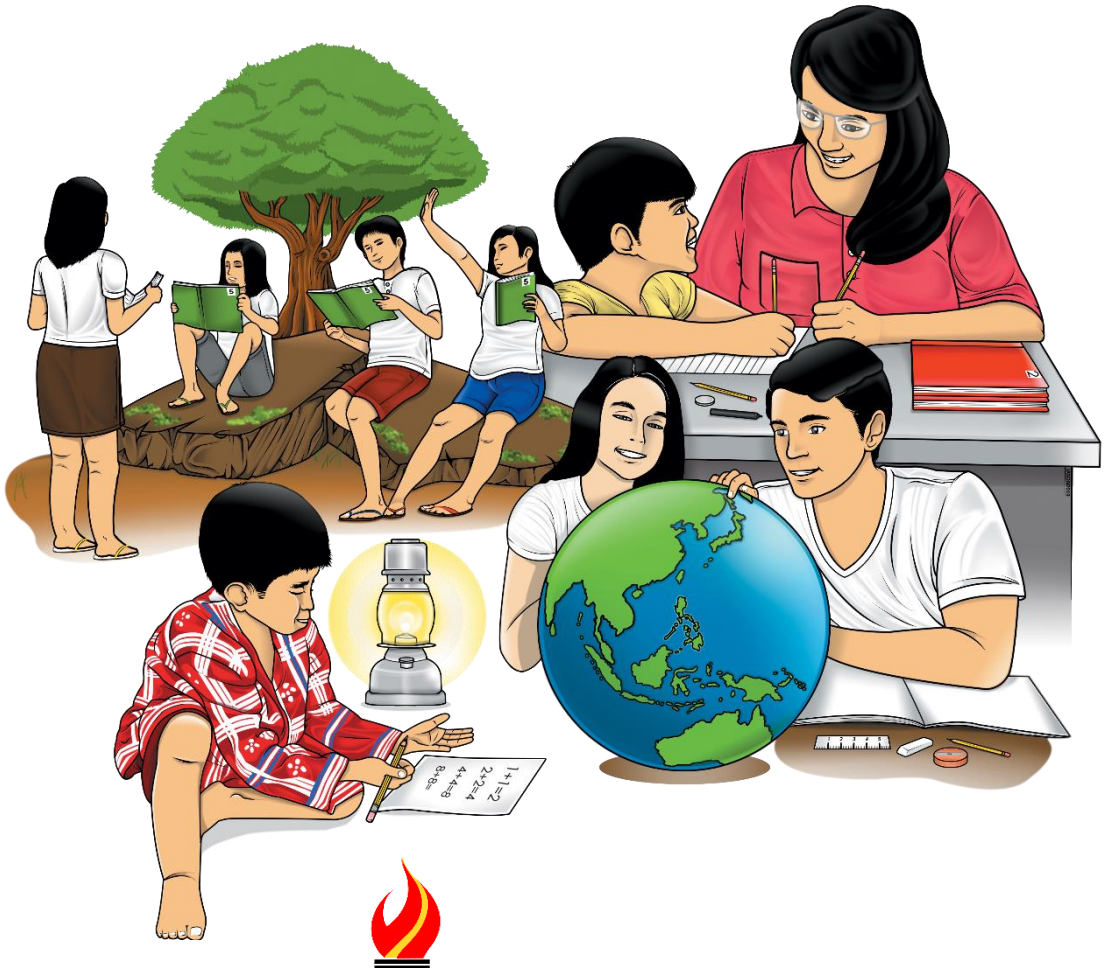
Senior High School

DepED
DEPARTMENT OF EDUCATION

Physical Science

Quarter 2 – Module 2: Investigating Principles Governing Motion



ALTERNATIVE DELIVERY MODE
ADM

Physical Science
Alternative Delivery Mode
Quarter 2 – Module 2: Investigating Principles Governing Motion
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Introductory Message

For the facilitator:

Welcome to Physical Science Grade 11/12 Alternative Delivery Mode (ADM) Module on Aristotelian and Galilean conceptions regarding motion, uniform acceleration, and the distinction between Newton's first law of motion to Galileo's assertion!

This module was collaboratively designed, developed, and reviewed to assist the teachers/facilitators in helping the learners meet the standards set by the K to 12 Curriculum while overcoming their personal, social, and economic constraints in schooling.

This learning resource hopes to engage the learners in guided and independent learning activities at their own pace and time. Furthermore, this also aims to help learners acquire the needed 21st - century skills while taking into consideration their needs.

In addition to the material in the main text, you will also see this box in the body of the module:

Notes to the Teacher

This contains helpful tips or strategies that will help you in guiding the learners.

As a facilitator, you are expected to orient the learners on how to use this module. You also need to keep track of the learners' progress while allowing them to manage their learning. Furthermore, you are expected to encourage and assist the learners as they do the tasks included in the module.

For the learner:

Welcome to Physical Science 11/12 Alternative Delivery Mode (ADM) Module on Aristotelian and Galilean conceptions regarding motion, uniform acceleration, and the distinction between Newton's first law of motion to Galileo's assertion!

Our hands are the most represented parts of the human body. It is often used to depict skill, action, and purpose. With our hands, we create, accomplish and learn. Hence, you are capable and empowered to successfully achieve the relevant competencies and skills at your own pace and time. Your academic success lies in your own hands!

This module was designed to provide you with fun and meaningful opportunities for guided and independent learning at your own pace and time. You will be able to process the contents of the learning resource while being an active learner.

This module has the following parts:

 ***What I Need to Know***	This will give you an idea of the skills or competencies you are expected to learn in the module.
 ***What I Know***	This part includes activity that will check what you already know about the lesson. If you get all the correct answer (100%), you may decide to skip this module.
 ***What's In***	This is a brief drill or review to help you link the current lesson with the previous one.
 ***What's New***	In this portion, the new lesson will be introduced to you in various ways such as a story, a song, a poem, a problem opener, an activity, or a situation.
 ***What is It***	This section provides a brief discussion of the lesson. This aims to help you discover and understand new concepts and skills.
 ***What's More***	This comprises activities for independent practice to solidify your understanding and skills of the topic. You may check the answers to the exercises using the Answer Key at the end of the module.
 ***What I Have Learned***	This includes questions or blank sentences/paragraphs to be filled in to process what you learned from the lesson.
 ***What I Can Do***	This section provides an activity that will help you transfer your new knowledge or skills into real-life situations.

 ***Assessment***	This is a task which aims to evaluate your level of mastery in achieving the learning competency.
 ***Additional Activities***	In this portion, another activity will be given to you to enrich your knowledge or skill of the lesson learned.
 ***Answer Key***	This contains answers to all activities in the module.

At the end of this module you will also find:

References	This is a list of all sources used in developing this module.

The following are some reminders in using this module:

1. Use the module with care. Do not put unnecessary mark/s on any part of the module. Use a separate sheet of paper in answering the exercises.
2. Don't forget to answer *What I Know* before moving on to the other activities in the module.
3. Read the instruction carefully before doing each task.
4. Observe honesty and integrity in doing the tasks and in checking your answers.
5. Finish the task at hand before proceeding to the next activity.
6. Return this module to your teacher/facilitator once done.

If you encounter any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator. Always bear in mind that you are not alone.

We hope that through this material, you will experience meaningful learning and gain a deep understanding of the relevant competencies. You can do it!

What I Need to Know

This module was designed and written with you in mind. It aims to help you master the Aristotelian and Galilean concepts regarding motion, uniform acceleration, and the distinction between Newton's first law of motion to Galileo's assertion. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course.

The module consists of only one lesson:

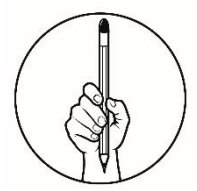
- Lesson 1 – Aristotelian and Galilean Conception of motion, Uniform acceleration and Newton's first law of motion and Galileo's Assertion

After going through this module, you are expected to:

1. Compare and contrast Aristotelian and Galilean conceptions of vertical motion, horizontal motion, and projectile motion;
2. Explain how Galileo inferred that objects in vacuum fall with uniform acceleration, and that force is not necessary to sustain horizontal motion;
3. Explain the distinction between Newton's 1st Law of Motion & Galileo's assertion that force is not necessary to sustain horizontal motion; and
4. Cite practical applications of principles involving motion in our day to day living.

Notes to the Teacher

This module provides learning activities which encourage self-directed learning. Moreover, your role is to facilitate the learning process by providing a clear understanding of how to maximize the use of this module, monitor the development of our learners, scaffold the acquisition of learning to achieve target mastery level, and provide positive feedback regarding their progress.



What I Know

DIRECTIONS: Read each question carefully. Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. Which of the following is **TRUE** about Galileo's assertion about free - falling bodies?
    a. Bodies will fall on the surface of the Earth at a constant acceleration.
    b. Bodies will fall on the surface of the Earth at a constant speed.
    c. Bodies will fall on the surface of the Earth at a constant velocity.
    d. Bodies will fall on the surface of the Earth at a constant projectile.

2. Which of the following is **NOT** considered part of Aristotelian's natural motion?
    a. A book resting on top of a table
    b. Pushing a cart
    c. An apple falling from a tree
    d. Smoke naturally rises

3. Which of the following is **NOT** an assertion of Galileo?
    a. A body that is in uniform motion will move a distance that is proportional to the time it will take to travel.
    b. A uniformly accelerating body will travel at a speed proportional to time.
    c. An object in motion will keep moving; and the external force is not necessary to maintain the motion.
    d. A body will fall on the surface of the Earth at a constant speed.

4. Which of the following is **TRUE** about Aristotle's assertion about vertical motion?
    a. The distance of a body is inversely proportional to the time it covers to travel a certain height.
    b. The mass of a body is inversely proportional to the time it covers to travel a certain height.
    c. The acceleration of a body is inversely proportional to the time it covers to travel a certain height.
    d. The velocity of a body is inversely proportional to the time it covers to travel a certain height.

5. Which of the following is **TRUE** about inertia based on Galileo's conception?
    a. Inertia is responsible for bringing a body to motion.
    b. Inertia is responsible for the continuous acceleration of a body.
    c. The amount of inertia of a body is directly proportional to its mass.
    d. The amount of inertia of a body is inversely proportional to its mass.

Lesson 1 Investigating Principles Governing Motion

"The physics of motion provides one of the clearest examples of the intuitive and unexpected nature of Science." -Lewis Wolpert

What's In

In the previous module, you have learned how ancient Greeks presented the concept of spherical Earth, cited different astronomical phenomena known before the advent of the telescope, and explained Brahe's inventions and discoveries which paved the way to the development of Kepler's laws of planetary motion. In this module, you will examine Aristotelian and Galilean conceptions regarding motion, describe a body in motion exhibiting uniform acceleration, explain the distinction between Newton's first law of motion to Galileo's assertion, and identify the practical applications of the aforementioned topics in our day to day living.

What's New

Fall for You

Materials: 5 peso-coin, 1 whole paper, meter stick, glue

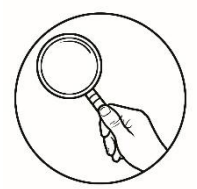
Setup A Directions : Hold a pen and 1 whole paper one meter above the ground. Drop both items simultaneously. Measure the time it hit the ground.

Setup B Directions: Attach the pen to the paper using a glue. Drop both items simultaneously. Measure the time it hit the ground.

Trials	**Setup A**		**Setup B**
	Recorded time in seconds		
	Pen	Paper	Pen & Paper
First			
Second			
Third			

Guide Questions

1. Give the time it took for the two items to hit the ground in both setups.
2. Describe your derived inference based on the activity.



What is It

Galilean Conceptions vs. Aristotelian Conceptions

According to Aristotle, motion is classified as natural or violent motion. He explained that in a **natural motion**, a body will move and will return to its natural state based on the body's nature and composition. In contrast, a body moving in a **violent motion** needs an external force for it to move. However, Galileo disproved Aristotle's claims and stated that the motion of a body is not due to its composition. He further asserted that the motion of a body can be described by measurement and the changes in quantifiable variables such as time and distance. Lastly, he further asserted that:

1. A body who is in uniform motion will move a distance that is proportional to the time it will take to travel;
2. A uniformly accelerating body will travel at a speed proportional to time; and
3. An object in motion will keep moving; and the external force is not necessary to maintain the motion.

With regards to the concept of vertical motion, Aristotle pointed out that the velocity of a body is inversely proportional to the time it covers to travel a certain height. On the other hand, Galileo emphasized that if two objects of different weights are dropped from a high point, both will hit the ground at the same time.

In terms of horizontal motion, Aristotle mentioned that bodies require force to maintain horizontal motion. In the contrary, Galileo asserted that if there is no interference, a body in motion will keep moving in a straight line forever. He further added that there is no need to apply force for it to continuously move. The external force will act upon the body not to keep it from moving, but for it to stop moving.

Lastly, with regards to projectile motion, Aristotle coined the concept of antiperistasis which is the resistance of a medium in response to the movement of a body; while Galileo explained that projectiles follow a curved path with a horizontal and vertical component.

Galileo and his Uniform Acceleration

Galileo asserted using his cannonball experiment that when objects are dropped simultaneously at the same height, they will reach the ground at the same time regardless of mass, size, and air resistance. This experiment paved the way for the discovery of the principle of uniform acceleration.

Furthermore, he noticed that falling objects increases their speed as they go down and he coined this change in speed as acceleration. His observations lead to remarkable conclusions that regardless of the mass, size, and shape of an object, and air resistance, falling objects will always have uniform acceleration and that, force is not necessary to sustain the horizontal motion of a body. He further asserted that the speed of a body is directly proportional to the time it travels a path and that the distance covered by a moving body is directly proportional to the square of time interval which implies that the speed of a falling object does not depend on a body's weight but on the time of fall. Lastly, using his inclined plane experiment and cannonball experiment, he came up with the following observations and conclusions:

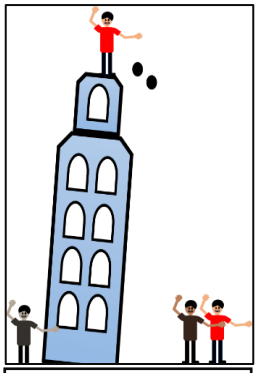


Figure 2. Galileo and his Cannon Ball Experiment

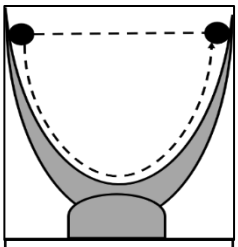


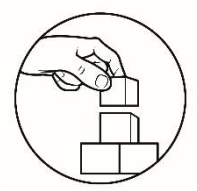
Figure 3. Inclined Plane Experiment

- A body moving down an inclined plane increases its acceleration by the same value after every second.
- The maximum acceleration of a body is attained when the inclined plane is positioned vertically as if the body is falling.
- Using the law of parabolic fall, he concluded that bodies fall with constant acceleration on the surface and that gravity pulling all bodies downward is a constant force. In this regard, he found out that force is not necessary to sustain horizontal motion.

Galileo's Assertion and Newton's Laws of Motion

Galileo Galilei proposed the first accurate principle governing motion and masses in his experiments wherein, remarkable findings such as bodies accelerate at the same rate regardless of their respective masses and sizes and that force is not needed to sustain horizontal motion were emphasized. He stated that the mass of an object is proportional to its resistance to move and that force is not necessary to keep an object in motion. However, Sir Isaac Newton proposed Laws on Motion anchored on the findings of Galileo and expounded his assertions. In his first law of motion, he mentioned that an object at rest will remain at rest unless acted upon by an external force and a body in motion will keep moving unless external force is acted upon it. Lastly, he stated that a body will only accelerate if an external force is acted upon it.

Newton's first law states that, if a body is at rest or in motion, it will remain at rest or keep in motion unless an external force is acted upon. This postulate is known as inertia which was proposed by Galileo in his experiment about horizontal motion wherein, he stated that a body requires an external force to move and that an external force must be acted upon for a body to rest. On the other hand, the second law states that the change in momentum of a body is equal to the magnitude and direction of force acting upon it. He further added that force is the product of the mass of an object and its acceleration. Lastly, the third law also known as the law of interaction states that when two bodies interact, both will apply equal amount of forces to one another in the opposite direction.



What's More

Activity 1 Great Motion Debate

Directions: Based on your understanding about Galilean and Aristotelian concept of principles governing motion, **COMPARE** and **CONTRAST** their assertions regarding vertical motion, horizontal motion, and projectile motion by completing the table below.

Concept	Aristotle	Similarities	Galileo
VERTICAL MOTION			
HORIZONTAL MOTION			
PROJECTILE MOTION			

Activity 2 Science Consensus

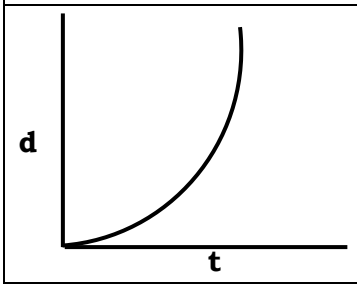
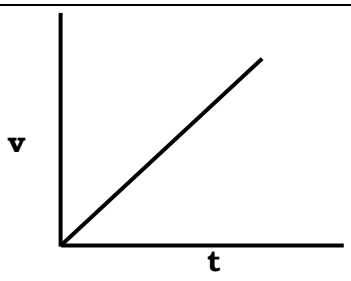
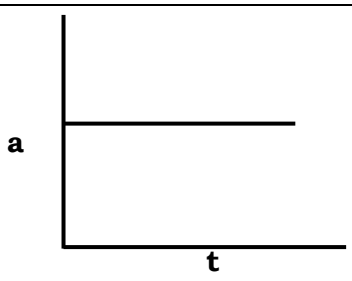
Directions: Explain the subtle distinction between Newton's first law of motion and Galileo's assertions regarding force and motion by completing the table below:

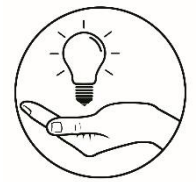
Isaac Newton	Concept	Galileo Galilei
	INERTIA	
	FORCE	
	BODY AT REST	
	BODY IN MOTION	

Activity 3 Graph it All the Way

Directions: Demonstrate understanding of uniform acceleration by analyzing and explaining the distance vs. time graph, velocity vs. time graph, and acceleration vs. time graph to explain the situation below.

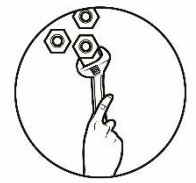
Situation: Describe the motion of a ball placed on an inclined plane with smooth surface.

Distance vs. Time graph	Velocity vs. Time graph	Acceleration vs. Time graph
		



What I Have Learned

1. The motion of a body can be described by the measurement and the changes in quantifiable variables such as time and distance.
2. Objects dropped simultaneously at the same height will hit the ground at the same time regardless of mass, size, and air resistance.
3. Force is not necessary to sustain horizontal motion.
4. Inertia refers to the ability of a body to resist change in motion.



What I Can Do

In order to concretize the concepts you have learned from this module, relate your understanding of the conceptions, assertions, and principles of motion to the safety on the road/transportation (safe vehicle distance, seatbelt, and airbags), sports, parachuting and in other practical applications. In addition, discuss how will you share your understanding of these concepts to others considering its implication to our life. Lastly, explain how early conceptions and assertions regarding motion paved the way to modern day understanding of fundamental principles of mechanics.

Assessment

DIRECTIONS: Read each question carefully. Choose the letter of the best answer. Write your answer on a separate sheet of paper.

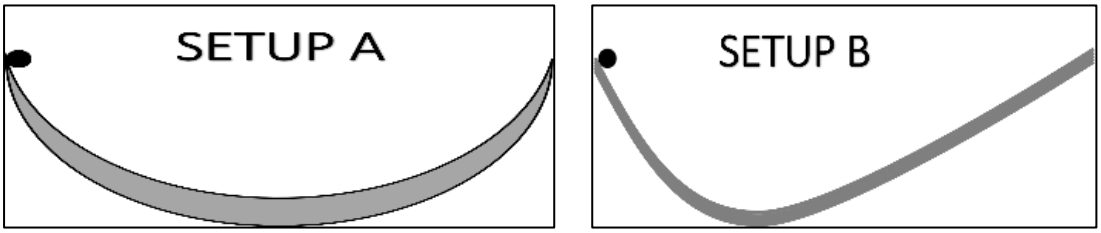
1. Rising of smoke is an example of what type of motion according to Aristotle?
   a. natural b. normal c. reaction d. violent
2. Which of the following is needed to put a body to rest?
   a. inertia b. force c. gravity d. mass
3. The resistance of a medium in response to movement of a body is known as;
   a. antiperistasis b. force c. inertia d. gravity
4. What will happen if an external force is acted upon a body at rest?
   a. it will move c. nothing will happen
   b. it will not move d. it will remain in motion
5. What will happen to the acceleration of the body if a marble moves in a sloped downward plane?
   a. accelerates b. decelerates c. nothing d. not determined

Additional Activities

Rolling in the Deep

Activity Objective: Investigate Galileo's assertion regarding uniform acceleration by performing the activity.

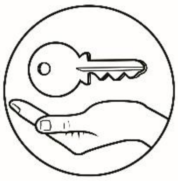
Materials: 2 long folders, 1 marble



Instructions: Cut the folder at the middle and create an inclined plane/ramp indicated on the right as your pattern. Hold 1 marble on 1 end of the plane/ramp and let it roll. Carefully observe the acceleration and distance covered by the marble as it rolls on the planes/ramps. Based on your observation and understanding of the lesson, analyze, illustrate and answer the guide questions below.

Guide Questions:

1. Describe the acceleration and the distance covered by the rolling ball by the two setups.
2. What factor causes the difference between the acceleration and distance covered by the two setups?
3. What do you think will happen to acceleration of the marble and to the distance it will cover considering factor in question number 2 is not present?
4. What do you think will happen to the rolling marble on a horizontal plane with initial velocity?
5. Describe how Galileo asserted his conception regarding motion using the activity.



Answer Key

Additional Activities	What's More	What I Know
The acceleration and distance covered is reduced in both setups, friction causes the deceleration and covering of shorter distance, acceleration will be uniform and the distance covered will is similar to the original height. It will continuously move unless external force is exerted upon it. Force is not necessary to keep a body in motion	1. Vertical motion: Aristotle: the velocity of a body is inversely proportional to the time it covers to travel certain height. Galileo: if two objects of different weight are dropped from a height both of them will hit the ground at the same time. Similarity: gravitational force acts on all bodies. Horizontal motion: Aristotle: bodies require force to maintain horizontal motion. Galileo: there is no need to apply force for it to continuously move. Similarity: force acts a factor causing a body to move. Projectile motion, Aristotle: antiperistasis is the resistance of a medium in response to the movement of a body. Galileo explained that projectiles follow a curved path with a horizontal and vertical component. Similarity: both considers the effect of body interacting with medium (antiperistasis and friction) upon traveling a trajectory. 2. Newton: resists motion, necessary to move a stationary body and to stop, remains at rest without external force, keeps a body in motion unless acted upon by external force. Galileo: Resists motion & Proportional to mass, not necessary to sustain a moving body, keeps a body at rest due to inertia, keeps a body in motion unless acted upon by force 3. D vs. T: the ball covers longer distance for a short period of time, V vs. T: velocity of the ball is increasing at constant rate, A vs. T. the ball is in uniform acceleration.	1. A 2. B 3. C 4. D 5. C **Assessment** 1. A 2. B 3. A 4. A 5. A

References

Bayo-ong, Roly., Coronacion, Maria Lourdes., Jorda, Annamae., & Restubog, Anna Jamille. *Physical Science for Senior High School* (1st edition). Quezon City: Educational Resources Corporation, 2017.

DepEd. *K to 12 Senior High School Core Curriculum – Physical Science Curriculum Guide*. Learning Resource Portal, 2020. https://lrmds.deped.gov.ph/detail/14519

DepEd. *Most Essential Learning Competencies (MELC)*. Teach Pinas, 2020. https://www.teachpinas.com/k-12-most-essential-learning-competencies-melc/

Malenab, Ryan., Catchiller, Gerry., Vibal, Pablito., & Martinez, Felipe. *Essentials of Physical Science*. Quezon City: Rex Bookstore, 2016.

Punzalan, Jervy., & Monserrat, Richard. *Science in Today's World for Senior High School: Physical Science*. Quezon City: Sibs Publishing House, 2016.

Santiago, Karen., & Silverio, Angelina. *Exploring Life through Science: Physical Science*. Quezon City: Phoenix Publishing, 2016.

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