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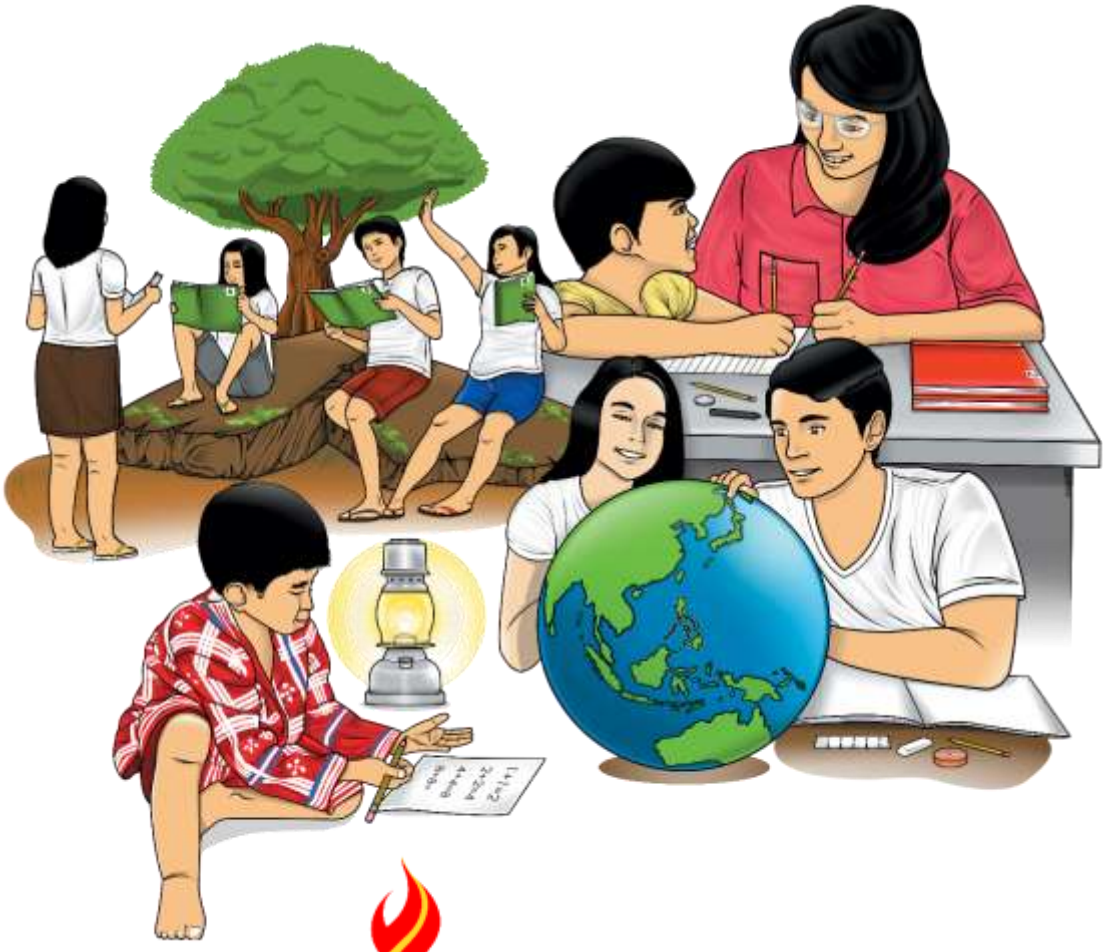
DEPARTMENT OF EDUCATION

Science

Quarter 4 – Module 6: Law of Conservation of Mechanical Energy



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Science

Quarter 4 – Module 6: Law of Conservation of Mechanical Energy

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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

This module was designed and written with you in mind. It is here to help you master the different constellations that we observe at the different times of the year. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

The module focuses on achieving this learning competency:

Infer that the total mechanical energy during any process remains the same. S9FE-IVe41

After going through this module, you are expected to:

1. Define the total mechanical energy; and
2. Derive a conclusion that the total mechanical energy in a given system is the same.

What I Know

Directions: Choose the letter of the best answer. Write your answer separately on your Science Interactive Notebook.

1. Which of the following is used to express the unit of energy?

A. watt
B. joule
C. coulomb
D. kilowatt hour

2. What form of energy is associated with motion?

A. Chemical Energy
B. Potential Energy
C. Sound Energy
D. Kinetic Energy

3. What law states that the total Energy in an isolated system remains the same?

A. Law of Conservation of Momentum
B. Law of Definite composition
C. Law of Conservation of Energy
D. Law of conservation of Mass

4. Which of the following equations represents the Law of Conservation of Mechanical Energy.

A. PE1+ KE1 = PE2 + KE2 = PE3 +KE3
B. PE1+ KE2 = PE2 + KE3 = PE3 +KE1
C. PE2+ KE1 = PE3 + KE2 = PE1 +KE3
D. PE3+ KE1 = PE1 + KE3 = PE2 +KE2

5. Which event does NOT describe potential energy being changed into kinetic energy?

A. A cart rolling down a hill.
B. A rubber foam being compressed
C. A student lets go a stretched slinky.
D. A twig falling from a branch

6. The potential energy of an 8-kg object on top of a hill is 256 J. What is its velocity in m/s just before it hits the ground?

A. 36
B. 18
C. 8
D. 3

7. A stone rolls down some distance and gains 50 J of kinetic energy. Neglecting air resistance, how much gravitational potential energy did the stone lose?

A. more than 50 J
B. exactly 50 J
C. less than 50 J
D. cannot be determined from the information

Use the following diagram below to answer question 8. Neglect the effect of resistance forces.

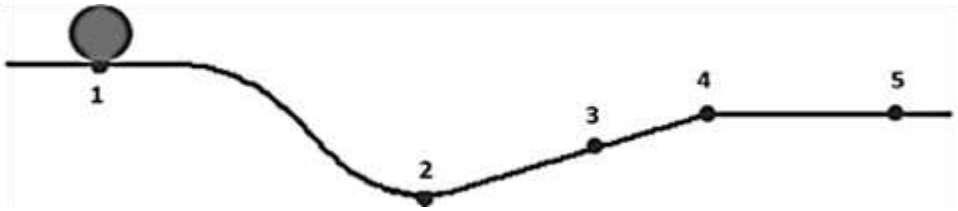


Figure A: The ball moves from point 1 to point 5
Illustrator: Jaylen S. Navato

8. What happens to the sum of its gravitational potential and kinetic energies, as the ball moves from point 1 to point 4 across the surface?

A. It decreases
B. It decreases and then increases
C. It increases and then decreases
D. It remains the same

For numbers 9-10, A pendulum is hanging from a point and its total mechanical energy is constant. Refer to the figure below.

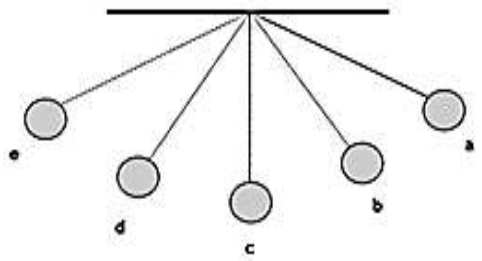


Figure B: Pendulum Motion
Illustrator: Jaylen S. Navato

9. At which point in the pendulum's motion where the kinetic energy is at its maximum

A. e
B. c
C. d
D. b

10. At which point of the pendulum's motion is the value of the change in the potential energy equal to the change in the kinetic energy?

A. b
B. e
C. a
D. c

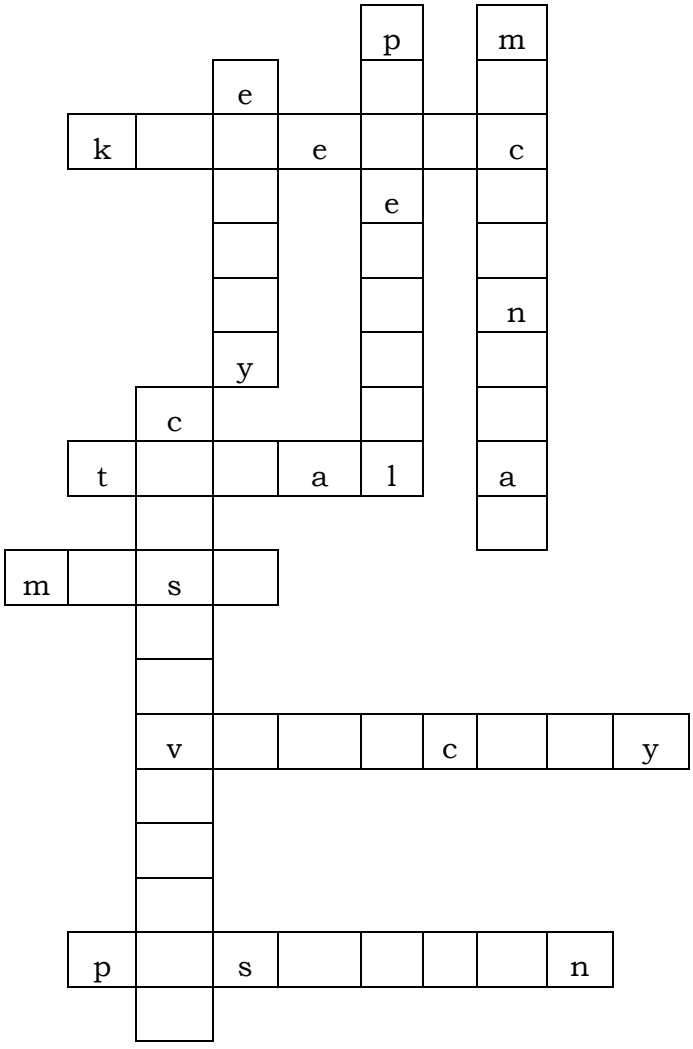
Lesson 1 Total Mechanical Energy

At the end of the lesson, you will be able to:

- Define total mechanical energy.

What's In

In the previous module you have performed activities to demonstrate conservation of mechanical energy. Let us check what you have learned from the terminologies in the previous modules. Fill in the empty boxes to complete the word.



What's New

Directions: Identify if it has Kinetic Energy or Potential Energy.

1. a. The mango in the tree has _____ energy.

   b. The mango falling in the tree has _____ energy.

2. a. unscratched rubber bands have _____ energy.

   b. Stretched rubber band has_____ energy.

3. a. When you hold a yoyo in your hand, it has _____ energy.

   b. Once the yoyo is released, it has _____ energy.

4. a. When the roller coaster is at the top, it has _____ energy.

   b. When the roller coaster moves downward, it gains _____ energy.

What is It

Potential energy is the stored energy by an object due to position. For example, figure 1 shows a woman holding a ball. The ball stored potential energy due to its position or height from the ground.

Figure 1. Girl holding a ball

Illustrator: Cherry Lou Sabinay

The formula for potential energy depends on the force acting on the two objects given by P.E. = mgh, where m is the mass in kilograms, g is the acceleration due to gravity (9.8 m / s^2 at the surface of the earth) and h is the height in meters

Kinetic energy is energy due to change in position. It is also termed as energy of movement or energy in motion.

The energy associated to the change in the position of the ball as it is dropped is called kinetic energy.

Figure 2. Girl released the ball.

Illustrator: Cherry Lou Sabinay

Kinetic energy can be defined mathematically as **KE=1/2mv²** where, m = mass, and v = velocity.

When the ball is at the top it has potential energy, however as it starts to fall, the potential energy is being converted to kinetic energy. When the ball reaches the ground, there is no more potential energy since all of its initial potential energy has been converted to kinetic energy.

Potential and Kinetic energy are forms of Mechanical Energy. And, the sum of Potential and Kinetic energy is called Total Mechanical energy.

The unit for energy is joule or $kg*m^2/s^2$ and mathematically it is defined as

MET = PE + KE

Where MET = Total Mechanical Energy

PE = Potential Energy; and

KE =Kinetic Energy

- For any mechanical process that occurs inside an isolated system and involves only conservative forces, the total mechanical energy is conserved. This means that the total mechanical energy remains constant in time.

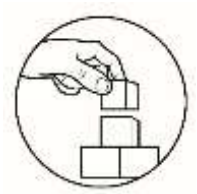
(A conservative force is a force with the property that the total work done in moving a particle between two points is independent of the path taken.)

$\Delta MET = \Delta KE + \Delta PE = 0$, Δ = change (Greek letter delta),

Δ KE = change of Kinetic Energy; and

Δ PE= change of Potential Energy

Another common unit of energy that is often used is the calorie (cal), which is equivalent to 4.184 J.



What's More

Since the Total mechanical energy is the sum of the Potential and kinetic energy, complete the table by finding the Total mechanical energy.

No.	**PE (J)**	**KE (J)**	**ME_T = PE + KE (J)**
1	200	100	_____
2	400	_____	500
3	25	20	_____
4	0	75	_____
5	40.5	59.5	_____
6	_____	36.75	100
7	75	_____	100
8	50	50	_____
9	375	_____	375

What I Have Learned

Direction: Modified True or False: Write True if the statement is correct. If the statement is False, change the underlined word or group of words to make the whole statement true.

_____ 1. Objects that have kinetic energy are <u>not moving</u>.

_____ 2. <u>Potential</u> energy is dependent upon the height or position of the object.

_____ 3. The <u>product</u> of potential energy and kinetic energy is called total mechanical energy.

_____ 4. The energy due to the change of height or position of the object is <u>Kinetic</u> energy.

_____ 5. The formula for Total Mechanical Energy is <u>$ME_T = PE + KE$</u>.

_____ 6. The SI unit of energy is <u>joule</u>.

_____ 7. Potential energy <u>depends</u> on the height or distance and mass of the object.

_____ 8. When you hit the hammer on the table, the stored potential energy in the hammer is <u>converted</u> to kinetic energy as the hammer moves down.

_____ 9. The <u>difference</u> between mechanical and kinetic is their ability to transform into each other.

_____10. When the book hits the floor, this energy of motion will again convert to <u>kinetic energy</u>.

Lesson 2 Conservation of Mechanical Energy

At the end of the lesson, you will be able to:

- Derive a conclusion that the total mechanical energy in a given system is the same.

What's In

Check the box PE if the scenario possesses Potential Energy. And check box KE if it has Kinetic Energy.

Scenario	PE	KE
1. Moving car		
2. Rock on the cliff		
3. Book on the table		
4. Rolling ball		
5. A boy playing on a slide		

Complete the missing values in the table given ME=PE+KE.

PE (J)	KE (J)	ME(J)
50		120
	40	70
30	80	
	25	50
20		45

What's New

Activity 1: Mood Swing

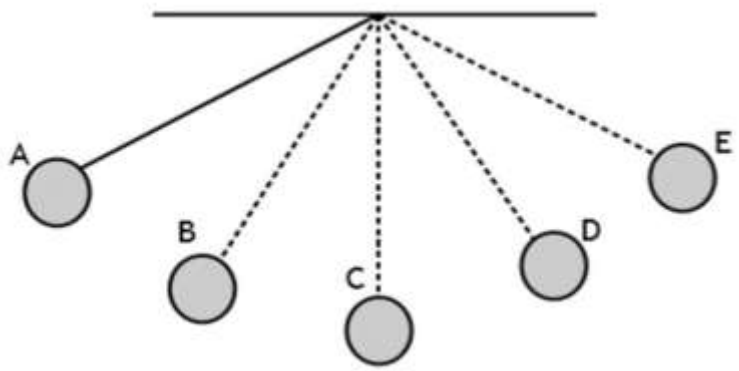


Figure 3. A pendulum swinging
Illustrator: Jaylen S. Navato

Look at the Figure above and give your best guess on the questions that follow: Write your answer in a separate sheet

1. At what point/s is the potential energy at its maximum?

A. A

B. B

C. C

D. D

2. The kinetic energy is maximum at point/s _____.

A. A

B. B

C. C

D. D

3. At what point/s is the kinetic energy zero?

A. A

B. B

C. C

D. D

4. At what point/s is the potential energy zero?

A. A

B. B

C. C

D. D

5. At what point/s do/es the values of kinetic and potential energies equal?

A. A

B. B

C. C

D. D

What is It

The figure below shows a pendulum that is hanging from a point and swings from A to E in which only the gravitational force is acting on it.

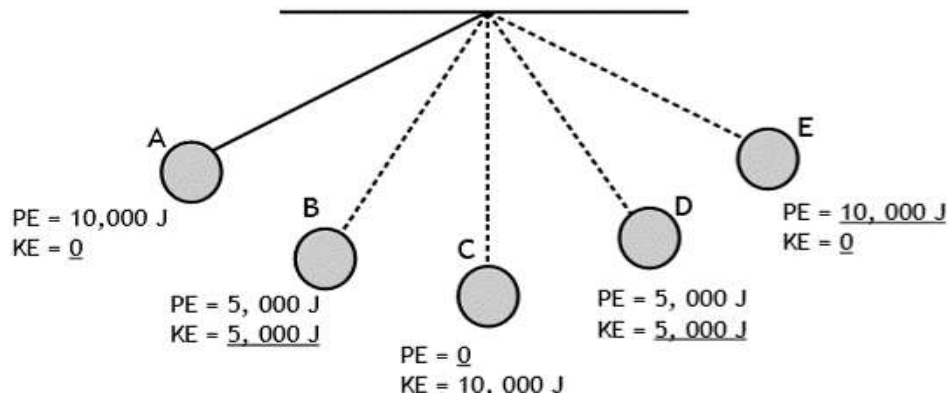


Figure 4. A pendulum swinging
Illustrator: Jaylen S. Navato

At A the Potential Energy is at its maximum due to its height or position. As the pendulum starts to move, the Potential Energy decreases while Kinetic energy increases because of the change in position.

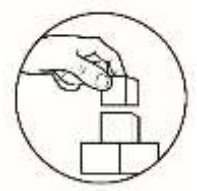
At B, half of the potential energy is lost and becomes kinetic energy. Hence, Potential energy is equal to kinetic energy (PE=KE)

At C, the height of the pendulum is at the minimum, thus potential energy is also at its minimum, while kinetic energy is at its maximum.

From C to E, the reverse will happen. It shall start with maximum kinetic energy at C. The kinetic energy will slowly transform to potential energy. Eventually, potential energy is at maximum while kinetic energy is at minimum at E.

At D, kinetic energy is equal to potential energy (KE=PE) which is also true at B.

Any loss of potential energy will result to a gain in kinetic energy and vice versa. There is no loss of energy in the system and energy is conserved. Therefore, the total mechanical energy at any point in the pendulum is constant.



What's More

Activity 2: Let Me Take a Ride!

Juan is riding a cart moving up on a frictionless ramp from points A to C. What happens to the Kinetic, Potential and Total Mechanical energy in every point?

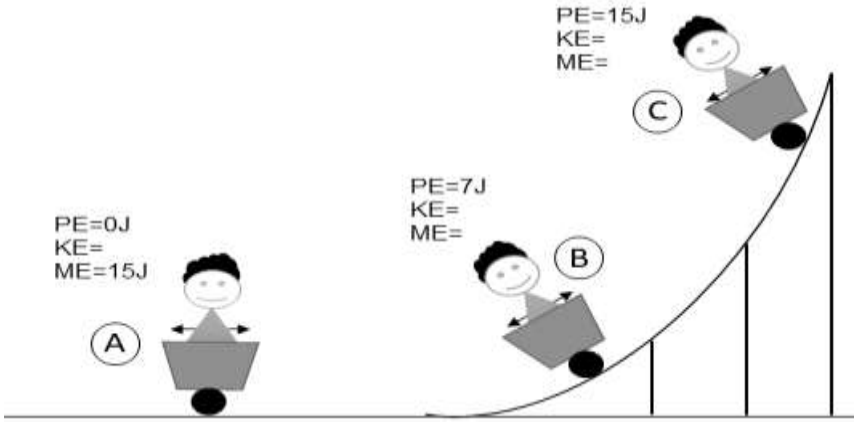


Figure 5. Let me take a ride. Illustrator: Jaylen Navato

Given the figure above, complete the data in the table.

Point	PE (J)	KE (J)	ME (J)
A	0		15
B	7		
C	15		

Guide Questions:

1. At which point/s is potential energy maximum?

_____

2. What happens to the total mechanical energy as the cart moves from A to C?

_____

3. What happens to the potential energy and kinetic energy as the cart moves from A to C?

_____

What I Have Learned

A. **THINK TANK!** Write True if the statement is correct, but if it's False, change the underlined word or group of words to make the whole statement true. Write your answers on your science notebook.

_____ 1. Mechanical energy consists of two types, the potential energy and kinetic energy.

_____ 2. Potential energy is energy due to its high velocity.

_____ 3. Kinetic energy is also termed as stored energy.

_____ 4. Given that PE is 50 J and KE is 10 J, then the total ME is 40 J.

_____ 5. ME is the product of PE and KE.

_____ 6. The object's kinetic energy is transformed into potential energy or vice versa.

_____ 7. When Potential Energy of a pendulum decreases as it swings down, Kinetic Energy increases as it gains speed.

_____ 8. At a point, Potential Energy is zero while Kinetic Energy is at its maximum.

_____ 9. When the vehicle is moving, there is a gain of potential energy.

_____ 10. When the vehicle is at rest, it has kinetic energy.

B. **FIXING POINT!** Based from the illustration, complete the table below.

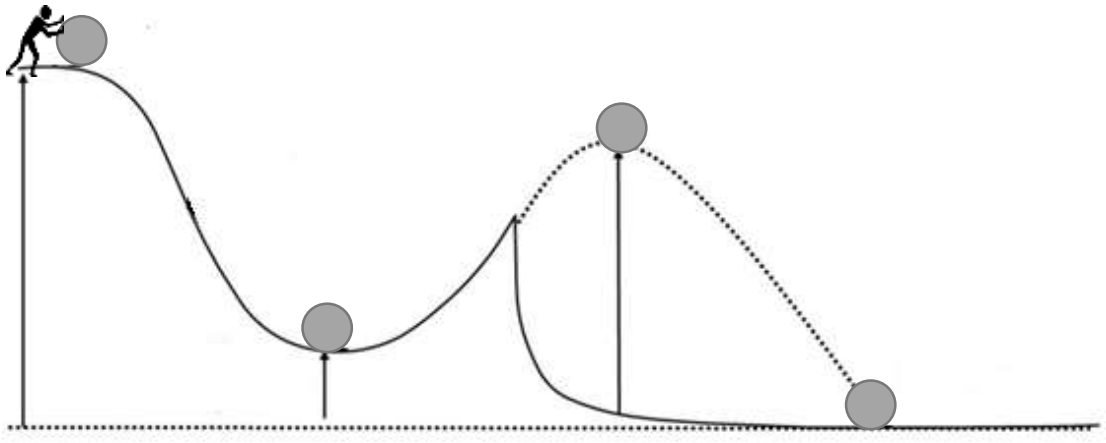


Figure. Fixing Point. Illustrator: Jaylen Navato

POINT	**PE (J)**	**KE (J)**	**ME_T = PE + KE (J)**
A	50 000 J	0 J	_____
B	_____	40 000 J	50 000 J
C	30 000 J	_____	_____
D	0 J	_____	_____

What I Can Do

PERFORMANCE TASK: I Think, Therefore I Am… An Engineer!

Performance Content: Create a device that shows conservation of mechanical energy and answer the questions that follow on the activity you have chosen.

(A) DIY MINIATURE SWING

Objective: To design and build your own miniature swing that will demonstrate the relationships between forces and energy to motion.

Here are some suggested materials to use or you may choose your own materials

- Set of Popsicle stick and chopstick (banana cue stick)
- String
- Stick glue/ Glue Gun

Things to do:

1. Name your swing. (5 pts)
2. Draw the blueprint on a bond paper (10 pts)
3. Include the following in the blueprint (drawing):
   - Highest Potential Energy (Hi PE)
   - Lowest Potential Energy (Lo PE)
   - Highest Kinetic Energy (Hi KE)
   - Lowest Kinetic Energy (Lo KE)

Demonstration:

1. State the name of your model.
2. Identify the components of the amusement ride.
3. Identify where PE and KE are maximum or minimum.
4. Define total mechanical energy.
5. Derive a conclusion that the total mechanical energy of the system remains the same.

Scoring Guidelines: Please refer to Appendix A.2 Rubric.

Summary

- Energy is essential to everyday life. In fact, we cannot do work without it. Though we know that energy is always present everywhere, it is not seen by our naked eye but we can detect evidences of it

- Law of Conservation of Energy. It states that energy cannot be created or destroyed. It can be transferred from object to object and changed into different forms, but the total energy before and after any process is always the same.

- Example of it: As a roller coaster car moves down the track and gains speed: PE is transformed into KE. As a roller coaster car moves up the track, it loses its speed; KE is transformed into PE.

- Conservation of Mechanical Energy states that "The total Mechanical Energy of an isolated system remains the same.

- The change in potential energy is equal to the change in its kinetic energy.

Thus, we say, ME1 = ME2 , that is,

PE1+ KE1 = PEF+ KEF

Where: PE = mgh

KE = ½ mv2

- For any mechanical process that occurs inside an isolated system and involves only conservative forces, the total mechanical energy is conserved. This means that the total mechanical energy remains constant in time.

(A conservative force is a force with the property that the total work done in moving a particle between two points is independent of the path taken.)

ΔMET = Δ KE + Δ PE = 0 , Δ = change (Greek letter delta),

Δ KE = change of Kinetic Energy; and

Δ PE= change of Potential Energy

- The equation above tells us that the initial total mechanical energy ME1=PE1+ KE1is equal to the final total mechanical energy MEF = PEF+ KEF. In other words, mechanical energy is always conserved.

- Whatever decrease in the amount of PE is also the amount of increase in KE, thus the total mechanical energy at any point remains the same.

Assessment

I. Multiple Choice: Choose the BEST answer. Write your answer on your notebook.

1. Which of the following happens to raindrops?

   A. Loses potential energy and gains kinetic energy.

   B. Loses both potential energy and kinetic energy.

   C. Gains potential energy and loses kinetic energy.

   D. Gains both potential energy and kinetic energy.

2. What is the energy of a motorcycle driven down a hill?

   A. entirely kinetic

   B. entirely potential

   C. entirely gravitational

   D. both kinetic and potential

3. Which event illustrates the direct transformation of potential to kinetic energy?

   A. A volleyball player blocks an incoming ball.

   B. A sleeping cow stirs awake.

   C. The wide-open spring door closes slowly.

   D. The spring of a broken toy shoots up

4. A runner jumps over a hurdle. Neglecting friction, the potential energy of the runner at the highest point compared to his kinetic energy at the lowest point is

   A. lesser.

   B. equal.

   C. greater.

   D. not related.

5. The total mechanical energy of a yoyo

   A. is equally divided between kinetic energy and potential energy.

   B. at any one instant, is either all kinetic energy or all potential energy.

   C. can never be negative.

   D. is constant, if only conservative forces act.

Use this figure to answer questions 6-8. Assume that the height at points 1 & 3 are the same.

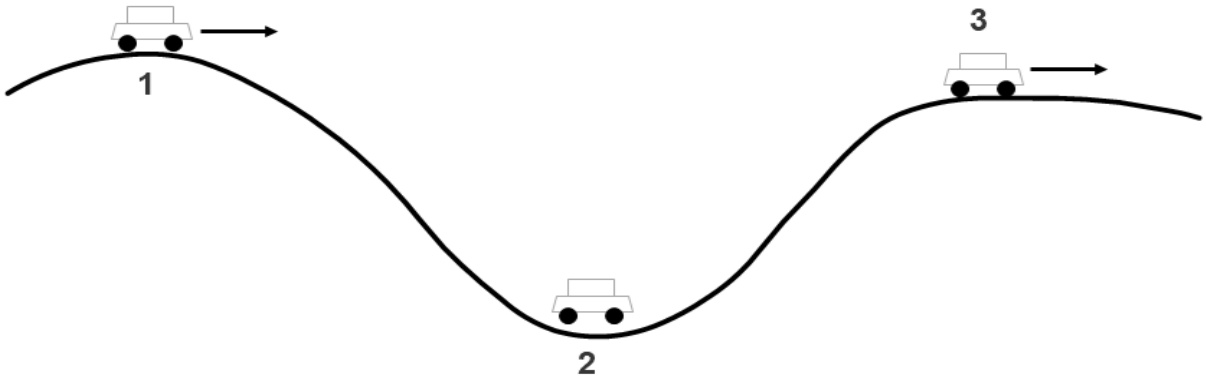


Figure 7. Illustrator: Jaylen Navato

6. In the figure, kinetic energy is being converted into potential energy from

   A. point 1 to point 2

   B. point 2 to point 3

   C. Only kinetic energy is here

   D. Energy is not being converted

7. In the figure, potential energy is being converted into kinetic energy from

   A. point 1 to point 2

   B. point 2 to Point 3

   C. Only PE is here

   D. Energy is not being converted

8. As the car moves from point 1, to point 2, and finally to point 3, the total energy of the car

   A. decreases from point 1 to point 2, then increases from point 2 to point 3

   B. increases from point 1 to point 2, then decreases from point 2 to point 3

   C. stays the same, but is converted between potential and kinetic energy

   D. is lost between points 2 and 3

9. A bag drops some distance and gains 90 J of kinetic energy. How much gravitational potential energy did the bag lose?

   A. more than 90 J

   B. exactly 90 J

   C. less than 90 J

   D. cannot be determined from the information given

10. If the total mechanical energy is 50, determine the potential energy if the kinetic energy is 30 J.

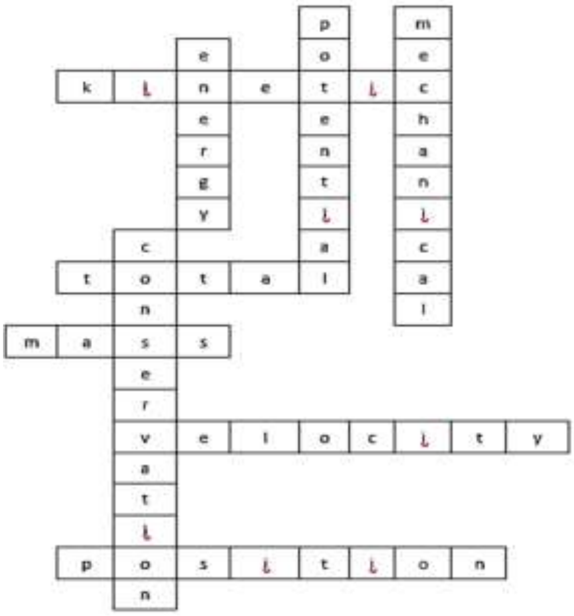
A. 50 J

B. 30 J

C. 20 J

D. 10 J

Lesson 1: What's New



1. A. POTENTIAL ENERGY B. KINETIC ENERGY
2. A. NEITHER P.E. & K.E B. POTENTIAL ENERGY
3. A. POTENTIAL ENERGY B. KINETIC ENERGY
4. A. POTENTIAL ENERGY B. KINETIC ENERGY

What I Know

1. B
2. D
3. C
4. A
5. B
6. C
7. B
8. D
9. B
10. A

Answer Key

What's More

Activity 2: Let Me Take a Ride!

Point	PE (J)	KE (J)	ME (J)
A	0	15	15
B	7	8	15
C	15	0	15

What's New

Mood Swing

1. A
2. C
3. A
4. C
5. C

Lesson 2: What's In

1. KE
2. P.E
3. Potential
4. Kinetic
5. P.E. and K.E.

PE (J)	KE (J)	ME(J)
50	70	120
30	40	70
30	80	110
25	25	50
20	25	45

What I have Learned

1. Moving
2. True
3. Sum
4. Potential Energy
5. True
6. True
7. True
8. True
9. primary relation
10. Potential Energy

What's More

Activity 2: I'm Falling for You

No.	PE (J)	KE (J)	ME_T = PE + KE (J)
1	200	100	300
2	400	100	500
3	25	20	45
4	0	75	75

Assessment

1. A	3. C	5.D	7.A	9. B
2. D	4. C	6.B	8.C	10. C

B. FIXING POINT

POINT	PE (J)	KE (J)	ME_T = PE + KE (J)
A	50 000 J	0 J	50, 000J
B	10,000 J	40 000 J	50 000 J
C	30 000 J	20,000 J	50, 000J
D	0 J	50, 000J	50, 000J

What I Have Learned: A. THINK TANK

1. True	2. Position	3. Potential	4. 60 J	5. sum
6. True	7. True	8. True	9. moving up	10. in motion

What's More
Guide Questions

1. C
2. Total Mechanical Energy from A-C is the same.

a. Student Answer Vary. The kinetic energy at point A is increased, because the cart now gains speed.
b. The potential energy and kinetic energy at point B is the same,
c. The point where kinetic energy is zero is at point C, because the cart now gains height.

3. The following are the events of the kinetic and potential energy as it travels from point A to C.

a. The kinetic energy at point A is increased, because the cart now gains speed.
b. The potential energy and kinetic energy at point B is the same,
c. The point where kinetic energy is zero is at point C, because the cart now gains height and stops for a moment at the highest point.

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