exploring Knowledge* in pairs. Elicit answers in whole class.

Development: Students should read the page. Guide them in the process.

Closing: In pairs, students should mind map the information.

Homework: Students should answer the questions in the section *How much did I learn?*

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Critical thinking skills: Mind mapping.

EVALUATION OF CONTENT

Students should get their mind maps checked by the teacher.

SESSION INFORMATION

Week: 29

Session: 172

Expected learning outcome: Recognize benefits and damage in nature and society related to the production and use of energy.

CONTENT DELIVERY

Start: Check students' homework research. Elicit the definition of energy.

Development: Divide the group into five teams. Each team will present one of the following topics, explained on pages 114 to 117: *Obtaining and using Energy introduction, Hydroelectric plants, nuclear power plants, Eolic energy, solar energy and Importance of Energy Use Oriented to Sustainable Consumption* during the following five to six sessions. Explain what you will evaluate in the presentations: Relevant, clear information, visuals, five comprehension-check questions, further information, collaborative work and language use.

Closing: Verify everyone knows what to present.

Expected Learning

Recognize benefits and damage in nature and society related to the obtainment and use of energy.

Obtaining and Using Energy. Benefits and Risks in Nature and Society

Exploring Knowledge

1. Write down the types of energy you know and give two examples of each one.
2. Explain:
   a) Wind energy.
   b) Nuclear energy.

You already know there are different types of energy and now you will study how some types of energy are used to obtain electric energy, as well as the risks and benefits of their use in society. There are several ways to obtain electric energy: through thermal, hydroelectric or nuclear power stations, **wind energy** and **solar energy**.

FIG. 4.50 A thermal plant.

Thermal or thermoelectric power stations produce electricity by burning carbon or oil. Basically, the plant is a gigantic cauldron, which raises the temperature of water when fuel is burnt, as shown in Fig. 4.51. Water is vaporized and released at high pressure, making **turbines** rotate at high speed. Turbines are connected to a generator, which produces electricity that goes to transformers, which raise the voltage up to 400,000 volts. The advantage of these plants is their easy design and construction. Their disadvantage is the crisis in the price of fuel, its coming scarcity and harm to the environment from emission of pollutants.

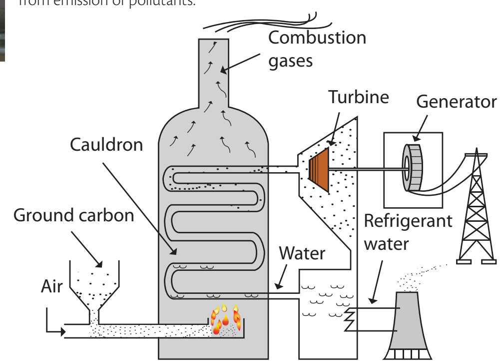


FIG. 4.51 Mechanism and turbine of a thermal plant.

Hydroelectric Plants

Hydroelectric plants, unlike thermal plants, only need the free fall of water through a dam to move the turbines. These plants are characterized by their height. The higher they are, the more potential energy, which turns into kinetic energy when the water falls, pushing the turbines and making generators work. The advantage of these plants is their cleanliness, since they do not pollute and produce sufficient energy. Their disadvantage is the price of construction. Also, there are not many rivers at high altitudes and building dams to raise the water level floods valleys, harms the local ecology and wipes out small towns.

SKILLS DEVELOPMENT

Interpersonal skills: Working as team members.

Critical thinking skills: Summarizing.

Verbal/Linguistic skills: Teaching others.

EVALUATION OF CONTENT

You will evaluate this session along with their presentations.

FIG. 4.52 A hydroelectric plant.

FIG. 4.53 Nuclear plant in Laguna Verde, Veracruz.

Nuclear Plants

Nuclear plants work in a very similar way to thermoelectric plants. The fission power of the atom of materials such as uranium is used to heat an insulated cauldron. This **nuclear fission** heats water that vaporizes and makes turbines rotate. The connected generator then produces electricity. The advantage is that a large amount of clean and efficient energy can be produced to supply an entire country. The disadvantage is that storing the atomic residue when it is no longer useful as fuel is expensive and complicated, as it emits radiation harmful to human health and remains active for thousands of years.

Glossary

Nuclear fission. It is the break of the nucleus of an atom, which releases energy produced by bombardment with neutrons of the nucleus.

➔ Activity

1. Explain what the greenhouse effect is and illustrate it.
2. Do some research and explain what acid rain is and why it is a pollutant.
3. Investigate what happens to the carbon residues of combustion in thermal plants.
4. Do some research about what the nuclear fission reaction is.
5. Research the nuclear accident in the Chernobyl nuclear plant and explain the main risks with these plants.

We call **renewable energies** or **green energies** those that produce a lesser impact on the environment and do not need any kind of fuel to work.

Eolian Energy

Eolian energy is obtained from wind. This is the kinetic energy produced by the effect of air currents. It belongs to the group of renewable energies, also called alternative energies. The aero generators use the wind to produce electric energy through the movement of their blades (mechanical energy). An aero generator is an electric generator moved by a turbine and pushed by wind (eolian turbine).

Plan of a wind turbine:

1. Ground
2. Connection to electric network
3. Contention tower
4. Access stairs
5. Orientation system
6. Gondola
7. Generator
8. Anemometer (used to measure the velocity of wind)
9. Brake
10. Transmission
11. Blades
12. Rotor blade to right
13. Pitch

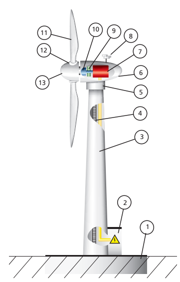


FIG. 4.54 Wind turbine.

SESSION INFORMATION

Week: 29

Sessions: 173, 174

Expected learning outcome: Recognize benefits and damage in nature and society related to the production and use of energy.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

SESSION INFORMATION

Week: 30

Sessions: 175, 176

Expected learning outcome: Recognize benefits and damage in nature and society related to the production and use of energy.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

Its advantage is the low cost of design and construction and the clean energy it produces. Its disadvantage is that the aero generator must be installed in an area with intense and continuous wind to produce enough electricity, far from urban centers to avoid sound pollution. In addition, it has been found that the use of these aero generators, affect the conduct pattern of birds and bats living in the area, as well as the migration pattern of some birds.

Solar Energy

Solar energy is energy produced by the Sun. The amount of solar energy that can be collected depends on the orientation of the receiving device. Collecting direct solar energy requires some devices called solar collectors. Once collected, energy is used in thermic, photoelectric or photovoltaic processes. In thermic processes, solar energy is distributed to heat a gas or a liquid that is then distributed. In the photovoltaic processes, solar energy is converted to electric energy without any other device. There are two types of solar collectors: flat plate or concentration. The disadvantage of photovoltaic devices is that they are not very efficient in the conversion of light into electricity. To satisfy the needs of a middle-size city, large extensions of land would be required to be covered with photovoltaic panels.

Flat plate collectors receive solar radiation in an absorption plate through which a carrying fluid runs. This liquid or gas fluid is heated when it goes through the heat transfer channels. The energy transferred by the carrying fluid, divided by the solar energy falling on the collector and expressed in a percentage, is called instantaneous efficiency of the collector. Flat plate collectors have the capacity to heat carrying fluids up to 82°C and obtain between 40 and 80% of efficiency.

For applications such as air conditioning and central generation of energy and heat to cover industrial needs, flat plate collectors do not supply, in general terms, fluids with temperatures high enough to be efficient. Concentrators must be placed to follow the Sun in order to be efficient; the moving devices are called heliostates.

FIG. 4.55 Solar cell.

Closing

How much did I learn?

Work in teams to answer the questions. Share your answers with the class.

1. Investigate if eolian and solar energy are used in Mexico to produce electricity, how this is done and in which other countries it is used.
2. Do some research about where the nuclear plant of Laguna Verde is located, if it is still working and if there is any risk for nearby population. You can find many articles about this topic on the Internet, newspapers and magazines.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

Importance of Energy Use Oriented to Sustainable Consumption

Sustainable consumption is the optimal use of energy, from the moment it is produced to its final consumption. On the other hand, energy efficiency is the group of actions that favor the reduction of energy use, without affecting the needs of the population. In other words, there is a lesser use of energy with the same outcome as the present one. **Sustainable use** looks to guarantee the electric supply and at the same time, reduce the **impact on the environment**.

Exploring Knowledge

Answer the following questions in your notebook:

1. Make a list of how many electrical devices you use every day and for how long.
2. Include in the list the ones your family uses.
3. How do you think you can, as a family, save **electric energy**?
4. Do you think there is an efficient way to save electric energy?

There are state and federal government programs to use energy and encourage sustainable consumption, but individual actions count for a lot. We must implement actions to efficiently use energy at home and at school. You can check the **appliances** at home, such as: iron, refrigerator, microwave oven, etc., as these devices cause 30% of the world **consumption of energy**. To reduce the consumption in this area, electro domestic appliances need to be working properly, you must unplug the ones you are not using and, if possible, change appliances like refrigerators and washing machine to en**ergy-saving** models.

When we talk about lighting, the world consumption of electricity to light houses, stores, movie theaters, schools and other places represent one fifth of the total consumption of the planet. If we change light bulbs to those that save electricity and we do not turn on lights we do not need or use, we will give our planet a break.

Regarding transportation, we have to make sure our cars work properly. If you a bicycle, walk, share a vehicle or use public transportation like the subway or energy-efficient buses, we could ensure the planet continues providing the resources we need without damaging the environment. What are you doing to use and save energy?

Expected Learning

Discuss the importance of developing basic actions for the sustainable consumption of energy at home and at school.

FIG. 4.56 Lighting represents the fifth part of the total consumption of the planet.

FIG. 4.57 Electric transportation is an ecological way to travel.

Closing

How much did I learn?

Work as a team to answer the questions. Share your answers with the class.

1. How many light bulbs are there in your house?
2. How long is each one in use?
3. What is the wattage of each one?
4. Do the calculations to know how many watts per hour each bulb consumes.
5. On the street, how many cars transport just one person?
6. If four people traveled in each car, how many fewer cars would there be according to your count?

SESSION INFORMATION

Week: 30

Sessions: 177 - 180

Expected learning outcome: Discuss the importance of developing basic actions for the sustainable consumption of energy at home and at school.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Metacognitive skills: Planning, organizing a presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

SESSION INFORMATION

Week: 31

Sessions: 181 - 186

Expected learning outcome: Create and develop in a more autonomous way, a plan for conducting research, showing responsibility, solidarity and equity.

Use information from experimentation or bibliographic research to create arguments, conclusions and proposals to reach solutions.

Design and create technical objects, experiments or models that include the descriptions, explanation and prediction of electrical and magnetic phenomena or their manifestations.

Recognize achievements and challenges related to the acquired knowledge, ways of work and participation in the development and communication of a project.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations.

Development: Students should give their presentations.

Closing: Students should ask their 5 comprehension-check questions to their partners. and self-evaluate using the projects' rubrics.

Project: *The Use of Light and Electricity in Everyday Life*

→ **Expected Learning**

Create and develop, in a more autonomous way, a plan for conducting research, showing responsibility, solidarity and equity.

Use the information obtained through experimentation or bibliographic research, to create arguments, conclusions and proposals to reach solutions.

Design and create technical objects, experiments or models, that include the description, explanation and prediction of electrical and magnetic phenomena or their manifestations.

Recognize achievements and challenges related to the acquired knowledge, ways of work and participation in the development and communication of a project.

→ **Proposed problems to define the project:**

- How is the electricity we use at home obtained, carried and used?
- What is a rainbow and how does it form?

Remember that if you or your team have another question or problem you want to research and solve, you are free to do so. Do not lose your enthusiasm vanish since these are only proposals: Try to choose something you find useful for yourself and your community.

→ **Developing the Project**

With your team, answer the following questions

1. Have we defined the main idea or problem of the project? What is it? Why is it relevant?

2. What is the plan to carry it out? What resources do we need? What have we done so far? What are we missing?

3. How and when will we carry it out? What impact are we expecting? What will we do if it does not work out? Do we have a plan B? What is it?

4. How are we going to communicate the outcome of the project to the rest of the class? And to the rest of the school body? And to the community?

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

With the help of your teacher, go over the project in general. Start an outline for the project in order to make decisions about the information you need and make sure the information you are using is correct and it comes from reliable sources.

➔ Communicating the results of the project

With your team, propose several kinds of communication media to help you present the project to the rest of the class and school body and to the community if you find it necessary.

Take into account that Information and Communication Technologies (ICT) help us in the socialization and in communicating the results of the project, although you may consider as well more traditional media, such as billboards, handouts, school newspapers or something more educational, like lectures, workshops with the school body, among others.

Do not forget to share everything you have done in the project. It may be useful to have a preliminary outline in writing, which you can support with models at the moment of presenting your results.

➔ Evaluating the Project

Once the project is finished and you have presented your results, meet with your work team and reflect on what you have done during this time to finish it. Consider the following questions:

1. Were the objectives of the project met? Why?
2. How do you evaluate the results? Are they positive or negative? What grade would you give it?
3. What obstacles did you face? How did you work them out? In case one of them was not overcome, why did it happen?
4. What could you have done better?
5. How was the participation of each team member in the project? Did all the members accomplish their responsibilities?

In your notebook write down a personal reflection where you explain what you learned regarding this topic during this project's development. Include your personal experiences while doing this project. Think about how you carried out the search for answers, faced obstacles and made decisions throughout the project.

SESSION INFORMATION

Week: 31

Sessions: 181 - 186

Expected learning outcome: Create and develop in a more autonomous way, a plan for conducting research, showing responsibility, solidarity and equity.

Use information from experimentation or bibliographic research to create arguments, conclusions and proposals to reach solutions.

Design and create technical objects, experiments or models that include the descriptions, explanation and prediction of electrical and magnetic phenomena or their manifestations.

Recognize achievements and challenges related to the acquired knowledge, ways of work and participation in the development and communication of a project.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations:

Development: Students should give their presentations.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, students should self-evaluate their presentations using the projects' rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

SESSION INFORMATION

Week: 32

Sessions: 187, 188

EVALUATION

CONTENT DELIVERY

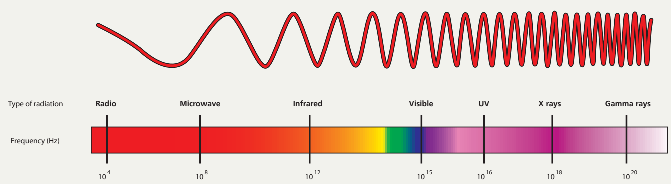
Start: Students should answer pages 120 and 121 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages 156 to 159 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

Evaluation

Read the text, answer the questions below.



In a vacuum, electromagnetic waves move at the same speed and differ in frequency.

An electromagnetic spectrum is the representation of the classification of the group of electromagnetic waves according to their frequency or wavelength as shown in the image above.

Radio waves are between 10^4Hz and 10^8 Hz and are used in radiobroadcasting and radio communication.

Microwaves have a frequency from 10^8 Hz to 10^{12} Hz and are used in ovens where they make water molecules rotate in substances, raising their temperature. They are also used in data transmission devices and radars.

Infrared rays have frequencies from 10^{12} Hz and 10^{14} Hz and are emitted by hot bodies. They are used for some special communication systems, as in astronomy to detect stars and other bodies and to guide weapons, where heat detectors are used to discover bodies in the dark. They are also used in remote controls for TVs and other devices.

Visible light has a frequency between 4.6×10^{14} Hz and 8×10^{14} Hz where colors can be seen in order: red, orange, yellow, green, blue, indigo and violet from lower to higher frequency.

Ultraviolet rays have frequencies up to 10^{18} Hz, which are emitted by the Sun and cause burns and skin cancer from prolonged exposition.

X-rays are electromagnetic waves with frequencies higher than UV radiation. They were discovered by German physicist Wihelm Conrad Röntgen: who named them that, because they were unknown before then. He realized they couldn't pass through the bones of people and took the first radiography when he printed the bones in his wife's hand in a photographic plate.

Gamma rays are emitted by decaying atomic nuclei, along with alpha and beta particles. Because of the high energy they possess, they are an ionizing type of energy capable of penetrating matter and harm the cell nucleus. They are used to sterilize medical equipment and food.

1. Look at the image of the electromagnetic spectrum and answer: what is the band of the electromagnetic spectrum with a lower wavelength? And the higher one?

Option	Lesser wavelength	Bigger wavelength
a.	radio waves	gamma rays
b.	radio waves	X-rays
c.	gamma rays	radio waves
d.	gamma rays	X-rays

2. Where are infrared radiations used?
   a. In astronomy, heat detectors and TV remote controls.
   b. In medicine to cure cancer and in radiographies.
   c. In weapons, radio broadcasting and radio communication.
   d. In ovens and to see in the dark.
3. What precautions do radiologists have to take when handling X-rays?
   a. To wear a cotton robe, not to drink water while working.
   b. To wear a lead apron, reduce the exposition time to minimum and to take intervals of days off.
   c. To wear a plastic robe, to drink a lot of water as a protection against ionizing radiation.
   d. To wear a leather robe, work alternate shifts to reduce time of exposition.
4. What are considered the most dangerous types of radiation? Why?
   Students' own answers.
5. Order the colors from more to less content of energy: green, blue, yellow, violet, orange, red.

red	**orange**	**yellow**	**green**	**blue**	**violet**

6. How does a microwave oven heat food?
   a. Electric current has the property generating heat through the flow of electrons and the Joule effect.
   b. A water molecule has two hydrogen atoms with a positive charge and one oxygen atom with two-negative charges. It behaves as an electric dipole rotating in its attempt to align with the alternate electric field of microwaves, thus raising its temperature.
   c. The oven bobbin produces a resonant effect in water molecules in food, raising the temperature.
   d. Magnetron provides potential energy to food and transmits heat by conduction, convection and radiation.
7. Is the invariable speed of electromagnetic waves a notable consequence of some basic principle of physics?
   a. Principle of superposition.
   b. Principle of conservation of linear movement.
   c. Principle of conservation of electric charge.
   d. Principle of conservation of energy.
8. Can it be said that radio electromagnetic waves are low-frequency light waves? Can it be said that a radio wave is also a sound wave?
   a. Yes, yes
   b. No, no
   c. Yes, no
   d. No, yes
9. Greenhouse effect.

Earth's atmosphere and glass in greenhouses are materials that allow the transparent flow of high-frequency waves coming from the Sun, but the long-wave energy reflected does not send them back and they remain trapped inside. Which electromagnetic waves enter the atmosphere and greenhouses, and which ones remain trapped?

	Short wave / long frequency radiation enters	Long wave / low frequency radiation remains trapped
a.	Visible light	Infrared rays of long wavelength
b.	Infrared rays with short wavelength	Visible light
c.	Infrared rays with long wavelength	UV rays, visible light, infrared of short wavelength
d.	UV rays, visible light, infrared of short wavelength	Infrared rays of long wavelength

SESSION INFORMATION

Week: 32

Sessions: 189, 190

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 120 and 121 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages 156 to 159 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Metacognitive skills: Planning, organizing a presentation.

EVALUATION OF CONTENT

Ask students to say which three topics sound new to them.

SESSION INFORMATION

Week: 32

Session: 191

SELF EVALUATION

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

Evaluation

Self-Evaluation

Evaluate your own way of working; check in the boxes what you are able to do with the themes in this unit.

SKILLS	YES	NO
I can apply physics to solve problems in my community, country and around the world.		
I can relate the knowldege of physics with the surrounding environment and with the ethical, economic, sociopolitical and cultural matters of my country and the world.		
I can use technical physics terms to communicate information.		
I use graphs, tables and models in my reports, homework and projects.		
I can search for information in the correct sources and organize it according to the report, project or assignment I'm working on, mentioning the sources of information.		
I establish mathematical models and solve problems related to physics.		
I analyze physics problems and can break up a whole in its parts, finding the relationship among the parts as well as identify cause and effect of the problem.		
Organize and analyze data, represent it in graphs and tables, evaluate the validity of ideas and the quality of work.		
Come to conclusions based on scientific reasoning.		
Make decisions related to my health and that of others, as I promote the culture of prevention.		
I am responsible and committed, work well with others and respect their point of view.		
I apply my knowledge and skills to solve problems in my community.		

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

SESSION INFORMATION

Week: 32

Session: 192

SELF EVALUATION

Peer Evaluation

Rubric

POINTS	VALUE	MEANING
10	Excellent	Perfect collaboration without mistakes.
8	Very good	Little, involuntary or justified mistakes.
6	Good	Has shown mistakes and lack of a helping attitude.
4	Barely accomplishes	Total lack of helping attitude, mistakes and excuses constantly present.
2	Not accomplished	Has not accomplished the task and shows irresponsibility.

Characteristics To Evaluate

	CHARACTERISTICS
A	Prepares his share of the work in a responsible way.
B	Makes his best effort at sharing his learning.
C	Handles conflicts constructively.
D	Shows trust, respect, acceptance, listens and support towards others.
E	Points out strengths and areas of opportunity during group processing.
F	Gives feedback to the group to improve on assignments and responsibilities.

Peer-Evaluation

Write the name of each of your teammates and check the box for each trait your partner has.

TEAM TO BE EVALUATED						
NAME OF STUDENT	A	B	C	D	E	F
	2-10	2-10	2-10	2-10	2-10	2-10
1						
2						
3						
4						
5						

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

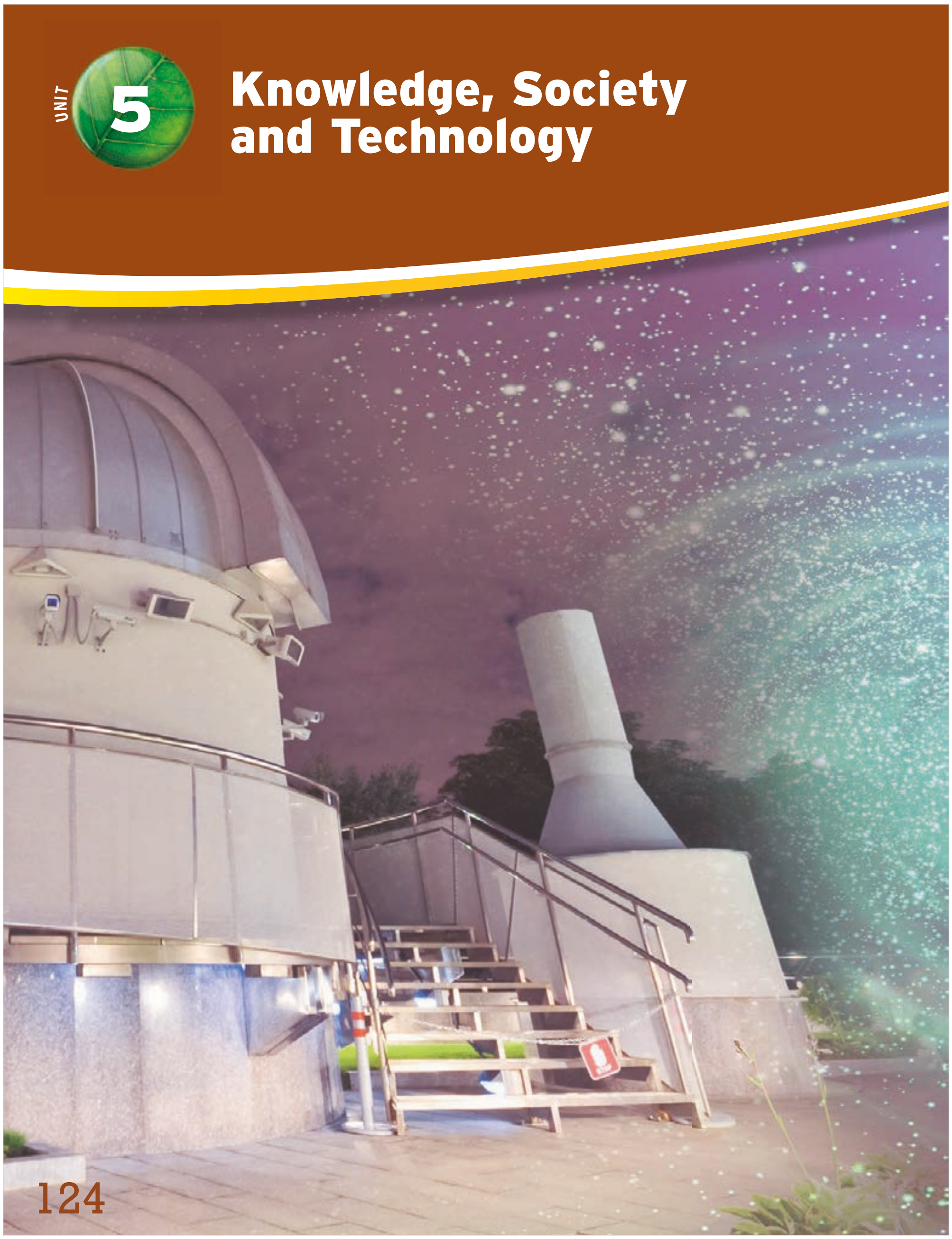
Students should get their self-evaluation instrument checked by the teacher.

SESSION INFORMATION

Week: 33

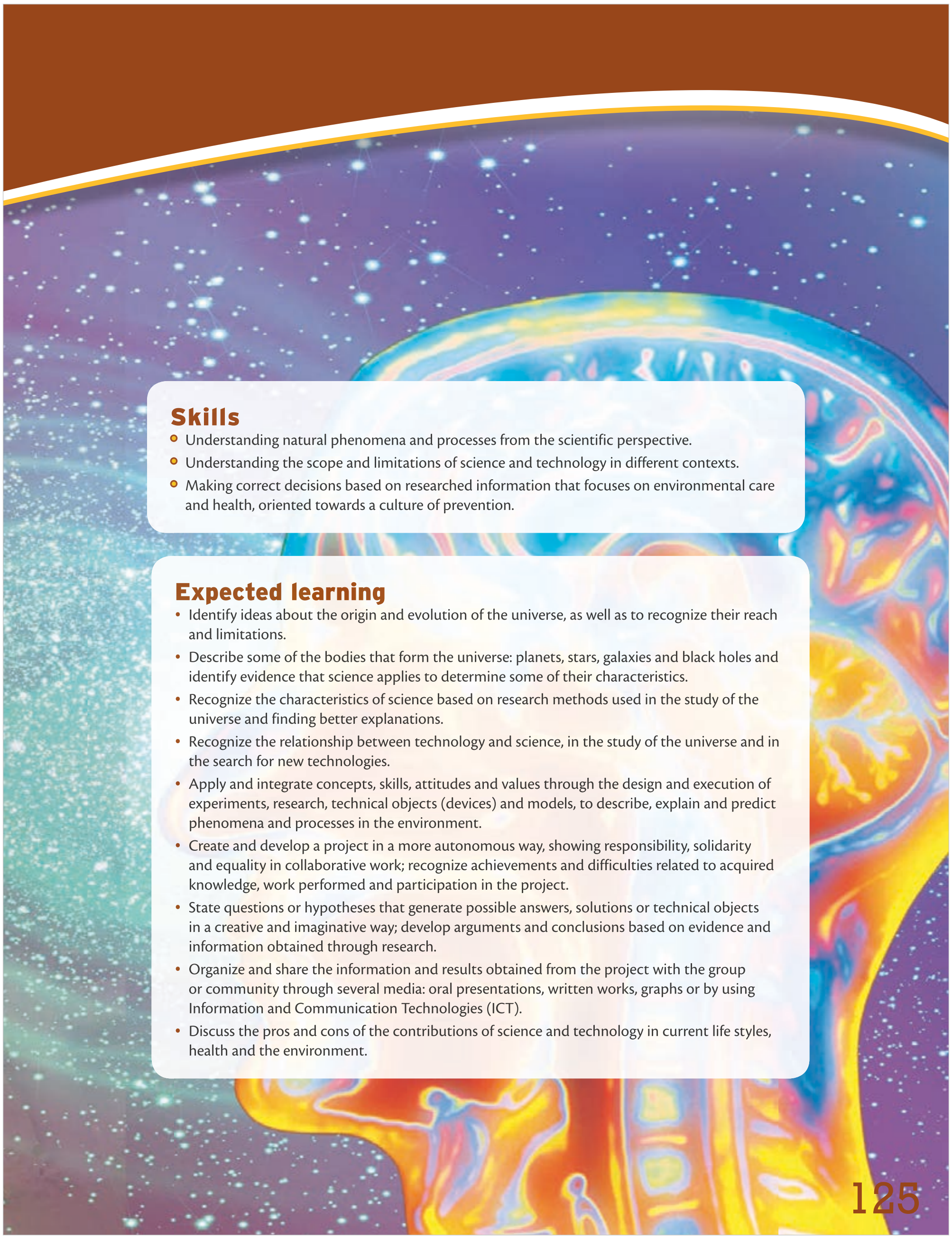
Session: 193

Expected learning outcome: Identify topics in the unit students consider will be hard to understand in order to make a study plan.



CONTENT DELIVERY

Project preparation: Organize four teams. Each team will present a segment in a TV show called “The Universe”. Segment the information on pages 126 to 128. Students should also support their presentation using some kind of multimedia. Explain what you will evaluate in the show: Relevant information, multimedia use, extra information, collaborative work and language use.



Skills

- Understanding natural phenomena and processes from the scientific perspective.
- Understanding the scope and limitations of science and technology in different contexts.
- Making correct decisions based on researched information that focuses on environmental care and health, oriented towards a culture of prevention.

Expected learning

- Identify ideas about the origin and evolution of the universe, as well as to recognize their reach and limitations.
- Describe some of the bodies that form the universe: planets, stars, galaxies and black holes and identify evidence that science applies to determine some of their characteristics.
- Recognize the characteristics of science based on research methods used in the study of the universe and finding better explanations.
- Recognize the relationship between technology and science, in the study of the universe and in the search for new technologies.
- Apply and integrate concepts, skills, attitudes and values through the design and execution of experiments, research, technical objects (devices) and models, to describe, explain and predict phenomena and processes in the environment.
- Create and develop a project in a more autonomous way, showing responsibility, solidarity and equality in collaborative work; recognize achievements and difficulties related to acquired knowledge, work performed and participation in the project.
- State questions or hypotheses that generate possible answers, solutions or technical objects in a creative and imaginative way; develop arguments and conclusions based on evidence and information obtained through research.
- Organize and share the information and results obtained from the project with the group or community through several media: oral presentations, written works, graphs or by using Information and Communication Technologies (ICT).
- Discuss the pros and cons of the contributions of science and technology in current life styles, health and the environment.

SKILLS DEVELOPMENT

Metacognitive skills: Planning, organizing studies content.

EVALUATION OF CONTENT

Students should get their study plan checked by the teacher.

SESSION INFORMATION

Week: 33

Session: 193

Expected learning outcome: Identify topics in the unit students consider will be hard to understand in order to make a study plan.

CONTENT DELIVERY

Start: Have students analyze and identify what they could do well in units 1 through 4; as well as what they should improve in unit 5. Ask them, for instance: What topics were easy? Did your previous study plan work? Didn't it work? Why? Did you really follow your study plan? Students should write down their reflections.

Development: Have students check the skills, learning outcomes and key concepts in unit 3. Ask them to identify the topics they consider the hardest ones. Then, they should plan how to study them and do better than the previous unit. If a strategy didn't work, then they should find another one. Help them with ideas. (Drawing mind maps, discussing with partners, making their own exams, making timelines, making associations, etc.)

Closing: Students should write down their study plan and have it checked.

SESSION INFORMATION

Week: 33

Session: 194

Expected learning outcome: Identify some ideas about the origin and evolution of the universe, as well as recognize their reach and limitations.

CONTENT DELIVERY

Start: Remind students what you will evaluate in the TV show: Relevant information, multimedia use, extra information, collaborative work and language use.

Development: Each team will present the segment they were assigned.

Closing: Students should be able to identify ideas about the origin and evolution of the universe.

➔ Expected Learning

Identify some ideas about the origin and evolution of the universe, as well as recognize their reach and limitations

The Universe

Big Bang Theory; Evidences That Support It, Reach and Limitations.

Exploring Knowledge

In teams of three, research and answer the following questions.

1. How big is the universe? Provide arguments to support your answer.
2. How old is the universe? Provide arguments to support your answer.

Brief History of Astronomy

Since classic Greece (fourth century BC), philosophers and thinkers wondered what the universe was made of and how it worked. Different cultures proposed several explanations, including a flat Earth that was the center of the universe. However, Aristotle put forward the idea that Earth was not flat, based on the observation of lunar eclipses that projected a round shadow of the Earth and by observing how ships were no longer in sight as they went further on the sea.

The Aristotelian model of the universe, however, did propose that Earth was the center of the universe and this idea prevailed for centuries. In the second century AD. Ptolemy established a model in which planets and stars moved in circular orbits around the Earth; this model was explained in a book titled *Almagest*.

Curious Facts

The word "*heliocentric*" refers to the planetary system in which the Sun is at the center of the universe. The word "Helios" means "air" and the Greeks believed the Sun was made of that element.

FIG. 5.1 Claudius Ptolemy

FIG. 5.2 Nicolaus Copernicus

It wasn't until the sixteenth century, when a Polish priest, Nicolaus Copernicus, wrote a book called *On the Revolutions of the Celestial Spheres* (1543), in which he established a new model for the universe: the heliocentric theory, in which Earth was no longer the center of the universe, but rather revolved, along with the other five planets known at the time, around the Sun.

Based on that book, people like the Danish astronomer Tycho Brahe started detailed observation of certain celestial bodies, particularly Mars, and Tycho assigned this difficult task to his assistant Johannes Kepler. When Tycho Brahe passed away, Kepler asked his family to give him all the data on Mars but they denied him the information; he then decided to take them himself by breaking into Tycho's office one night. This information helped him to establish his famous three laws and take a step further in describing the universe.

Galileo Galilei, a contemporary of Kepler, was forced to renounce his Copernican ideas because they contradicted the Bible. The same year Galileo died, Isaac Newton was born. He established the laws of motion for objects on Earth and in space. Once he was famous, he was asked how he had managed to achieve so many things and he answered with his quote: "If I have seen further, it is by standing on the shoulders of giants".

FIG. 5.3 Tycho Brahe.

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SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Summarizing.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics on page 164.

During the eighteenth century, great telescopes were built to observe the universe more and more precisely. One of those telescopes was built by William Herschel in 1781, it had a magnification of 6,450x and allowed him to discover a new celestial body, Uranus. It was the first planet discovered once man could observe the night sky more clearly. The understanding of the universe took on a whole new dimension now that the **Solar System** had six planets besides Earth; Many scientists started speculating about the existence of more planets.

In 1843, English mathematician John Couch Adams began a detailed study to predict the existence of a new planet, but it wasn't until 1845 when a French astronomer, Urbain-Jean-Joseph Le Verrier, mathematically calculated the existence of the planet that was discovered a year later by German astronomer Johann G. Galle and that was named Neptune.

FIG. 5.4 Johannes Kepler

FIG. 5.5 William Herschel.

FIG. 5.6 Uranus.

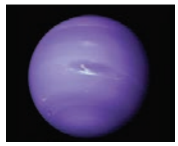


FIG. 5.7 Neptune.

Reflect, Explain and Share

In everyday life, people confuse **astronomy** with **astrology**. Even though both have a common origin in history, they are in fact two very different things. In ancient times, cultures used observation of celestial bodies to predict natural phenomena, but also the future of events that had no relation with the stars. Today, astronomy is a science based on rigorous observation and a very well established scientific methodology while astrology is not a science.

FIG. 5.8 Astrology treaty.

Curious Facts

The word galaxy comes from the Greek glakt, that means "milky", thus the name means "road of milk". According to Greek mythology, the Milky Way was formed when Hera, the wife of Zeus ,spilled her own milk when brusquely taking Hercules, the son of Zeus, off her breast.

➔ Activity

To realize how powerful astronomy is compared to astrology, carry out the following activity.

1. Do some research, in several books or on the Internet, and read Newton's Laws, what do you notice? Do all the books or information state the laws the same way?
2. Now look up your horoscope in several newspapers, what do you see? Do all the horoscopes say the same thing?
3. What conclusions can you obtain from this activity? Explain your answer and compare it with your classmates in a plenary.

The Big Bang Theory

With the discovery of new planets, the vision of the universe changed radically. Scientists of several disciplines contributed with new ideas about its dimensions and behavior. The advances in technology provided greater evidence. In 1904, the largest observatory of the time was built: Mount Wilson in Pasadena, California. With the help of this telescope, American astronomer Edwin Hubble discovered in

SESSION INFORMATION

Week: 33

Sessions: 195, 196

Expected learning outcome: Identify some ideas about the origin and evolution of the universe, as well as recognize their reach and limitations.

CONTENT DELIVERY

Start: Remind students what you will evaluate in the TV show: Relevant information, multimedia use, extra information, collaborative work and language use.

Development: Each team will present the segment they were assigned.

Closing: Students should be able to identify ideas about the origin and evolution of the universe.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Summarizing.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics on page 164.

SESSION INFORMATION

Week: 33

Session: 197

Expected learning outcome: Identify some ideas about the origin and evolution of the universe, as well as recognize their reach and limitations.

CONTENT DELIVERY

Start: Remind students what you will evaluate in the TV show: Relevant information, multimedia use, extra information, collaborative work and language use.

Development: Each team will present the segment they were assigned.

Closing: Students should be able to identify ideas about the origin and evolution of the universe.

Homework: Students should do research in order to answer the questions on page 129 stated in the section *Exploring Knowledge*.

Project preparation: Divide the group into five groups. Each team will make a poster during the following three sessions about one of the topics in the sequence *Characteristics of Celestial Bodies*...(pages 129 to 131) In the poster; they should summarize information from the book and draw or paint images that illustrate each concept. In the end, all the posters together will be used to make an informative mural.

FIG. 5.9 Edwin Hubble

1927 that galaxies seemed to pull away from one another. Based on these observations, Russian physicist George Gamow proposed a theory in 1940 in which it was established that the universe had been created by means of a gigantic **explosion**. Analyzing the possible evolution of the universe, it was determined that it was about 15 billion years old. In 1965, Bell telephone company engineers Amo Penzias and Robert Wilson made a discovery that would definitely boost the **Big Bang** theory to explain the origin of the universe. These observations consisted of picking up a noise that did not come from any source on Earth. After several tests, they realized that said noise was nothing less than radiation from the universe and a remnant of the "Big Bang".

Today, the most widely accepted theory of the origin of the universe is the Big Bang Theory that proposes that the universe was originated from a point where matter and energy were concentrated and when it exploded it originated the expansion of matter such as **Hubble** observed in relation to galaxies, that is, an inflation.

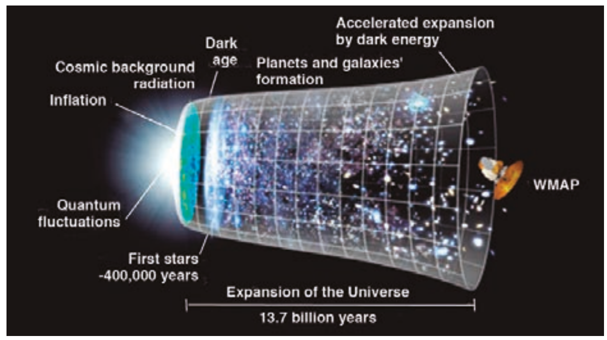


FIG. 5.10 The expansion of the universe.

The Expansion of the Universe and its Future: Expansion and Contraction

The age of the universe is estimated at 13.7 billion years, however, the question that many astronomers ask themselves nowadays is: will the universe expand indefinitely or will it stop at some point? There are in fact three possible scenarios that answer this question. The first one is yes, it will. In a second scenario, the universe will expand until it reaches equilibrium. And in a third scenario, the universe will follow a reverse process, contracting itself until it reaches the initial stage.

Closing

How much did I learn?

Work in teams to answer the questions. Share your answers with the class.

1. Create a table that summarizes the history of astronomy from Aristotelian ideas up to the discovery of Neptune.
2. Explain in your own words the difference between astronomy and astrology.
3. Explain what the Big Bang Theory is and what evidence supports it.
4. How old is our universe and what may be its possible future?

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Summarizing.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics on page 164.

Characteristics of Celestial Bodies: Dimensions, Types; Emitted Electromagnetic Radiation, Evolution of Stars; Components of Galaxies, among Others. The Milky Way and the Sun.

→ Expected Learning

Describe some of the bodies that form the universe: planets, stars, galaxies and black holes and identify evidence that science applies to determine some of their characteristics.

Exploring Knowledge

Work in teams to answer the questions. Share your answers with the class.

1. Explain what stars are.
2. List three differences between planets and stars.
3. You have surely heard that Pluto is no longer considered a planet. Do you know why and when it happened? Investigate and explain.
4. What kind of galaxy is the Milky Way?

Astronomers all over the world devote themselves to study the origin, structure and evolution of the universe. In order to do that, they need to know about the objects that form the universe and how they were formed.

Stars

Stars are made up of gas and interstellar dust that originated from the death of an earlier star.

Stars are enormous gas spheres, mainly hydrogen and helium, that produce energy that is transported to its surface and irradiated towards space in every direction. Stars maintain their spherical shape thanks to an equilibrium force denominated **hydrostatic balance**. This equilibrium is produced between the force of gravity, that pushes matter towards the center of the star, and the pressure that the gas exerts to the outside and tends to expand it.

Curious Facts

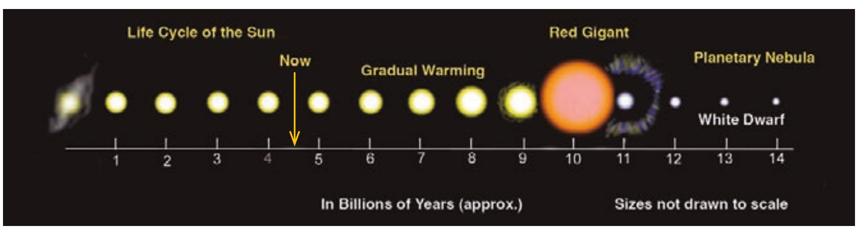
Remember the density of matter is the amount of matter in a body divided by the volume it occupies.

Evolution of Stars

The life of the stars depends on their initial mass, because it determines the time the star will produce energy in its nucleus. The more mass a star has, the shorter its life will be because it consumes the hydrogen and helium in its nucleus more quickly, making its temperature higher. Stars have varied sizes that go from several hundred times the size of the Sun to several times smaller. Larger stars are extremely bright.

The life cycle of a star is several billion years. When a star has exhausted its nuclear fuel, its period of hydrostatic balance ends and the process of stellar death begins, its ending depends on the initial mass of the star. In the first stage, the nucleus contracts while the temperature in the nucleus rises, the external layers expand quickly and the star may become a Red Giant if its initial mass is comparable to the Sun or a Red Supergiant star if its mass is several times larger.

FIG. 5.11 Life cycle of the Sun.



SESSION INFORMATION

Week: 33

Session: 198

Expected learning outcome: Describe some of the bodies that form the universe: planets, stars, galaxies and black holes and identify evidence that science applies to determine some of their characteristics.

CONTENT DELIVERY

Start: Check students' homework (answers to the section *Exploring Knowledge* on page 129). Elicit answers in whole class.

Development: Teams should organize work and create the poster illustrating the segment they were assigned from pages 129 to 131.

Closing: Once they finish the poster, all of the group should find the way to stick them all together in order to make the mural.

SKILLS DEVELOPMENT

Reading skills: Scanning, reading for detail.

Interpersonal skills: Working as team members; collaboratively working.

Visual/Spatial skills: Drawing information.

EVALUATION OF CONTENT

Students should actively participate in the poster making process.

SESSION INFORMATION

Week: 34

Session: 199

Expected learning outcome: Describe some of the bodies that form the universe: planets, stars, galaxies and black holes and identify evidence that science applies to determine some of their characteristics.

CONTENT DELIVERY

Start: Students should build the poster in class.

Development: Teams should organize work and create the poster illustrating the segment they were assigned from pages 129 to 131.

Closing: Once they finish the poster, all of the group should find the way to stick them all together in order to make the mural.

Curious Facts

In the case of the Sun, astronomers have predicted that during its Red Giant stage its outer layers will expand until they swallow the Earth. Then, a planetary nebula will form and finally it will end its existence as a white dwarf.

Once the star has become a Red Giant or Red Supergiant, the star experiences several stages of contraction of the nucleus and expulsion of matter from its outer layers towards space. If it is a Red Giant, the expulsion of matter gives origin to a planetary nebula.

After these phenomena, there is nothing left of the body other than a small inert nucleus in progressive cooling. Stars like the Sun will end their existence turning into a white dwarf.

The most massive stars, after their stage as Red Supergiants, end their life with a great explosion turning into what astronomers call a **supernova**, releasing enormous amounts of energy in the form of radiation, to later extinguish completely.

In some cases, the residual nucleus of these stars begins a process of matter collapse, transforming in super dense objects called **neutron stars**. In some occasions, the gravitational collapse is so strong that they turn into black holes, astronomical objects with such large gravity that not even light can escape.

GLOSSARY

Spectrum. distribution of the intensity of radiation in terms of a characteristic magnitude, such as wavelength, energy, frequency or mass.

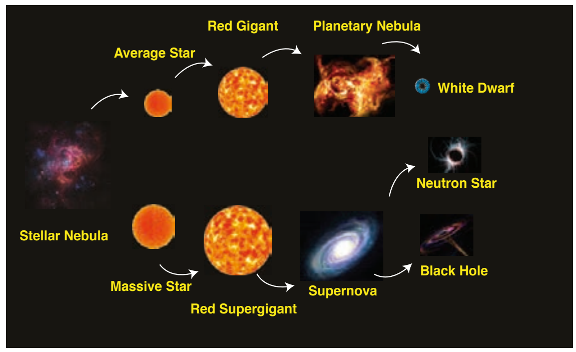


FIG. 5.12 Star evolution.

Stellar Classification

In astronomy, stellar classification is the classification of stars based on their luminous **spectrum** (electromagnetic radiation shed by its surface) and their surface temperature. The surface temperature determines its spectral class and thus its color. Most stars are currently classified under the Morgan-Keenan system (MK), using the letters: O, B, A F, G, K and M, going from higher to lower temperature.

Star types O, B and A are very hot and stars type M are considerably colder. Our Sun is a yellow star with an approximate surface temperature of 6,000°C, thus being a type G.

This is not, however, the only way to classify stars. They can also be classified according to their luminosity, their position in a star cluster, whether they have a planetary system or whether they are part of a binary star (two stars linked by gravitational force).

FIG. 5.13 Our Sun.

Planets

A planet is, according to the definition of the International Astronomical Union on August 24, 2006, a celestial body that meets the following conditions:

- Orbits around a star or star remnants.
- Has enough mass so that its gravity overcomes the forces of the rigid body, so that it takes a shape in hydrostatic balance (mostly spherical).
- Has cleared its orbit of **planetesimals**.

According to this definition, the Solar System has eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Pluto, considered a planet until 2006, is currently classified as a **dwarf planet**.

GLOSSARY

Planetesimals. Solid objects that are believed to exist in protoplanetary discs, a matter structure shaped like a ring and situated around a star.

SKILLS DEVELOPMENT

Reading skills: Scanning, reading for detail.

Interpersonal skills: Working as team members; collaboratively working.

Visual/Spatial skills: Drawing information.

EVALUATION OF CONTENT

Students should actively participate in the poster making process.

Dwarf planet is the term coined by the International Astronomical Unit on August 24, 2006 to define a new class of celestial bodies, different from a planet and from a minor body in the Solar System.

Curious Facts

The word "planet" comes from Latin and means "wandering".

FIG. 5.14 Pluto.

Bodies that revolve around other stars different from the Sun, are called **extrasolar planets** or **exoplanets**. The conditions they must meet to be considered as such, are the same as the definition of planet for the solar system, but they have an additional condition about the limit of their size: their mass must not me larger than 13 times the mass of Jupiter.

Galaxies

Galaxies are enormous groups of stars, dust and gas, mainly. The first galaxies began forming about 1 billion years after the Big Bang. The largest amount of stars is concentrated at the center of galaxies. All bodies belonging to a galaxy move because of the attraction of other bodies and they all move around the galactic center.

The size of galaxies is varied; there are enormous galaxies like Andromeda or smaller ones like its neighbor M32; their shape is also varied, according to Hubble they are classified in spherical, lenticular, elliptical, spiral and irregular.

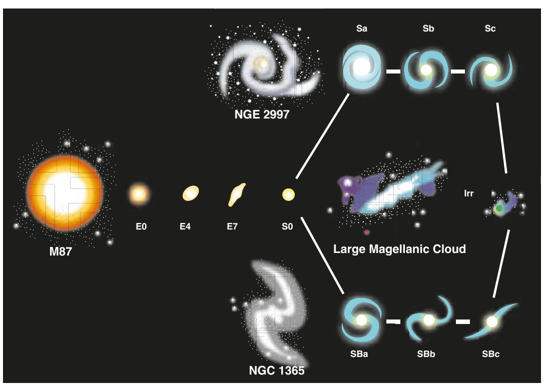


FIG. 5.15 Hubble's classification of Galaxies

SESSION INFORMATION

Week: 34

Session: 200

Expected learning outcome: Describe some of the bodies that form the universe: planets, stars, galaxies and black holes and identify evidence that science applies to determine some of their characteristics.

CONTENT DELIVERY

Start: Students should make the poster in class.

Development: Teams should organize work and create the poster illustrating the segment they were assigned from pages 129 to 131.

Closing: Once they finish the poster, all of the group should find the way to stick them all together in order to make the mural.

Homework: In teams, students should answer the questions in the section *How much did I learn?* On page 132.

Students should do research on "The Doppler Effect".

SKILLS DEVELOPMENT

Reading skills: Scanning, reading for detail.

Interpersonal skills: Working as team members; collaboratively working.

Visual/Spatial skills: Drawing information.

EVALUATION OF CONTENT

Students should actively participate in the poster making process.

SESSION INFORMATION

Week: 34

Session: 201

Expected learning outcome: Recognize the characteristics of science based on the research methods used in the study of the universe and finding better explanations.

CONTENT DELIVERY

Start: In teams, students should answer the questions in the section *How much did I learn?* To wrap up the topic of characteristics of celestial bodies. Elicit answers in whole class.

Development: Check students' homework on the Doppler Effect.

Closing: Students should read the rest of the page and explain in their own words how astronomers use The Doppler Effect to explore space.

Curious Facts

The Milky Way is a spiral galaxy with a mass 10^{12} times the mass of the sun and an average diameter of 1 quintillion kilometer. It contains from 200 to 400 billion stars and it is part of a group of 40 galaxies called Local Group.

In the universe there are billions of galaxies that group forming larger structures called **galaxy clusters.**

FIG. 5.16 The milky way, seen from the Earth.

Closing

How much did I learn?

1. Draw a concept map summarizing what galaxies, stars and planets are.
2. Research and explain:
   a) What is the difference between meteorite, meteoroid and meteor?
   b) The difference between a natural and artificial satellite.
   c) What is a comet?
   d) How are the planets in the Solar System classified?

Expected Learning

Recognize the characteristics of science based on the research methods used in the study of the universe and finding better explanations.

Astronomy and its Research Procedures: Observation, Data Systematization, Use of Evidence

Exploring Knowledge

Work in teams of four and answer the following questions. Share your answers with the class.

1. What devices or inventions do you know that help observe the sky?
2. Do some research on the Doppler Effect and explain what it consists of.

Astronomers receive information about space from electromagnetic waves of different frequencies, which allow them to study objects that are not visible at first sight.

To analyze if a star is getting nearer or farther from Earth, astronomers use the **Doppler Effect**, which is the change in frequency of a wavelength (or other periodic event) moving relative to its source. If the source is pulling away, a redshift is observed in the wave's radiation spectrum, which has in fact been detected when observing galaxies like Hubble did. On the other hand, if they are approaching, the spectrum will shift towards purple or blue.

SKILLS DEVELOPMENT

Critical thinking skills: Doing research, paraphrasing.

EVALUATION OF CONTENT

Students should be able to explain what the Doppler Effect is used to do space exploration.

FIG. 5.17 An astronomical observatory studies the light coming from celestial bodies.

Reflect, Explain and Share

Doppler Effect for sound is that in which a change is perceived in the pitch of the sound of an ambulance, when it is approaching and when it is moving away from us. How do frequencies change in this case?

Curious Facts

To calculate stellar distances, many methods are used, such as the apparent movement of a body when observing it from different positions – called parallax. So that you can get an idea of it, place your finger in line with your eyes and look at it, with each eye, closing first the left one and then the right one. Another method is the position of stars as a reference, such as the Cepheus constellation.

The Doppler Effect is an essential tool in astronomy because it provides astronomers with information to research the movement of celestial bodies and their chemical composition.

Atoms emit and absorb energy that corresponds to different wavelengths of electromagnetic radiation. When the light (electromagnetic radiation), emitted by a star goes through its outer gas layers, those atoms absorb the waves of certain longitudes. In the light spectrum emitted by a star, we see lines of absorption, represented by dark bars; when a star is pulling away or approaching us, the Doppler Effect changes the wavelengths perceived, making the lines in the spectrums change places.

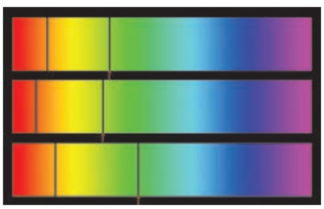


FIG. 5.18 Light spectrum in the Doppler Effect

Activity

1. On the internet, research what the 21 centimeter line is and what astronomers use it for.
2. Research how astronomers use the spectra of stars to know their chemical composition.
3. Research how an astronomer finds out if a star is young, in its middle age or old.

Virtual Observatories

The Virtual Observatory (VO) is a project that started in the year 2000 to increase the speed and efficiency to access existing information in archives and astronomical services as well as in the analysis of said information. The efficiency of virtual observatories resides in the storage of files with astronomical data that can be used for several years by different research groups for different projects.

It is estimated that the amount of astronomical files stored in virtual observatories is over a petabyte, that is 10^{15} bytes or 1,000,000,000,000,000 bytes and it increases 0.5 petabytes every year. It is estimated that by the year 2020 there will be 60 petabytes available in total in astronomical archives and data bases.

Curious Facts

INES (IUE Newly Extracted Spectra) is a data base of the IUE satellite (International Ultraviolet Explorer) that stores stellar spectra. Thanks to the archive that stores the data obtained by the Hubble Space Telescope since 2006, more articles have been published based on these data than based on new data.

SESSION INFORMATION

Week: 34

Session: 202

Expected learning outcome: Recognize the characteristics of science based on the research methods used in the study of the universe and finding better explanations.

CONTENT DELIVERY

Start: Ask students to explain how astronomers use The Doppler Effect to explore outer space.

Development: Students should read the page and do research where indicated. Help them in the process. It is desirable that you do research to help them and suggest the best websites to check.

Closing: Students should summarize the information from the page in a synoptic table.

Homework: Students should answer the questions in the section *How much did I learn?* On page 134.

SKILLS DEVELOPMENT

Reading skills: Summarizing.

Visual/Spatial skills: Charting.

EVALUATION OF CONTENT

Students should get their synoptic table checked by the teacher.

SESSION INFORMATION

Week: 34

Session: 203

Expected learning outcome: Recognize the relationship between technology and science, in the study of the universe and in the search for new technologies.

CONTENT DELIVERY

Start: Check students' homework. Elicit answers in whole class.

Development: Organize trios. They should answer the questions in the section *Exploring knowledge*. Elicit answers in whole class. Once they finish, they should read the rest of the page. Help them with visuals to illustrate information. They should recognize the relation between technology and science to study the universe. Help them with comprehension-check questions.

Closing: Every trio will prepare the activity and the closing activity answers on page 135. Ask them to mind map it or summarize it or make a graphic organizer.

Closing

How much did I learn?

1. Do some research on how radio telescopes work and what astronomers use them for.
2. Find out the difference between space and earth observatories. Describe briefly how they work and what they are used for.
3. Investigate why it is said that when astronomers observe the universe, they are looking at the past.
4. Write why you think it is important for us to study the universe.
5. Research if Mexico has a virtual observatory.

Expected Learning

Recognize the relationship between technology and science, in the study of the universe and in the search for new technologies.

Interaction of Technology and Science in The Knowledge of The Universe

Exploring Knowledge

Answer the following questions with your team and share your answers with the class.

1. Explain two ways in which astronomers can collect information to investigate the universe.
2. Can you think of a different way to collect information about the universe? State it and explain how you would do it and what you would need to do it.

Undoubtedly our knowledge and understanding of the universe would be very limited if we did not have the technology we currently have. From the invention of the **telescope** in Holland, around 1608, and the use Galileo gave it, new kinds of telescopes were developed – like the one Newton developed.

Today, mankind has an optical telescope orbiting 600 kms above our planet, the Hubble telescope, and with it astronomers have been able to observe the confines of the universe, discover new galaxies and distant objects. But the Hubble is not the only telescope in space, there is also the **Spitzer**, which can pick up infrared radiation; the **Chandra**, which picks up radiation in X-rays; the **Cobe**, which picks up traces of the radiation that Penzias and Wilson discovered in 1965 and some others.

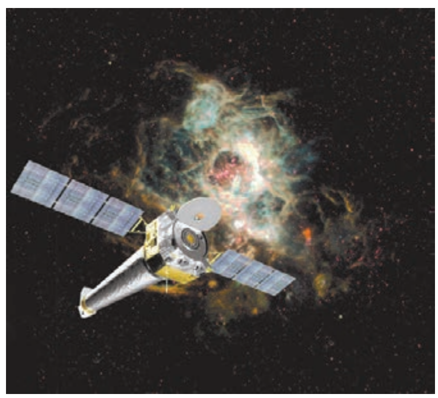


FIG. 5.19 Space telescope Chandra

SKILLS DEVELOPMENT

Critical thinking skills: Mind mapping or summarizing.

EVALUATION OF CONTENT

Students should get their mind map or summary or graphic organizer checked by the teacher.

➔ Activity

1. Explain the difference between a telescope and an observatory.
2. Investigate what the International Space Station is, when the project began, what countries are participating in it and what research work is carried out.
3. Write four tasks astronauts in space must complete.
4. Research what advances there have been in making clothes for astronauts and in food preparation for use in space.

ICT

One of the best astronomy books ever written is *Cosmos* by Carl Sagan. Check it out here:
http://prof.usb.ve/rescal/Cosmos.pdf

FIG. 5.20 A radio telescope

Here on Earth there are not only optical telescopes but also **radio telescopes**, which are large antennae that pick up radiation coming from space in the radio region of the electromagnetic spectrum, no matter if it is day or night or if it's clear or cloudy. The dish of a radio telescope is made of metal and it has a parabolic shape because its geometrical properties help to pick up very weak signals.

Closing

How much did I learn?

1. Research which devices originally invented for astronomers to use have contributed to the development of technologies used in everyday life, or in other sciences like chemistry or medicine.
2. Visit this website http://www.nrao.edu/whatisra/radioimage–s.shtml and discover how you can make a **radio image** like the ones astronomers make from the data obtained in radio telescopes.
3. Investigate what the Soho probe and observatory is used for.
4. Find out what devices have been invented to search for and detect extrasolar planets.

SESSION INFORMATION

Week: 34

Session: 204

Expected learning outcome: Recognize the relationship between technology and science, in the study of the universe and in the search for new technologies.

CONTENT DELIVERY

Start: Check students' homework regarding the activity questions. Elicit answers in whole class.

Development: Students should share the mind map or summary or graphic organizer with other students. They will compare whose piece of work is more complete. Then, elicit examples.

Closing: Check the answers to the section *How much did I learn?* In whole class.

SKILLS DEVELOPMENT

Reading skills: Reading for specific information, scanning.

EVALUATION OF CONTENT

Students should get their research homework checked by the teacher.

SESSION INFORMATION

Weeks: 35 - 38

Sessions: 205 - 228

Expected learning outcome: Look at the expected learning outcomes on the left of the miniature page.

Project: Science at The Service of the Development of Societies and Quality of Life

Expected Learning

Apply and integrate concepts, skills, attitudes and values through the design and execution of experiments, research, technical objects (devices) and models to describe, explain and predict phenomena and processes in the environment.

Create and develop a project in a more autonomous way, showing responsibility, solidarity and equality in collaborative work; recognize achievements and difficulties related to acquired knowledge, work performed and participation in the project.

State questions or hypotheses that generate possible answers, solutions or technical objects in a creative and imaginative way; develop arguments and conclusions based on evidence and information obtained through research.

Organize and share the information and results obtained from the project with the group or community through several media: oral presentations, written works, graphs or by using the Information and Communication Technologies (ICT).

Discuss the pros and cons of the contributions of science and technology in current life styles, health and the environment

We have concluded the topics and subtopics with specific content for the school year. Now it is up to you and your team to generate a project on your own, from all that you have learned during the school year. To this end, you are presented with three thematic areas: knowledge, science and society, which will help you, create a new project.

Creating and Planning the Project

(Estimated time: 4 to 8 weeks)
The proposed topics, orientations and questions to define your project are listed below. Answer the questions according to the topic you choose.

Topic: Science and Technology in Current Lifestyles	Topic: Physics and the Environment	Topic: Science and Technology in the Development of Society
What are the contributions of science to health care and its conservation?	How can I prevent and reduce risks from natural disasters by applying scientific and technological knowledge in the place where I live?	How does science contribute to the development of culture and technology?
How do technological devices that favor the diagnosis of diseases from tests like sonograms work?	How and with what resources do we solve the energy crisis?	How have physics and technology evolved in Mexico?
How do telecommunications work nowadays?	How do electric taxis that operate in Mexico City work?	What professional activities are related to physics and what is their relevance in society?
Which TV sets are better, LCDs or plasma? Why?	How do self-sustaining houses, schools and buildings work?	What does a physicist do in his professional work for the development of society?
Would it be possible to live or survive without technology nowadays? How?	What is the contribution of technology to the preservation of wild life in rural areas in Mexico?	How are astronomical phenomena far away from our planet observed and studied?

Developing the project

Once the planning stage is finished, the project needs to be carried out; we recommend you to write in detail how you will do it. Remember you have to consider two important purposes in the project: the socialization of science, by communicating the project to the community and the resolution of a problem or question that constitutes the main theme of the project. As you know, every project usually begins with the search and recollection of information. To this end, it will be useful to answer the following questions for each activity, taking care in indicating the number and name of said activity.

1. What does the activity consist of?
2. Who is the person responsible for it?
3. What resources do we need to carry it out?
4. How is it linked to the main problem in our project?
5. What results did we obtain?

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

Remember it is important you consider doing at least three activities for the project. Use the questions on the previous page for all the activities and include them in the report as a project blog.

With the help of your teacher and your teammates, define the steps to follow in the upcoming weeks with the purpose of achieving goals and results in time. Go over the information you have, to start the communication stage of the project.

Communicating the results of the project

From the projects you made throughout the course, you've had experience with the resources, how to share them and the communities they are aimed at. Now you must consider that your project is broader, which means the impact of this communication will be more noticeable. Remember that a good project doesn't just provide solutions and present results; it also states challenges and future projections to sustain its contributions and relevance in time. Among what you must consider for the communication of your project, take into account the media to use, timeline, people responsible and the target audience.

Evaluating the project

Once the project is finished and you have presented your results, meet with your team and reflect on what you have done during this time to carry out the whole process. Consider the following questions:

Stage of the Project	Evaluation Questions
Creation	Were the questions stated relevant to the development of the project? Did those questions allow the integration of the content covered in the course? Did those questions respond to the objectives? What were the difficulties and strengths of the statement?
Planning	Were different strategies established to carry out the project? Did you choose the most convenient strategy according to your possibilities? With this strategy, is the selected problem alleviated or solved? What would you change in the event of a similar project?
Development	Were the proposed activities creative? Did the execution of the project contribute to the generation of innovative products, solutions and techniques? Give examples. Was there adequate participation of all team members in the organization and execution to discuss the project outcomes? What problems arose during the project development? What worked best in your team?
Communication	Were communication strategies adequate? Did you manage the desired impact? What would you change for a better presentation? Were the topics in the presentation welcomed and understood by the audience? Did you present proposals or future projects in addition to your results?

When you answer the questions above, take into account the contents, abilities and attitudes you have learned throughout the course.

Recommended information sources for your project:

Units 1 to 4 of this Physics textbook. Here you will find the bases for content related to the projects suggested to end the school year.

Almanza Salgado, R. (2008). Energía y cambio climático: energías renovables. México: II-UNAM. Available at: *http://aplicaciones.iingen.unam.mx/ConsultasSPII/buscarpublicacion.aspx*

Ávila, J., Escobar, J. et al. (2010) El terremoto de Chile del 27 de febrero de 2010. Mw 8.8. México: II-UNAM. Available at: *http://aplicaciones.iingen.unam.mx/ConsultasSPII/buscarpublicacion.aspx*

Gutiérrez, R. (2005). Hacia un sistema de telecomunicaciones completamente óptico. México: II-UNAM. Available at: *http://aplicaciones.iingen.unam.mx/ConsultasSPII/Buscarpublicacion.aspx*

López, E. (2012). Guía para la planeación y desarrollo de parques tecnológicos en México. México: II-UNAM. Available at: *http://aplicaciones.iingen.unam.mx/ConsultasSPII/buscarpublicacion.aspx*

Petrich, M et al. (2011) Biología. Ciencias 1. México: Editorial Esfinge. (This first year textbook will help you find information about sciences applied to the study of environment and health)

To learn more, go to *http://basica.sep.gob.mx/escuelasegura/start.php* where you will find information about the Safe School program of the Ministry of Public Education. In the section “materials” you will also find brochures and emergency safety guides for both students and teachers.

SESSION INFORMATION

Weeks: 35 - 38

Sessions: 205 - 228

Expected Learning Outcome: Look at the expected learning outcomes on the extreme left of the previous page.

CONTENT DELIVERY

Start: Briefly explain what you will evaluate in their presentations: Relevant, clear information, visuals, the comprehension-check questions and further information.

Development: Students should give their presentations. Assign time according to your class length. Help as necessary.

Closing: Students should ask their 5 comprehension-check questions to their partners. Then, ask them to self-evaluate their presentations using the same presentation parameters described in the rubrics.

SKILLS DEVELOPMENT

Reading skills: Scanning.

Critical thinking skills: Formulating questions.

Listening skills: Understanding the message.

Metacognitive skills: Delivering content, self-monitoring, self-evaluating their presentation.

EVALUATION OF CONTENT

Follow the projects rubrics, Teacher's Guide page 164.

SESSION INFORMATION

Week: 39

Sessions: 229, 230

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 138 and 139 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages 160 to 163 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

Evaluation

Read the following questions and circle the correct answer.

1. Person who proposed the model in which the Earth was no longer the center of the universe but rather revolved, along with the other five planets known at the time, around the Sun.
   - **a.** Aristotle
   - **b.** Claudius Ptolemy
   - **c.** Nicolaus Copernicus
   - **d.** Tycho Brahe
2. According to the Big Bang Theory, the universe:
   - **a.** Was in rest and now is in motion by effect of an external force.
   - **b.** Originated from a point where all matter and energy were concentrated.
   - **c.** Will start contracting at the speed of light in the midst of a great explosion.
   - **d.** Was contracted because of the enormous gravity force that stars exerted.
3. What does the life of a star depend on?
   - **a.** Surface temperature
   - **b.** Initial mass
   - **c.** Color
   - **d.** Speed at which it turns around its own axis
4. Our galaxy, the Milky Way:
   - **a.** has a spherical shape and is formed by a billion stars.
   - **b.** has a spiral shape and is brighter than Andromeda.
   - **c.** has a spherical shape and has between 200 and 400 thousand stars.
   - **d.** has a spiral shape and is part of the Local Group.

5. Radio telescopes are large antennae that pick up radiation coming from space thanks to:

a. the great velocity of radio waves that allow them to reach greater distances.

b. a large portion of this radiation reaches the atmosphere.

c. their large size.

d. they can't be observed at a glance.

6. What did you like the most in this unit?

SESSION INFORMATION

Week: 39

Sessions: 231, 232

EVALUATION

CONTENT DELIVERY

Start: Students should answer pages 138 and 139 prior to taking the unit assessment. Go through the answers; help them with techniques to study content they do not clearly remember.

Development: Students are to take the unit assessment. You can find it in the Teacher's Guide pages160 to 163 along with the answer key.

Closing: Check their assessments, record the score and provide with feedback. You might want to use the Attendance and Evaluation formats that you can find the Teacher's Guide pages 165 to 167.

SESSION INFORMATION

Week: 39

Session: 233

SELF EVALUATION

Evaluation

Self-Evaluation

Evaluate your own way of working; check in the boxes what you are able to do with the themes in this unit.

SKILLS	YES	NO
I can apply physics to solve problems in my community, country and around the world.		
I can relate the knowldege of physics with the surrounding environment and with the ethical, economic, sociopolitical and cultural matters of my country and the world.		
I can use technical physics terms to communicate information.		
I use graphs, tables and models in my reports, homework and projects.		
I can search for information in the correct sources and organize it according to the report, project or assignment I'm working on, mentioning the sources of information.		
I establish mathematical models and solve problems related to physics.		
I analyze physics problems of physics and can break up a whole in its parts, finding the relationship among the parts as well as identify cause and effect of the problem.		
Organize and analyze data, represent it in graphs and tables, evaluate the validity of ideas and the quality of work.		
Come to conclusions based on scientific reasoning.		
Make decisions related to my health and that of others, as I promote the culture of prevention.		
I am responsible and committed, work well with others and respect their point of view.		
I apply my knowledge and skills to solve problems in my community.		

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

SESSION INFORMATION

Week: 39

Session: 234

SELF EVALUATION

Peer Evaluation

Rubric

POINTS	VALUE	MEANING
10	Excellent	Perfect collaboration without mistakes.
8	Very good	Little, involuntary or justified mistakes.
6	Good	Has shown mistakes and lack of a helping attitude.
4	Barely accomplishes	Total lack of helping attitude, mistakes and excuses constantly present.
2	Not accomplished	Has not accomplished the task and shows irresponsibility.

Characteristics To Evaluate

	CHARACTERISTICS
A	Prepares his share of the work in a responsible way.
B	Makes his best effort at sharing his learning.
C	Handles conflicts constructively.
D	Shows trust, respect, acceptance, listens and support towards others.
E	Points out strengths and areas of opportunity during group processing.
F	Gives feedback to the group to improve on assignments and responsibilities.

Peer Evaluation

Write the name of each of your teammates and check the box for each trait your partner has.

TEAM TO BE EVALUATED						
NAME OF STUDENT	A	B	C	D	E	F
	2-10	2-10	2-10	2-10	2-10	2-10
1						
2						
3						
4						
5						

CONTENT DELIVERY

Start: Explain to students why evaluation is important.

Development: Get students to answer the self-evaluation and check it.

SKILLS DEVELOPMENT

Metacognitive skills: Self-monitoring, self-evaluating.

EVALUATION OF CONTENT

Students should get their self-evaluation instrument checked by the teacher.

International System of Units (SI)

Quantity names and symbols of base units in the SI		
MAGNITUDE	UNIT NAME	UNIT SYMBOL
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Quantity names and symbols of supplementary units of the SI		
Magnitude	Name	Symbol
Angle	radian[1]	rad
Solid angle	steradian[2]	sr

[1] It's the flat angle comprised between two radiuses of a circle that intercept over the circumference of an arch of length equal to its radius.
[2] The solid angle that has its vortex in the center of a sphere and that intercepts over the surface of the sphere an area equal to the one of a square that measures the radius of the sphere on each side.

Examples of SI units, derived, without a special name		
Magnitude	Name	Symbol
Surface	Square meter	m^2
Volume	Cubic meter	m^3
Velocity	Meter per second	m/s
Acceleration	Meter per square second	m/s^2
Wavenumber	Meter to the negative one	m^{-1}
Volume mass, density	Kilogram per cubic meter	kg/m^3
Specific volume	Cubic meter per kilogram	m^3/kg
Current density	Ampere per square meter	A/m^2
Electric field density	Ampere per meter	a/m
Concentration	Mol per cubic meter	mol/m^3
Luminance	Candela per square meter	cd/m^2

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Appendix 1

Quantity names and symbols of some derived units in the SI		
MAGNITUDE	NAME	SYMBOL
Frequency	hertz	Hz
Force, weight	newton	N
Pressure, stress	pascal	Pa
Energy, work, heat	joule	J
Power, radiant flux	watt	W
Electric charge or quantity of electricity	coulomb	C
Voltage (electrical potential difference), electromotive force	volt	V
Electric capacitance	farad	F
Electric resistance, impedance, reactance	ohm	Ω
Luminous flux	lumen	lm
Illuminance	lux	lx
Temperature relative to 273.15 K	degree Celsius	°C

Prefixes for multiples and fractions			
Name	Symbol	Scientific Notation	Magnitude
peta-	P	10^{15}	1,000,000,000,000,000
tera-	T	10^{12}	1,000,000,000,000
giga-	G	10^{9}	100,000,000
mega-	M	10^{6}	100,000
kilo-	k	10^{3}	1,000
hecto-	h	10^{2}	100
deca-	da	10^{1}	10
deci-	d	10^{-1}	0.1
centi-	c	10^{-2}	0.01
milli-	m	10^{-3}	0.001
micro	µ	10^{-6}	0.000 00 1
nano-	n	10^{-9}	0.000 000 00 1
pico-	p	10^{-12}	0.000 000 000 00 1
femto-	f	10^{-15}	0.000 000 000 000 00 1
atto-	a	10^{-18}	0.000 000 000 000 000 00 1

In accordance to the General Regulation Directorate of the Ministry of Economics

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Physics

Unit **1 Assessment**

Date: ______________________________

Name: ______________________________

UNDERLINE THE CORRECT ANSWER

1. To describe motion it is essential to define:

- **a)** The moving object's size.
- **b)** The time interval.
- **c)** The starting point.
- **d)** A reference point.

2. Trajectory length of a moving object is known as:

- **a)** Displacement.
- **b)** Velocity.
- **c)** Distance.
- **d)** Graph.

3. Displacement is defined:

- **a)** The difference between starting and ending points.
- **b)** Trajectory length of a moving object.
- **c)** Distance per time unit.
- **d)** Direction and the velocity vector module.

4. The relation between displacement of a moving object and the time interval in which it occurs is called:

- **a)** Velocity.
- **b)** Distance.
- **c)** Speed.
- **d)** Trajectory.

5. Speed is the relation or change rate between:

- **a)** Displacement and time.
- **b)** Velocity and time.
- **c)** Distance and time.
- **d)** Trajectory and time.

6. Which of the following statements is not true for linear motion?

- **a)** The moving object covers equal distances in equal time intervals.
- **b)** The moving object velocity is variable.
- **c)** The moving object experiments equal displacements in equal time intervals.
- **d)** The moving object trajectory in a straight line.

7. If motion is linear and uniform, how is the position-time, x-t graph?

   a) A circumference.

   b) A parabola.

   c) A polygonal line.

   d) A straight line.

8. The slope in the x-t graph physically corresponds to:

   a) Velocity.

   b) Trajectory.

   c) Speed.

   d) Position.

9. In an x-t graph, a negative slope represents motion in which:

   a) The moving object moves away from the origin or reference point.

   b) The moving object is in repose according to the reference point.

   c) The moving object is going downhill or descending on a leaning plane.

   d) The moving object is near the origin or reference point.

10. In an x-t graph a positive slope represents motion in which:

    a) The moving object moves away from the origin or reference point.

    b) The moving object is in repose according to the reference point.

    c) The moving object is going downhill or descending on a leaning plane.

    d) The moving object is near the origin or reference point.

11. In an x-t graph, a neutral slope represents motion in which:

    a) a) The moving object moves away from the origin or reference point.

    b) b) The moving object is in repose according to the reference point.

    c) c) The moving object is going downhill or descending on a leaning plane.

    d) d) The moving object is near the origin or reference point.

12. Acceleration is the rate of change between:

    a) Speed and time.

    b) Velocity and time.

    c) Distance and time.

    d) Trajectory and time.

13. From the following sentences regarding free falling, the only one which is true is:

    a) Free falling is a linear motion.

    b) In free falling velocity is constant.

    c) The time that it takes for objects to fall depends on their weight.

    d) The shape of objects that fall on Earth does not influence the falling time.

14. Who was the scientist who affirmed that all objects have a natural place where they belong and they will try to go back to it if they move away from it?

a) Archimedes.

b) Galileo.

c) Newton.

d) Aristotle.

15. Which is the position-time, x-t graph for a motion under constant acceleration?

a) A semi-circumference.

b) A semi-parabola.

c) A semi-ellipse.

d) A semi-straight.

16. In a velocity-time graph (v-t graph), a positive slope represents motion in which:

a) The moving object has zero velocity.

b) The moving object has constant acceleration.

c) The moving object has zero acceleration.

d) The moving object has constant deceleration.

17. In a velocity-time graph (v-t graph), a negative slope represents motion in which:

a) The moving object is in repose.

b) The moving object has constant acceleration.

c) The moving object has zero acceleration.

d) The moving object has constant deceleration.

18. In a velocity-time graph (v-t graph), a neutral slope represents motion in which:

a) The moving object has a velocity equal to zero.

b) The moving object has constant acceleration motion.

c) The moving object has linear motion.

d) The moving object has free falling motion.

19. If there is linear motion, how is the acceleration-time graph (a-t graph)?

a) A horizontal, straight line that is on the time axis.

b) A leaning straight line with a positive slope.

c) A vertical straight line that is on the acceleration axis.

d) A leaning straight line with a negative slope.

20. All of the following are scalars, except for:

a) Time.

b) Distance.

c) Speed.

d) Position.

Physics

Unit **1 Assessment** Answer Key

1. d
2. c
3. a
4. a
5. c
6. b
7. d
8. a
9. d
10. a
11. b
12. b
13. a
14. d
15. b
16. b
17. d
18. c
19. a
20. d

Physics

Unit **2 Assessment**

Date: ____

Name: ____

UNDERLINE THE CORRECT ANSWER

1. How is the quantity of an object movement calculated?

- **a)** Mass x acceleration.
- **b)** Distance x time.
- **c)** Mass x velocity.
- **d)** Force x distance.

2. Which parts make a vector?

- **a)** Magnitude and size.
- **b)** Direction and sense.
- **c)** Size and velocity.
- **d)** Magnitude and Direction.

3. If I push a sphere of 3 kg mass with a force of 100N, what is the acceleration?

- **a)** 300 m/s^2
- **b)** 33.3 m/s^2
- **c)** 3.3 m/s^2
- **d)** 3300 m/s^2

4. Which of the following sentences is true?

- **a)** Mass and weight is the same thing.
- **b)** Mass only depends on the object, whereas weight is the measurement of the attraction force.
- **c)** Weight is always more than mass.
- **d)** The weight of an object is the same in every planet in the Solar System.

5. If in the Earth surface the gravitational acceleration is 9.81 m/s2, how much is the weight of an object whose mass is 10kg?

- **a)** 98.1 N.
- **b)** 0.981 N.
- **c)** 9.81 N
- **d)** 34 N.

6. Which is the force that is responsible for the Earth spinning around the Sun?

- **a)** Electric.
- **b)** Magnetic.

- **c)** Gravitational.
- **d)** Nuclear.

7. Lightning is an example of a/an ______________________________ phenomenon.

- **a)** Electric.
- **b)** Magnetic.
- **c)** Gravitational.
- **d)** Ferromagnetic.

8. The electricity that comes out of an outlet is:

- **a)** Positive electric charge.
- **b)** Thermal energy.
- **c)** Atoms in movement.
- **d)** Negative electric charge.

9. Between two equal magnetic poles there is:

- **a)** Repose.
- **b)** Repulsion.
- **c)** Attraction.
- **d)** Acceleration.

10. Force is proportional to:

- **a)** Repose.
- **b)** Position.
- **c)** Velocity.
- **d)** Acceleration.

11. In photosynthesis, energy changes from:

- **a)** Gravitational to thermal one.
- **b)** Electromagnetic to chemical one.
- **c)** Potential to kinetic one.
- **d)** Chemical to physical one.

12. Energy is measured in:

- **a)** Watts.
- **b)** Newtons.
- **c)** Joules.
- **d)** Pascals.

13. If an object has kinetic energy 0, it means that:

- **a)** It has no velocity.
- **b)** It has no height.
- **c)** It has no temperature.
- **d)** It has no force.

14. The compass heads North because:

a) There are electric charges in the north of Earth.

b) The total magnetic field on Earth is lined up north - south.

c) The spinning axis of Earth goes from North to South.

d) The gravity of Earth is stronger in the North.

15. All interactions:

a) Imply contact among objects.

b) Are electromagnetic.

c) Are neutral.

d) Imply an energy exchange.

16. Force is measured in:

a) Joules

b) Kg m/s^2

c) Watts.

d) Meters.

17. The momentum of an object of plus 8 kg and velocity 5m/s is:

a) 40 m/s^2.

b) 5 x 8 kg m/s.

c) 1.6 J.

d) 4 N.

18. Potential energy is:

a) Consequence of velocity.

b) A quantity that is always preserved.

c) The one that is in the nucleus.

d) Saved energy.

19. Energy:

a) Disappears when we use it.

b) Appears in the sun.

c) Cannot be created or destroyed. It can only be changed from one form to another.

d) Is heat.

20. If I double the distance between two loaded particles, the force between them:

a) Doubles.

b) Is maintained.

c) Inverts.

d) Is reduced 4 times.

Physics

Unit **2 Assessment** Answer Key

1. c
2. d
3. a
4. b
5. a
6. c
7. a
8. d
9. b
10. d
11. b
12. c
13. a
14. b
15. d
16. b
17. b
18. d
19. c
20. d

Physics

Unit **3 Assessment**

Date: ______________________________

Name: ______________________________

UNDERLINE THE CORRECT ANSWER

1. Energy:

- **a)** Disappears when we use it.
- **b)** Appears in the sun.
- **c)** Neither appears, nor disappears, only changes.
- **d)** Is heat.

2. What is energy?

- **a)** Something that moves.
- **b)** The body temperature.
- **c)** The capacity to do work.
- **d)** The substance that attracts a body.

3. Which of the following sentences describes correctly what happens at the summit of a roller coaster, one second before a cart starts descending?

- **a)** Kinetic energy equals potential energy at that point.
- **b)** There is maximum potential energy and minimum potential energy.
- **c)** There is maximum potential energy and kinetic energy is cero.
- **d)** The total mechanical energy is cero.

4. When we measure the temperature of a metal spoon and a wooden spoon that were in a room with no sun light for a few hours, we find that:

- **a)** The temperature of the wooden spoon is more than the one of the metal spoon.
- **b)** The temperature of the wooden spoon is lower than the one of the metal spoon.
- **c)** The temperature of the wooden spoon is as much as the one of the metal spoon.

5. In an ideal gas, the rise in the collisions number with the recipient walls implies an increase of gas pressure.

- **a)** True.
- **b)** False.

6. In an ideal gas, if temperature is constant, a reduction in the recipient volume implies a lower gas pressure.

- **a)** True.
- **b)** False.

7. In an ideal gas, if temperature is risen, the kinetic energy of the gas particles:

a) Increases.

b) Decreases.

c) Is maintained.

d) Goes back.

8. Gold density is 1.93×10^4 kg/m^3, while silver density is 1.05×10^4 kg/m^3. If I want to make a similar size gold and a silver medal, which one has the lower mass?

a) The gold medal.

b) The silver medal.

c) Both have the same mass.

d) The bronze medal.

9. Due to the quantity of salt in the Death Sea, a human will always float in its waters. Which of the following sentences best describes this situation?

a) The human body's density is more than the one of the Death Sea.

b) This phenomenon has nothing to do with the Death Sea density.

c) The human body density is lower than the one of the Death Sea and that is why it never sinks.

d) The human body's density is exactly equal to the density of the Death Sea.

10. When measuring certain substance temperature, a mercury thermometer gives a measure of 24° C, what temperature does the mercury have?

a) 12° C.

b) 24° C.

c) The mercury temperature is just a more than the substance temperature.

d) The mercury temperature is lower than the substance temperature.

11. Heat flux direction will always be:

a) From the body with more temperature to the one with lower temperature.

b) From the body with lower temperature to the one with more temperature.

c) At the same time, in both ways.

d) First from the more to the lower and then from the lower to the more.

12. The transformation of matter from solid to liquid is known as:

a) Solidification.

b) Condensation.

c) Fusion.

d) Sublimation.

13. In the ISU, temperature is measured in:

a) Centigrade or Degrees Celsius.

b) Fahrenheit.

c) Kelvin.

d) Calories.

14. What is the name of the phase change from liquid to solid?

a) Solidification.

b) Superficial tension.

c) Vaporization.

d) Condensation.

15. In a pot with boiling water, heat is transmitted to water by:

a) Convection.

b) Radiation.

c) Convergence.

d) Conduction.

16. Temperature measures:

a) The quantity of heat in a body.

b) The molecules size.

c) The aggregation state.

d) The average kinetic energy.

17. The Sun transmits heat to Earth by:

a) Convection.

b) Radiation.

c) Convergence.

d) Conduction.

18. The property of gasses of increasing their volume when external forces stop acting on them is known as:

a) Volume.

b) Density.

c) Expandability.

d) Compressibility.

19. The main aggregation states of matter are:

a) Solid, liquid, atomic.

b) Plasma, solid, atomic.

c) Atomic, gas, liquid.

d) Gas, solid, liquid.

20. How much is 40K in oC?

a) 233 °C.

b) O °C.

c) -233 °C.

d) -243 °C.

Physics

Unit **3 Assessment** Answer Key

1. c
2. c
3. c
4. c
5. a
6. a
7. a
8. b
9. c
10. b
11. a
12. c
13. c
14. a
15. a
16. d
17. b
18. c
19. d
20. c

Physics
Unit **4 Assessment**

Date: ______________________________

Name: ______________________________

UNDERLINE THE CORRECT ANSWER

1. Which phenomena cannot be explained by the kinetic theory?

- **a)** Solids, liquids and gasses.
- **b)** Temperature of a body.
- **c)** Lightning and compasses.
- **d)** Pressure.

2. Which model did Thompson propose?

- **a)** The chemical atom.
- **b)** The planetarium model.
- **c)** The quantum model.
- **d)** The plum pudding model.

3. Electric charges from the same charge:

- **a)** Repel each other.
- **b)** Attract each other.
- **c)** Like each other.
- **d)** Are the same size.

4. If you break a magnet in halves, you get:

- **a)** A magnetic pole in one and the opposite one in the other.
- **b)** Two halves that no longer work as a magnet.
- **c)** Two magnets, each one with two charges.
- **d)** Two electric charges.

5. What charge does a proton have?

- **a)** Positive.
- **b)** Negative.
- **c)** Neutral.
- **d)** A lot.

6. The electron mass:

- **a)** Equals the proton one.
- **b)** 2000 times lower than the proton.
- **c)** 10 times more than the proton.
- **d)** 7.4 times the proton mass.

7. Which of the following electromagnetic waves has lower frequency?

a) Radio.

b) Green color.

c) X rays.

d) Gamma rays.

8. Which of the following electromagnetic waves has more wavelengths?

a) Radio.

b) Green color.

c) X rays.

d) Gamma rays.

9. What is the cause of magnetism?

a) Magnetosphere.

b) Temperature.

c) Electric charges.

d) Magnetite.

10. What is voltage?

a) The amount of electric charge per second.

b) Volts.

c) The electric potential that each charge has.

d) The potential of a battery.

11. Which particle did Rutherford discover?

a) Electron.

b) Neutron.

c) Neutrino.

d) Proton.

12. The magnetic field unit is the:

a) Watt.

b) Ampere.

c) Volt.

d) Tesla.

13. En general, a wave has more energy if:

a) It has lower frequency.

b) It has more wavelengths.

c) It has more periods.

d) It has more frequency.

14. If in a 10 Ohms resistance circuit there is one ampere current, how much was the voltage?

- **a)** 10 volts.
- **b)** 5 volts.
- **c)** 1 volt.
- **d)** 0 volts.

15. The fact that a material be insulating means:

- **a)** Charges can move freely in it.
- **b)** It is hard and smooth.
- **c)** It easily heats.
- **d)** Charges cannot move a lot in it.

16. Light is:

- **a)** Electrons traveling.
- **b)** Moving protons.
- **c)** An electromagnetic wave.
- **d)** A color.

17. The Dalton atom:

- **a)** Can be divided without losing its chemical properties.
- **b)** Cannot be divided.
- **c)** It can be divided, but the chemical properties are lost.
- **d)** It has negative charge.

18. What model of matter did Bohr propose?

- **a)** The planetarium atom.
- **b)** The quantum atom.
- **c)** The neon atom.
- **d)** The plum pudding.

19. The refraction phenomenon explains:

- **a)** That rays bend in mirrors.
- **b)** That we look at a distorted straw when it is inside a glass of water.
- **c)** That there are colors we cannot see.
- **d)** That light travels in space.

20. Which of the following electromagnetic waves has more energy?

- **a)** Radio.
- **b)** Infrared.
- **c)** Blue color.
- **d)** Ultraviolet.

Physics

Unit **4 Assessment** Answer Key

Match the columns

1. c

2. d

3. a

4.c

5. a

6. b

7. a

8. a

9. c

10. c

11. d

12. d

13. d

14. a

15. d

16. c

17. c

18. b

19. b

20. d

Physics
Unit **5 Assessment**

Date: ____________________

Name: ____________________

UNDERLINE THE CORRECT ANSWER

1. What evidence is there of The Big Bang?

- **a)** Stars.
- **b)** Radiation of a body.
- **c)** A sacred book.
- **d)** It can be seen in telescopes.

2. What is the science that studies celestial bodies?

- **a)** Geology.
- **b)** Astrology.
- **c)** Chemistry.
- **d)** Astronomy.

3. What is a light year?

- **a)** A time scale.
- **b)** A distance scale.
- **c)** A velocity.
- **d)** The same as a year.

4. Why are telescopes orbiting outside the atmosphere?

- **a)** Because the atmosphere blocks many light frequencies.
- **b)** Because they don't break down that much.
- **c)** Because they have to be cold.
- **d)** Because scientists get more publicity.

5. How is it known what stars are made of?

- **a)** Little pieces of star are analyzed.
- **b)** Humans don't really know.
- **c)** Light frequencies from them are analyzed.
- **d)** Because of the way they move.

6. Which of the following medical developments is linked to physics study?

- **a)** Aspirin.
- **b)** Magnetic Resonance Imaging.
- **c)** Scalpel.
- **d)** Penicillin.

7. Which of the following medical technologies uses electromagnetic waves?
   - **a)** Ultrasound.
   - **b)** X-rays.
   - **c)** Anesthetic.
   - **d)** Defibrillator.
8. Which is an example of information transmission in space?
   - **a)** Radio.
   - **b)** Telegraph.
   - **c)** Internet.
   - **d)** Sound.
9. Why short wave radios can tune in radio stations that are in the other side of the world?
   - **a)** Because the waves of that frequency bounce in the atmosphere.
   - **b)** Because they're very powerful.
   - **c)** Because they have antennas all over the world.
   - **d)** Because there is no interference.
10. Who invented the radio receptor?
   - **a)** Guillermo Marconi.
   - **b)** Nikola Tesla.
   - **c)** Alexander Graham Bell.
   - **d)** Samuel Morse.
11. According to Einstein's theory of relativity, which is the fastest speed to transmit data?
   - **a)** Sound speed.
   - **b)** 299.792.458 m/s.
   - **c)** The speed of electrons in a wire.
   - **d)** Infinite.
12. What's a barometer for?
   - **a)** To measure temperature.
   - **b)** To measure pressure.
   - **c)** To measure magnetic field.
   - **d)** To measure electric power.
13. What's the unit to measure an earthquake's intensity?
   - **a)** Pascals.
   - **b)** Kelvin degrees.
   - **c)** Pound over square foot.
   - **d)** Richter.

14. Which is the natural phenomenon consequence of an earthquake?

a) Tsunami.

b) Waves.

c) Tide.

d) Hurricane.

15. Which is the alternative energy that nowadays could substitute petroleum?

a) Eolic.

b) Geothermal.

c) Hydrogen.

d) None of the previous.

16. What is the area of Physics in which Mexico is recognized worldwide?

a) Astronomy.

b) Quantum.

c) Relativity.

d) Nanotechnology.

17. Which of the following options is a historical process deeply influenced by physics?

a) The French Revolution.

b) The Industrial Revolution.

c) The Russian Revolution.

d) The Protestant Reform.

18. Which are the actions that can help decrease the effects of global weather change?

a) Energy saving.

b) Fossil fuel consumption.

c) Wash hands.

d) Lithium batteries use.

19. Which is the discipline from which modern physics was born?

a) Alchemy.

b) Hermetic.

c) Optics.

d) Astronomy.

20. How many Mexican people have won a Nobel Prize because of scientific work?

a) 1.

b) 2.

c) 3.

d) 4.

Physics

Unit **5 Assessment** Answer Key

Match the columns

1. b
2. d
3. b
4. a
5. c
6. b
7. b
8. a
9. a
10. a
11. b
12. b
13. d
14. a
15. d
16. a
17. b
18. a
19. d
20. a

Projects Rubrics

Aspect	Beginner	In process	Expert
Theoretical framework	The introduction is weak or there are major inaccurate aspects.	The introduction does not fit with the rest of the project or there are minor inaccurate aspects.	The introduction provides with accurate and relevant information.
Project evidence	The project has inaccurate data. It is irrelevant or repetitive and it contains questionable evidence.	The project has minor errors or it is not very elaborated.	The project is clearly explained.
Project design and performance	The variables are not controlled. The study object is not focused. There's a lack of data.	Some variables are controlled. The study object is focused. The data has mistakes.	The variables are under control. The study object is clearly focused. There are few data mistakes.
Conclusion	There is not a conclusion or it is not sustained.	There is a conclusion, but it is weakly sustained.	The conclusion is well sustained.
References	The reference list contains one or two sources but the references are incomplete.	The reference list contains three sources with complete references.	The reference list contains four or more sources with complete references.
Language use	The project is not very clear. It lacks organization, coherency or appropriate grammar use.	The project is clear, with a few flaws on organization, coherency or appropriate grammar use.	The project is coherently described and clearly stated with few grammar and spelling mistakes.
Collaborative work	Not all the members of the team presented or participated.	Some of the members of the team presented or participated.	All the members of the team presented or participated.

Physics

Attendance and Evaluation List

School: ____________________ School year: ________________ Teacher: ______________________________

Student's name	Unit attendance																Sequences grades			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				

Physics

Attendance and Evaluation List

School: ______________ School year: ______________ Teacher: ______________

Student's name	Unit attendance																Sequences grades			
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32				

Physics

Attendance and Evaluation List

School: ______________ School year: ______________ Teacher: ______________

Student's name	Unit attendance																Sequences grades				Unit Project	Unit grade
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48						

Exercises

Potential Energy

1. What is the potential energy that an object has when suspended at 25 m height and 12kg mass?
2. How high is an object which has 32kg mass and its potential energy is 52000J?
3. An object that weighs 4900N is 45m high. How much potential energy does it have?
4. The potential energy of a 15kg object is 650J. How high is it?
5. The potential energy of an object suspended at 18m high is 4000J. What's its mass?
6. The potential energy of an object suspended at 22m high is 5000J. How much does it weight?
7. An object that weighs 637N has 1000J of potential energy. How high is it?
8. An object whose mass is 12kg and that was 15m high, lost 400J of potential energy when it was relocated. How high was it placed?
9. A 52N weight object was at 15m high; then it was raised and won 300J of potential energy. How high was it placed?
10. A 35kg object was 14m high and then it was placed at 21m. How many joules difference does it have now?

Answers:

1. **PE= 2943J**
2. **h= 165.64m**
3. **PE= 220500J**
4. **h= 4.41**
5. **m=22.65**
6. **w= 22.27N**
7. **h=1.56m**
8. **h=8.60m**
9. **h=20.76m**
10. **Difference= 2403.45J**

Kinetic energy

1. An object moves at 9m/s and has 14kg mass. What is its kinetic energy?
2. An object has 1000J kinetic energy. If its mass is 20kg, how fast is it?
3. A mobile moves at 5m/s and weighs 981N. How much kinetic energy does it have?
4. A mobile moves at 14m/s and has 900J of kinetic energy. What is its mass?
5. An object is 400N and moves at 7m/s. What is its kinetic energy?
6. An object with 750J kinetic energy moves at 9m/s. How much does it weigh?
7. An object is 158N weigh and has 2000J kinetic energy. How fast is it?
8. An object, which is 3kg weigh, is dropped at a height of 15m. How much kinetic energy does it have when crashing with the floor?
9. An object slides with an acceleration of 1.5 m/s2. How much kinetic energy does it have when it has been sliding for 3 seconds? Consider that it starts on repose.
10. The kinetic energy of an object, which is 9 kg, is 89J. How fast does it move?

Answers

1. **KE = 567J**
2. **v = 10m/s**
3. **KE = 1250J**
4. **m = 9.18 kg**
5. **KE = 998.86J**
6. **KE = 181.58 N**
7. **v = 15.76m/s**
8. **KE = 441.45J**
9. **KE = 405 J**
10. **v = 14.06 m**/s

Answers to the exercises

Page	Section	Answers
11	How much did I learn?	• Because Earth begins motion in a starting point and ends in the same spot. • Students should discuss. • The factors that define an object's motion are trajectory and displacement. • Yes, it is possible because they describe movement. • It depends on how different they are. • Yes, it is possible. • Students' own answers.
13	Reflect, Explain and Share	• Speed: 120 km/h. • Velocity: 120 km/h from South to North.
13	How much did I learn?	• To calculate an object's speed it is necessary to know the traveled distance and the time it took. • To calculate an object's velocity it is necessary to know the traveled distance and direction. • Speed and velocity are not the same because velocity is a vector whereas speed is a scale.
13	Exploring Knowledge	• Students should discuss the question. • Science reports use graphs and data tables to represent information. • A graph is an image or diagram that represents data in a simple way. • To locate a point on the Cartesian plane, it is necessary to have two values.
13	Reflect, Explain and Share	• Students' answers may vary.
13	Activity	• That the same distance is traveled in the same time intervals. • The velocity of the car is 0.08 m/s.
14	How much did I learn?	• The graph on the left represents constant movement. • The graph on the right represents the speed.
15	Exploring knowledge	• The rope moves. • Students' own answers.
16	Experiment	a) The difference is the perturbation made in each of them. The spring makes longitudinal waves and the rope makes transverse waves. b) No, it did not move. c) It moves in a longitudinal way.

17	How much did I learn?	• A wave is periodic movement; it is the expansion of a perturbation from one point to another. • Transverse waves and longitudinal waves. • The sound is a longitudinal wave. • The three main characteristics of sound are: pitch, tone and loudness or volume. • Yes, it is possible because underwater, sound travels faster. • No, it cannot.
18	Experiment	1. The wrestler falls down slowly because of air. 2. No. It does not have anything to do with the mass.
20	How much did I learn?	• A wrapped piece of paper falls faster because the wrapped piece hits less air as it falls down. • They would fall at the same speed if there was no air. • Students' own answers.
20	Reflect, Explain and Share	• Galileo lived during the Renaissance. This period's main characteristics were: the rebirth of humanism and the new discoveries in fine arts, music, literature, philosophy, science, technology, architecture, religion and spirituality.
21	How much did I learn?	• If the experiment goes wrong, students might get incorrect results.
23	How much did I learn?	• To calculate the velocity, the distance is divided by the time. • To calculate the acceleration, students have to follow the formula Speed change divided by taken time. • There is no acceleration because speed is constant. To calculate the velocity, the distance is divided by the time. • To calculate the acceleration, students have to follow the formula Speed change divided by taken time. • There is no acceleration because speed is constant.
24	Exploring Knowledge	1. Students' own answers. 2. The vertical axis represents the velocity and the horizontal axis represents time. 3. The vertical axis represents the acceleration and the horizontal axis represents time.
24	Activity	• Velocity: 0.6m/s in each case.
29	How much did I learn?	1. Yes, by sitting on a chair we exert some force on it. 2. Students' own answers. 3. The horse pulls the cart forward, and there is a backward force from the ground or friction. 4. The forces on the horse include: the backward force the cart exerts on it and the forward force on the ground on its hooves.

30	Exploring Knowledge	• The vector, which best represents the motion of the box, is the second from bottom to top, if both apply the same force. • Because the object will follow the direction of the person who is pushing it.
33	Exploring Knowledge	• Rest refers to the state of an object that is stationary, without moving. • Yes, there are forces acting upon it.
35	Activity	• There are two forces acting on the piñata, tension forces from the rope and the gravity force (weight).
35	How much did I learn?	1. Yes, because the forces acting in this case are equilibrated. 2. Students' own answers. 3. The tension force in rope 3 should be pushing towards the box, with a force of 40N.
44	Exploring Knowledge	1. Because there is friction. 2. An external force needs to act upon it. 3. When there is friction.
45	Activity	• No, they are not moving all the time. • Student's own answers. • The person may feel he or she is in state of rest.
45	How much did I learn?	1. Newton's first law in students' words. 2. Because there is no friction between the objects, there is inertia. 3. Inertia is the tendency of bodies to maintain their state of rest or uniform linear movement. 4. It is easier to move a body with little inertia because the bigger an object is and the higher velocity it has, the more inertia it has and the more difficult it will be to modify the state of rest.
46	Team Work	1. The acceleration force is 34 m/s2 in 5s. 2. The acceleration is 3.63 m/s2 3. The mass is 3.33 kg. 4. The first bod is 6 m/s2 and the second body is 3 m/s2. Their accelerations are different because of their mass.
47	How much did I learn?	1. Students should paraphrase Newton's Second Law. 2. Yes, it does. 3. The one with the less weight. 4. The one with the higher force. 5. a) 48N b) 7.46 m/s2 c) 88.77kg.
48	Activity	1. To kick a football is an action and a reaction. The foot exerts a force on the soccer ball. At the same time the soccer ball exerts an equal but opposite force on the foot. 2. To row a boat is an action and a reaction. The person propelling the row in the water is the action; the reaction is the water pushing the boat forward.

48	How much did I learn?	1. Newton's Third Law of Motion quoted by students. 2. It states that "For every action, there is an equal and opposite reaction". 3. Students' own answers. 4. Students' own answers. 5. Students will explain each case and represent the forces with vectors.
50	Team Work	a) 178 x 1019N b) 49.05 x 1019 N c) 21.80 x 1019N
50	How much did I learn?	1. It is the force of attraction that exists between two masses or two bodies. 2. The weight of a body is the force it has due to gravity. 3. It depends on its mass. 4. It shows the mass of the body in grams or kilograms. 5. It depends on the mass of the object. 6. It doubles as well.
52	How much did I learn?	1. Because the moon follows the curvature of Earth in its trajectory. 2. Because of the inertia and Earth's orbital motion. 3. Students' own perception.
53	Exploring Knowledge	1. Energy is a basic quantitative property of an object. 2. Students' own answers.
54	Activity	1. Heat, light, chemical energy. 2. Walking, running, flowing water. 3. A wrecking ball, a hammer.
54	How much did I learn?	1. It depends on the bodies' position. 2. It depends on the mass. 3. It is the sum of potential energy and kinetic energy. 4. A ball on the floor, for example.
54	Exploring Knowledge	1. The law of conservation of energy states "Energy cannot be created or destroyed, but only transferred or transformed from one form to another". 2. Examples may vary. Some options are: a) A television changes electrical energy into thermal energy and light. b) A toaster changes electrical energy into thermal energy and light. c) A flashlight changes chemical energy from batteries into light. 3. Its speed increases.
55	How much did I learn?	1. Students should draw the graph. 2. The motion is linear.
67	How much did I learn?	• Models are a representation used to understand physical phenomena. • A planetary model. • Yes, phenomena can be understood by using models.

72	How much did I learn?	1. Density is an intensive property. 2. Answers may vary according to the selected materials.
75	Exploring Knowledge	1. By using a thermometer. 2. It is possible to detect a fall or rise of temperature with them. 3. Because of the effect of extreme temperature.
78	How much did I learn?	1. Temperature is a measure of the average kinetic energy of particles. 2. Heat is energy that may manifest in many ways. 3. Heat is thermal energy; temperature is the measurement of average kinetic energy of particles. 4. Students' own answers.
80	Exploring Knowledge	1. Energy is the ability or capacity to do work. 2. Mechanical, including potential energy and kinetic energy; radiant or solar, thermal, chemical, electrical, electromagnetic, mass or nuclear. 3. In different tasks. 4. Yes, all objects have energy.
82	How much did I learn?	1. Energy is the capacity of a system to do work. Work is the force that acts on an object. 2. Students' own answers. 3. 750J. 4. It is the energy needed to create the system. 5. Students will do research about the generation of energy in hydroelectric industries. 6. Students should write a text to explain the Law of Conservation of Energy.
82	Exploring Knowledge	1. Students' own answers. 2. Thermal equilibrium refers to steady states of temperature.
82	How much did I learn?	1. Absolute zero cannot be achieved, although it is possible to reach temperatures close to it. 2. Some examples may be: setting ice cubes in hot water, a waterfall and a turbine to get hydroelectric power. 3. Thermodynamics studies the energy of motion and heat. 4. It uses vacuum to insulate the inside from the outside. Vacuum reduces the ways heat can be dissipated.
83	Exploring Knowledge	1. Both mercury and alcohol increase when heated and decrease when cooled. Inside the glass tube of a thermometer, the liquid has no place to but up higher when the temperature is hot and down when the temperature is cold. 2. Yes, they do. 3. Because we can feel it. By conduction, convection and radiation.

83	How much did I learn?	1. Yes, the rise in temperature will be the same. 2. Some examples may include: Radiation: heat from a light bulb, heat from a fire. Conduction: when a computer is on for a long time, when touching hot sand. Convection: a radiator, a hot air balloon, a lava lamp.
101	How much did I learn?	1. Students should explain their answers. 2. It should have either gained a negative charge or lost a positive one. 3. Students should explain in their own words what an ion is.
106	How much did I learn?	1. Metals, in general are good conductors, but silver, copper and gold are the best. 2. Vacuum, silica, cork, cotton, hemp, wool and wood. They are used to control combustion, to absorb moisture, provide impermeability, etc. 3. Diamonds, silicon, germanium have great thermal conductivity, and are used in computers. 4. Some examples may include: Hair dryers, toaster, electric ovens, and Christmas trees lights.
108	Exploring Knowledge	1. It is the electromagnetic radiation that is visible to human eyes and it is responsible for the sense of sight. 2. Students' own answers.
109	Exploring Knowledge	1. It is the range of all possible frequencies of electromagnetic radiation. 2. Ultraviolet (UV) rays, are invisible rays that are part of the energy that comes from the sun. They are dangerous to human skin, eyes and hair if unprotected. 3. No, they are not the same; sound waves are compression waves that oscillate in the direction of travel at speed of sound. Radio waves are translational waves that oscillate perpendicularly to the travel direction. 4. Sound waves require a medium and light waves do not. Sound waves are longitudinal and are of different frequencies. Light waves are electromagnetic and their different frequencies results in colors.
113	Exploring Knowledge	1. It is the electromagnetic radiation of any wavelength that is visible to the human eye. 2. Because when light hits an object, the object absorbs some of the light and reflects the rest. 3. It is the range of all possible frequencies of electromagnetic radiation

113	How much did I learn?	1. Gamma rays cannot pass through lead because of its density. 2. It is the emission of energetic particles or waves from atoms. 3. They are materials that contain unstable elements, like Uranium and Plutonium. They are used in medical or pharmaceutical industries.
129	Exploring Knowledge	1. A star is a massive, luminous sphere of plasma held together by its own gravity. 2. Stars have their own light and twinkle at night. Their relative positions do not undergo any noticeable change: stars have very high temperatures. Planets are smaller and solid, they shine by reflecting the light, planets have lower temperatures and there are fewer in the solar system. 3. In 2006, the International Astronomical Union definition of a planet excluded Pluto and it was reclassified as a dwarf planet. 4. The Milky Way Galaxy is considered a Barred Spiral type of galaxy.
132	How much did I learn?	1. Meteor is the flash of light we can see in the sky. Meteoroid is a piece of interplanetary matter. Meteorite is any part of meteoroid that survives the fall through the atmosphere and lands on Earth. 2. Natural satellites are formed naturally and we do not have control over them; they orbit a planet and do not have life expectancy. Artificial satellites are the ones made by humans; we control them and choose the type of information they carry; they can be set in specific locations. 3. A comet is an icy small body that heats and outgases displaying a visible atmosphere or coma. 4. Planets are grouped into several different classifications; the main ones are: interior, gas giant, inner planets, outer planets and superior planets.
132	Exploring Knowledge	1. Telescopes, radars and electronic space telescopes, like the Hubble.

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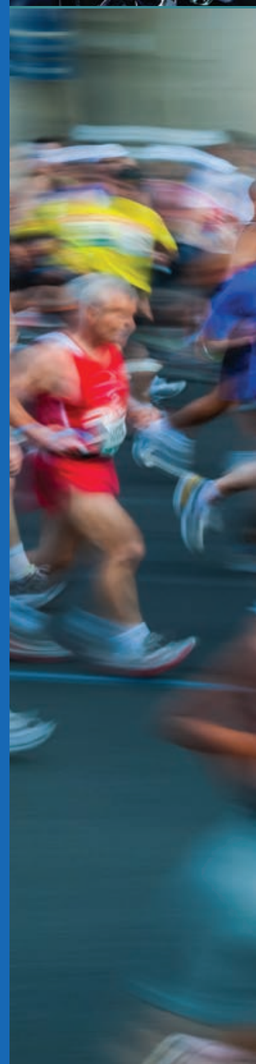

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