General Phyics 1 12 Q1 Mod6 Work Energy-and-Energy-Conservation Version 1

Business (Asian College)

Senior High School

General Physics 1

Quarter 1 - Module 6

Work, Energy and Energy Conservation

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Senior High School

General Physics

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Work, Energy and Energy Conservation

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We value your feedback and recommendations.

Department of Education ● Republic of the Philippines

Table of Contents

Module 6
Work, Energy and Energy Conservation

What This Module is About

This module demonstrates your understanding on the concepts of Work, Power, Energy and Energy Conservation specifically on how Physics define Work and how it is calculated based on Force and Displacement. It also discusses the different forms of energy and how these energy able to do Work on an object.

Specifically, this module will discuss two (2) lessons:

- **Lesson 1 - Work**
- **Lesson 2 – Energy and Energy Conservation**

What I Need to Know

At the end of this module, you should be able to:

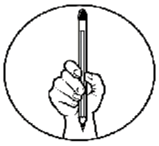
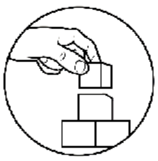
1. Calculate the dot or scalar product of vectors (**STEM_GP12WE-If-40**)
2. Determine the work done by a force (not necessarily constant) acting on a system (**STEM_GP12WE-If-41**)
3. Define work as a scalar or dot product of force and displacement (**STEM_GP12WE-If-42**)
4. Interpret the work done by a force in one-dimension as an area under a Force vs. Position curve (**STEM_GP12WE-If-43**)
5. Relate the gravitational potential energy of a system or object to the configuration of the system (**STEM_GP12WE-Ig-48**)
6. Relate the elastic potential energy of a system or object to the configuration of the system (**STEM_GP12WE-Ig-49**)
7. Explain the properties and the effects of conservative forces (**STEM_GP12WE-Ig-50**)
8. Use potential energy diagrams to infer force; stable, unstable, and neutral equilibria; and turning points (**STEM_GP12WE-Ig-53**)
9. Solve problems involving work, energy, and power in contexts such as, but not limited to, bungee jumping, design of roller-coasters, number of people required to build structures such as the Great Pyramids and the rice terraces; power and energy requirements of human activities such as sleeping vs. sitting vs. standing, running vs. walking. (Conversion of joules to calories should be emphasized at this point.) (**STEM_GP12WE-Ih-i-55**)

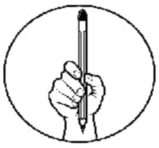
How to Learn from this Module

To achieve the objectives cited above, you are to do the following:

- Take your time reading the lessons carefully.
- Follow the directions and/or instructions in the activities and exercises diligently.
- Answer all the given tests and exercises.

Icons of this Module

	What I Need to Know	This part contains learning objectives that are set for you to learn as you go along the module.
	What I know	This is an assessment as to your level of knowledge to the subject matter at hand, meant specifically to gauge prior related knowledge
	What's In	This part connects previous lesson with that of the current one.
	What's New	An introduction of the new lesson through various activities, before it will be presented to you
	What is It	These are discussions of the activities as a way to deepen your discovery and under-standing of the concept.
	What's More	These are follow-up activities that are in-tended for you to practice further in order to master the competencies.
	What I Have Learned	Activities designed to process what you have learned from the lesson
	What I can do	These are tasks that are designed to show-case your skills and knowledge gained, and applied into real-life concerns and situations.



What I Know

Multiple Choice. Answer the question that follows. Choose the best answer from among the given choices.

1. In which situation is there work done on the system?
   a. a basket being lifted b. a man carrying a bag of cement
   c. a boy pushing against the wall d. a weightlifter holding a barbell in the air
2. A rock is thrown straight up from the surface of the Earth. Which one of the following statements describes the energy transformation of the rock as it rises? Neglect air resistance.
   A. The total energy of the rock increases.
   B. The kinetic energy increases and the potential energy decreases.
   C. Both the kinetic energy and the potential energy of the rock remain the same.
   D. The kinetic energy decreases and the potential energy increases.
3. _________ happens when a force causes an object to move in the same direction that the force is applied.
   A. Work B. Power C. Energy D. Heat
4. Energy is
   A. the ability to do work.
   B. the work needed to create potential or kinetic energy.
   C. the work that can be done by an object with PE or KE.
   D. all of the above.
5. Which of the following happens to a coconut that falls freely?
   A. Loses PE and gains KE B. Loses both PE and KE.
   C. Gains PE and loses KE D. Gains both PE and KE
6. A torchlight fell from a watch tower. The potential energy of the torchlight at the highest point compared to its kinetic energy at the lowest point is
   A. lesser. B. equal. C. greater. D. not related.
7. The wind-up toy that is fully wound and at rest possesses
   A. kinetic but no potential energy
   B. potential but no kinetic energy
   C. both potential and kinetic energy in equal amounts
   D. neither potential nor kinetic energy
8. In which case is there a decrease in gravitational potential energy?
   A. Amada stretches horizontally a rubber band.
   B. A car ascends a steep parking ramp.
   C. Pamela's puppy jumps down the chair.
   D. Water is forced upward through a pipe.
9. Which one has more kinetic energy and why? A baseball or a soccer ball
   A. a soccer ball because it is bigger C. a baseball because it is smaller
   B. a soccer ball because it is lighter D. a baseball because it is heavier
10. How can you increase the potential energy of a diver in the Olympics?
    A. go to a higher diving board B. go to a lower diving board
    C. work out and loose weight D. jump

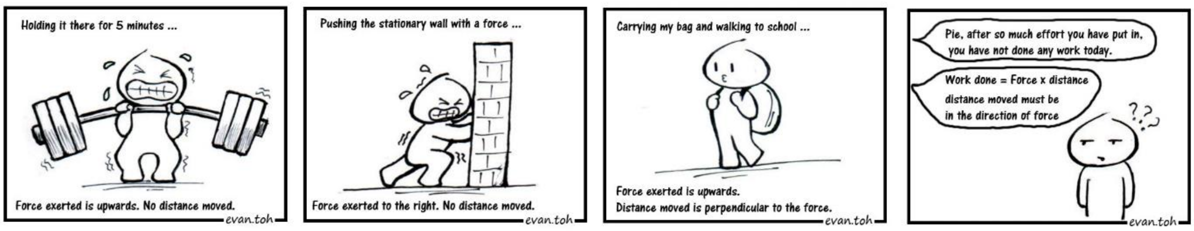
Lesson 1

Work

What I Need to Know

In the previous module you have learned how force affects the motion of an object. All of the activities that we do daily involves force. Force is simply defined as pulling or pushing an object that may cause it to move, change direction, move faster or slower or even stop its motion. Whenever Force is applied, energy is exerted. This process would then may result to Work.

But does the presence of Force always imply that Work is done on an object? As depicted in the picture below, not all the time the Force that acts on an object does Work. So when is work present? What are conditions that we need to check?



Exerpted from: https://evantoh23.wordpress.com/category/24-comics/

In this module you will understand further how Physics defines Work and its relationship to Force and Energy. Specifically, you are expected to learn the following:

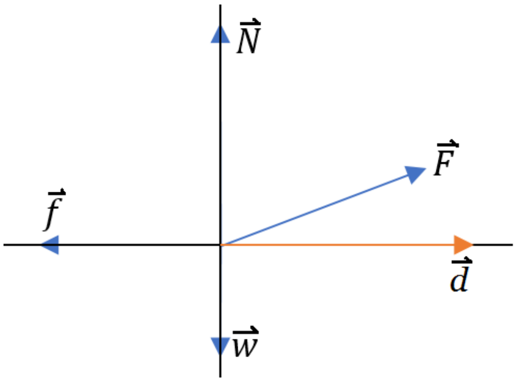
1. Define Work and derive its mathematical equation applying your knowledge in the dot product of vectors
2. Identify the Force that do Work on the system
3. Learn the conditions needed for Work to be done
4. Calculate Work done in an object in various situation

What's New

Instruction: Answer the questions below as directed.

1. A box is lying still on the table. Construct a Free-Diagram showing all the forces acting on the box.

2. A schematic diagram below shows the Forces acting on an object as it is being pulled eastward.
   a. Draw the components of the applied force parallel and perpendicular to the object's motion and label it with $F_{//}$ and $F_{\perp}$.
   b. Place the following quantities, with values if present, in the diagram appropriately.
      θ_F – angle between the Force applied and the displacement
      θ_N – angle between the Normal Force and the displacement
      θ_w – angle between the weight and the displacement
      θ_f – angle between the friction force and the displacement



3. Put a check (√) before the item if work is done to an object or person.
   ____ a. a girl swimming across the pool
   ____ b. a boy jumping with joy as he carries his new puppy
   ____ c. a dog being lifted
   ____ d. a person inside an elevator going down
   ____ e. a person inside a cruising airplane

What Is It

In our daily life, work simply refers to any form of activity that may require mental and physical involvement. However, in Physics, not all these activities can be defined as Work.

When a teacher carries a book while walking from her table going infront of the class, we can simply say that she is doing work. But in Physics, she did not, even if she has exerted energy in carrying it. When your mother asks you to carry a pail of water from your toilet going outside to water her plants, there is work the moment you carry the pail, however, no work is done anymore on it while carrying it going outside.

So how does Physics defines Work? Consider the figures below.

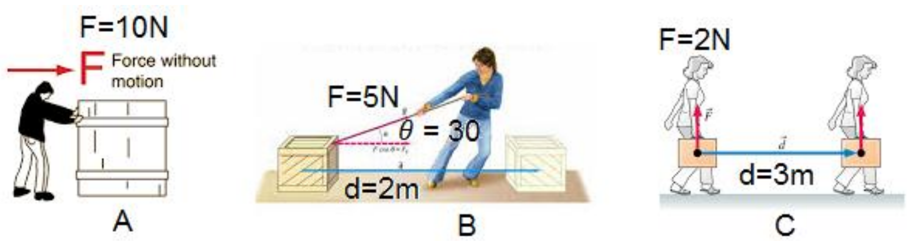


Figure 1. *Work done by a force applied at different directions*

In figure 1.A you exerted a Force by pushing the box but it was not enough to make it move. Figure 1.B shows the force you exerted on the box causing it to move to a distance, d. And in Figure 1.C you are carrying the box to a distance d. Which of these illustrations do you think involve the presence of work?

To answer this question, let us derive the Mathematical Equation of Work as to how it is being defined in Physics.

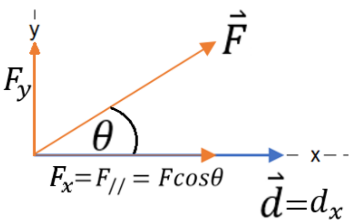
Work is a scalar quantity and is described only by its magnitude. It is simply defined as the dot product of the Force and the displacement.

In vector form: $\vec{F} = F_x\hat{\imath} + F_y\hat{\jmath}$ and $\vec{d} = d_x\hat{\imath} + d_y\hat{\jmath}$

To calculate the work done, we get the dot product of the two quantities.

$$W = \vec{F}.\vec{d} = (F_x + F_y).(d_x + d_y) = F_x d_x(\hat{\imath}.\hat{\imath}) + F_y d_y(\hat{\jmath}.\hat{\jmath})$$
$$W = \vec{F}.\vec{d} = F_x d_x + F_y d_y \qquad where: \quad (\hat{\imath}.\hat{\imath}) = 1 \text{ and } (\hat{\jmath}.\hat{\jmath}) = 1$$

Consider the figure below.



A force is applied at an angle θ causing it to move to a distance d. Calculating the work done:

$$W = \vec{F}.\vec{d} = F_x d_x + F_y d_y$$

There is no y-component of the displacement giving $d_y = 0$

$$W = \vec{F}.\vec{d} = F_x d_x + F_y(0) = F_x d_x$$
$$where: \quad F_x = F_{//} = Fcos\theta$$

$F_{//}$ *is the component parallel to the motion of the object*

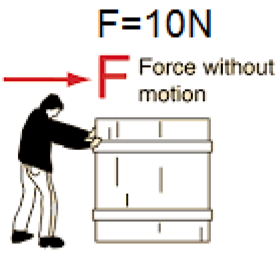
$$W = F_x d_x = (Fcos\theta)d = Fdcos\theta$$

Thus, in Physics: $\boxed{W = Fdcos\theta}$ SI Unit of Work: Joules = 1Nm

Where:

F is the force applied on the object
d is the distance the object moved and
θ is the angle between F and d

Using the mathematical definition of Work, let us now check the work done in Figure 1.



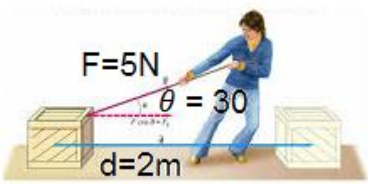
A

Figure 1.A

Notice that the object did not move when you pushed it. The displacement is this case is equal to zero. ($d = 0$).

$$W = Fdcos\theta = (10N)(0)cos\theta = 0$$

Therefore, No Work is done in pushing the box that did not move.



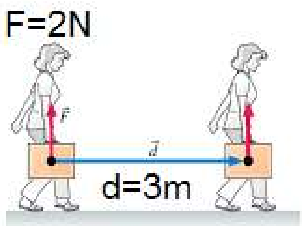
B

Figure 1.B

The object in this Figure moves in the same direction as the Force applied ($F_{//}$).

$$W = Fdcos\theta = (5N)(2m)cos30 = 8.67N$$

Therefore, Work is done.



C

Figure 1.C

In this case, the Force applied is directed upward (along y-axis) while the object, moving with you, is going to the right (along x-axis). They are perpendicular with each other giving the angle between them θ = 90°.

$$W = Fdcos\theta = (2N)(3m)\cos 90° \; ; \cos 90° = 0$$

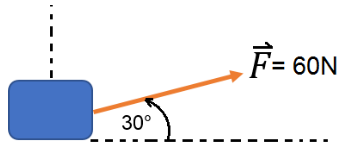
$W = 0$ Therefore, no work is done in carrying the box to a distance d.

In summary, Work is being done only when all the following conditions are satisfied:

1. There is Force applied on an object.
2. The object moves to a distance d as the Force is applied.
3. The Force applied has a parallel component with the object's motion.

Sample Problems:

1. What is the work done in pulling a crate 20m horizontally when a Force of 60N is applied on a rope which makes an angle 30° with the ground?

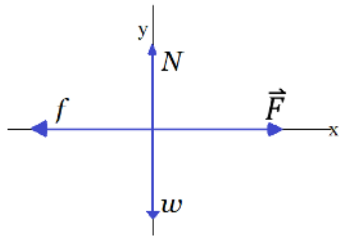


   Solution: $W = Fd\cos\theta = (60N)(20m)(\cos 30°) = 1039.2J$

2. How much work is done when a 2.5-kg package is pulled to a distance of 2m along a level floor? *(The coefficient of friction is 0.2).*

   Solution:

   We need to solve first the value of the applied force. From Newton's 1st Law of Motion:



   $\sum F_x = F - f = 0$ $\quad\quad$ $\sum F_y =$

   $N - w = 0$

   $F = f = \mu_k N = \mu_k mg$ $\quad\quad$ $N = w = mg$

   $W = F.d = \mu_k mg.d = (0.2)(2.5kg)(9.8m/s^2)(2m) = 9.8J$

3. A factory worker pushes horizontally a 30-kg crate to a distance of 4.5 m along a level floor at a constant velocity. The coefficient of kinetic friction between the crate and the floor is 0.25.

   a. What magnitude of Force (F_w) must did the worker apply?

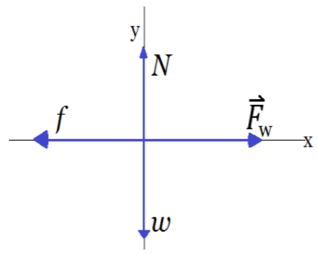
   b. How much work is done on the crate by this force?

   c. How much work is done on the crate by the friction force?

   d. How much work is done by the normal force? By the gravity?

   e. What is the net work done on the crate?

   Solution:



   a. From Newton's 1st Law:

   $$\sum F_x = F_w - f = 0 \quad \rightarrow \quad F_w = f$$

   Where $f = \mu_k N$ and from the Forces on the y-axis

   $$\sum F_y = N - w = 0 \quad \rightarrow \text{N} = \text{w}$$

   Thus $F_w = f = \mu_k N = \mu_k mg(0.25)(30kg)(9.8m/s^s) = 73.5N$

   b. $W = F_w d\cos\theta = (73.5N)(4.5m)\cos 0 = 330.75J$

   c. $W = fd\cos\theta = (73.5N)(4.5m)\cos 180° = -330.75J$

   d. $W_N = Nd\cos\theta$ the angle between N and the displacement is 90° since they are perpendicular with each other as well as the force exerted by the gravity which is represented by weight w. Therefore, $W_N = 0$ and $W_{grav} = 0$

   e. $W_{tot} = W_{F_w} + W_f + W_N + W_{grav} = 73.5N + (-73.5N) + 0 + 0 = 0$

What's More

Let's Work it Out

Direction: Using the Physics concepts, determine if Work is done in the following cases. Justify your answer.

Scenario	FBD (include the displacement)	Is there Work Done? (Yes/No)	Justification
1. You go up a flight of stairs			
2. You tug a stubborn carabao which refuses to budge			
3. A ripe mango falls from the tree			
4. You pushed against an immovable concrete wall for 5 minutes			
5. You push your classmate on a swing			

What I Have Learned

You Work on This!

1. What conditions must be satisfied if work is to be done?

2. List down 5 chores you do everyday that exhibits Work. Justify briefly your answer.

3. How much work would you do if you climbed 8m up a tree? (Use your own weight)

4. A crate weighing 50kg requires 100N of force to slide it along a level floor. How much work is done when the crate is
   a. pulled 10m?

   b. lifted 10m high?

Lesson 2

Energy and Energy Conservation

What's In

In the previous lesson, you have learned the conditions needed for a Force to do Work on an object. This time you are going to investigate the relationship between Work, Power and Energy and how each of the type of Energy enables you to do Work on an object.

When you push or lift a box on a floor, you applied a Force causing it to displace to a certain distance d. Thus work is done on an object. You were able to climb a tree or a run up a flight of stairs because of the Force you exerted to compensate the Force due to gravity acting on you.

But there is one quantity that plays a vital role in all of these activities. What makes you able to carry things? To run up the stairs? And how were you able to exert those Forces?

It's Energy! Energy enables you to exert Force to be able to do Work. Thus the common definition of Energy as the "ability to do Work" justifies its important role.

Force, Energy and Work are quantities closely related to each other. In this module, you will learn how these three quantities affects one another.

What I Need to Know

In this lesson, you are expected to

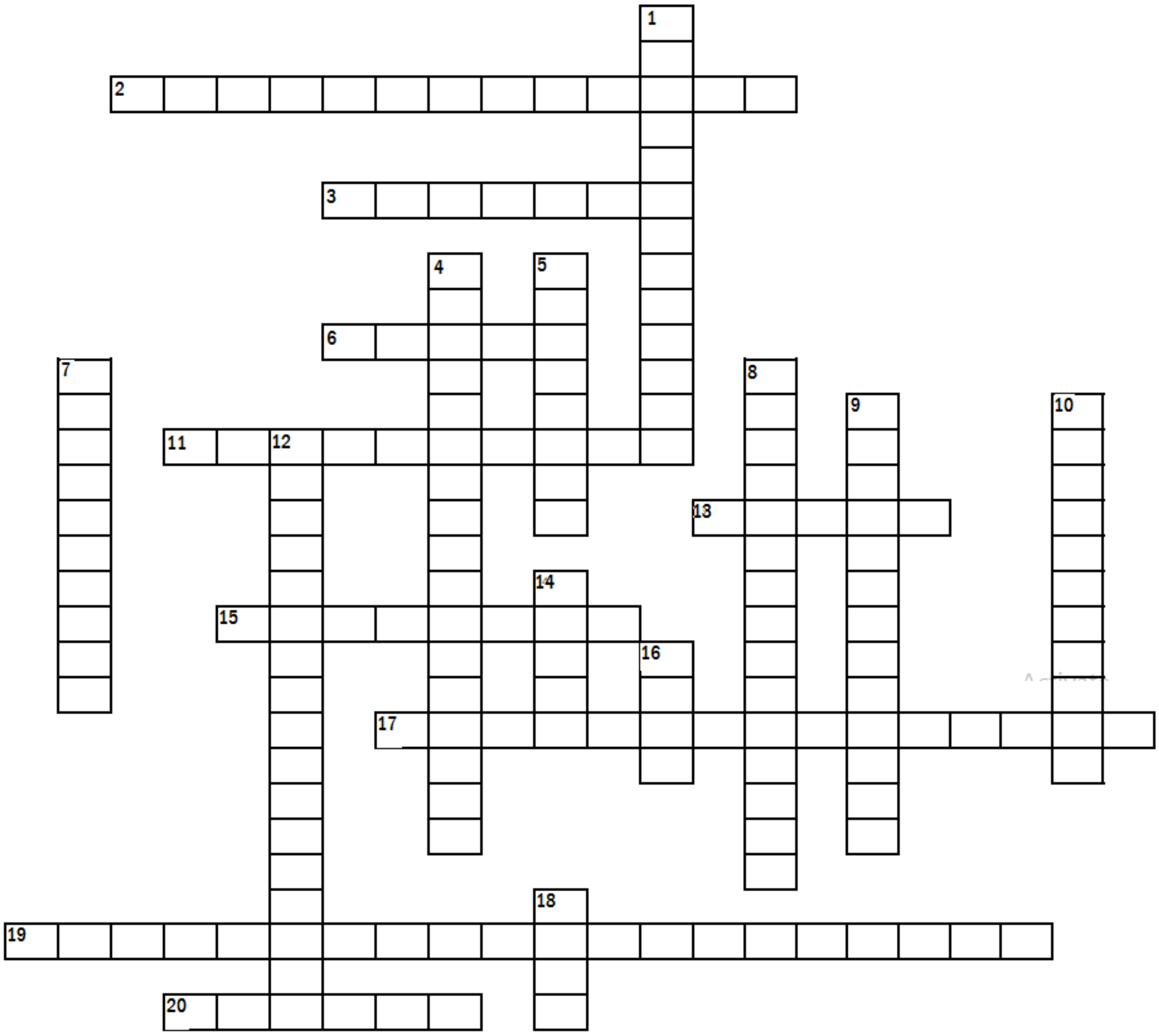
1. Derive the Work-Energy Theorem to understand the relationship between Work and Energy.
2. Define and derive the following quantities in relation to Work:
   a. Kinetic Energy
   b. Gravitational Potential Energy
   c. Elastic Potential Energy
   d. Power
3. Solve problems involving Work, Power and Energy

What's New

Crossword-Puzzle.

Direction: Answer the puzzle below to recall your knowledge on Work, Power and Energy

Work, Power and Energy



Across

2. form of energy involved in weighing fruit on a spring energy

3. a stretched rubber band or a stretched or compressed spring are examples of which potential energy

6. a push or pull

11. the sum of an object's potential and kinetic energy

13. work done in a certain amount of time

15. the force that opposes motion between two surfaces that are in contact

17. stored energy

19. states that energy cannot be created nor destroyed, but only transformed from one form into another

20. the ability to do work

Down

1. friction converts kinetic energy to

4. the net work done on an object is equal to its change in kinetic and potential energy

5. energy that is stored in chemical bonds

7. a roller coaster track is an example of a

8. friction and air resistance is an example of what type of force

9. energy of a moving object

10. the sum of kinetic energy and all forms of potential energy

12. the gravitation force is called a

14. SI unit of work

16. he unit of power equal to one joule of energy transferred in one second

18. the product of the force exerted on an object and the distance the object moves in the direction of the force

What Is It

There many types of energy surrounding us that enables us to do Work. In this lesson, we will focus how Energy is related to work. Also the two (2) types of energy namely: Kinetic Energy and Potential Energy. Under Potential energy are Gravitational Potential Energy (GPE) and Elastic Potential Energy (EPE)

Work-Energy Theorem and Kinetic Energy

Consider the Figure below. A ball with mass m is thrown to a distance d with velocities v_i and v_f. When the ball is thrown, a net Force, F_{net}, is exerted causing it to move to a distance d. The ball's velocity changes from its initial state. This change in velocity results to the ball's acceleration.

From Newton's 2nd Law of Motion: $\sum \overrightarrow{F_{net}} = ma$

If the net Force is constant, then $a = \frac{v_f^2 - v_i^2}{2d}$ $(\text{Motion with Constant Acceleration})$

Calculating the Work done:

$$W = F.d = (ma).d = m\left(\frac{v_f^2 - v_i^2}{2d}\right).d = m\left(\frac{v_f^2 - v_i^2}{2}\right) = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$where$ $\frac{1}{2}mv^2$ is the **Kinetic Energy** of the object.

Thus, in terms of Kinetic Energy: $W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = K_f - K_i = \Delta K$

This equation is called the **Work-Energy Theorem** which shows the relationship between Work and Energy.

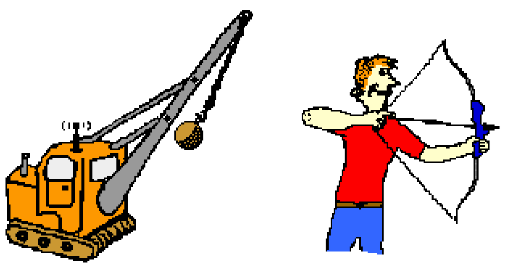
Potential Energy (U):

Gravitational Potential Energy (U_{grav}) and Elastic Potential Energy (U_{el})

Potential energy is the energy possessed by an object due to its position.

When the massive ball of the demolition machine is not lifted, it cannot do Work on another object. But when raised above the ground, it gains potential energy which capacitates it do Work.

Same thing happens to the bow and arrow. The arrow can only be released if the bow is stretched.

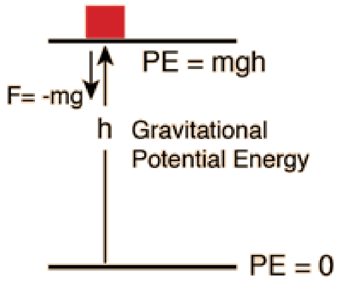


The massive ball of a demolition machine and the stretched bow possesses stored energy of position - potential energy.

Hence, the word "potential" means that something is capable of doing Work.

To understand further, let us define Potential Energy mathematically. Consider the figure below.

Gravitational Potential Energy



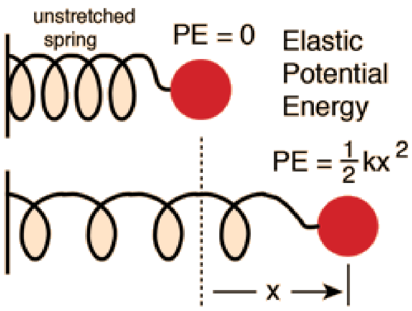
In moving the box to a height, h, it gains Gravitational Potential Energy equal to: $U_{grav} = mgh$

where: $F = -mg$ is the force acting due to gravity

The work done on the box by this force can be calculated as:

$$W_{grav} = F.d = -mg(y_f - y_i) = mgy_i - mgy_f = U_i - U_f = -\Delta U_f$$

Elastic Potential Energy



Stretching or compressing a spring or any elastic materials enables it to do Work, thus potential energy is gained.

In the figure shown, as the spring is stretched is possess potential energy equal to: $U_{el} = \frac{1}{2}kx^2$

where: $F_{spring} = -kx$ and k is the spring's constant

The work done in stretching the spring is calculated as follows:

$$W_{spring} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 = U_i - U_f = \Delta U$$

Summary of the Different Types of Energy

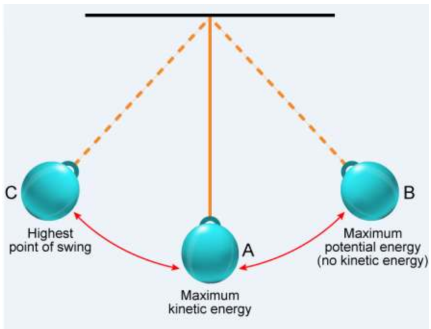
Energy Type	Formula	When to use
Kinetic Energy	$K = \frac{1}{2}mv^2$	Presence of Moving object
Gravitational Potential Energy	$U_{grav} = mgy$	Object is elevated with respect to a reference point
Elastic Potential Energy	$U_{el} = \frac{1}{2}kx^2$	Presence of Elastic materials

Energy Conservation

As simply defined, Energy is the capacity to do Work and it comes in many forms. In process of doing Work, Energy can be changed from one form to another but the total energy in the system stays the same.

Energy Transformation

Consider the figure on the right. The swinging pendulum possess both Potential and Kinetic Energy. At points C and B, it gains its maximum Potential Energy and Minimum Kinetic Energy. As it descends, the PE is converted into Kinetic energy. When it reaches the lowest point, A, it gains its maximum Kinetic energy and minimum Potential energy.



As it swings back and forth, the energy constantly change from Potential to Kinetic and vice versa. The total energy of the system does not change.

This is called the Principle of Conservation of Energy which states that energy cannot be created nor destroyed; it is just converted from one form to another.

Mathematically, $\sum E_i = \sum E_f$ where $E_i = K_i + U_i$ and $E_f = K_f + U_f$

The quantity E is called Mechanical Energy and is equal to $K + U$.

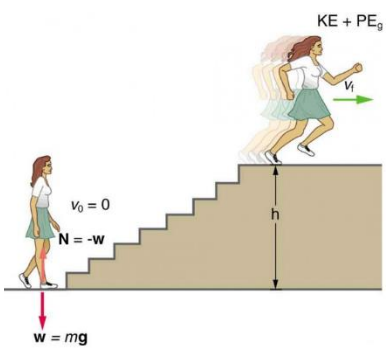
$\sum E_i = \sum E_f \quad \leftrightarrow \quad K_i + U_i = K_f + U_f$ ***Principle of Conservation of Energy***

Where: $K \rightarrow Kinetic\ Energy$ and
$U \rightarrow Potential\ Energy$ which can be $U_{grav} = mgy$ or
$U_{el} = \frac{1}{2}kx^2$ or both

Power

Another quantity that is closely related to Work and Energy is Power. To understand this consider the given Figure. When you walk up the stairs, Work is done. But is the work done the same when you are running up the stairs? This question can be answered by understanding the quantity Power.

Power is defined as the rate of doing work. Mathematically, $P = \frac{\Delta W}{\Delta t}$. When you go up the stairs fast, you expend more energy in a shorter time than when you go slowly.

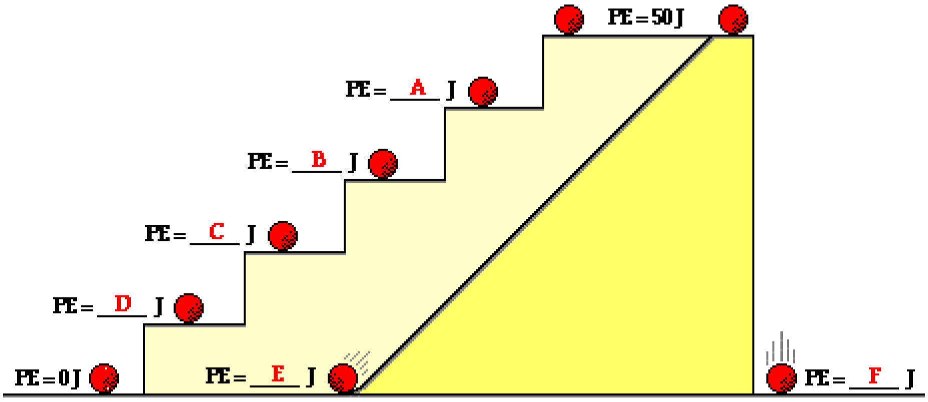


The SI Unit of Power is $\frac{Joules}{second} = Watts$

Sample Problems:

1. Determine the kinetic energy of a 625-kg roller coaster car that is moving with a speed of 18.3 m/s.
Solution:
$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(625kg)(18.3m/s)^2 = 1.05x10^5J$$

2. Use this principle to determine the blanks in the following diagram. Knowing that the potential energy at the top of the tall platform is 50 J, what is the potential energy at the other positions shown on the stair steps and the incline?



http://www.physicsclassroom.com/class/energy/u5l1b.cfm

Solution:
A: PE = 40 J (since the same mass is elevated to 4/5-ths height of the top stair)
B: PE = 30 J (since the same mass is elevated to 3/5-ths height of the top stair)
C: PE = 20 J (since the same mass is elevated to 2/5-ths height of the top stair)
D: PE = 10 J (since the same mass is elevated to 1/5-ths height of the top stair)
E and F: PE = 0 J (since the same mass is at the same zero height position as shown for the bottom stair).

3. What is the elastic potential energy of a car spring that has been stretched 0.5m? The spring constant for the car is 90N/m.
Solution: $$U_{el} = \frac{1}{2}kx^2 = \frac{1}{2}(\frac{90N}{m})(0.5m)^2 = 11.25J$$

4. A pitcher hurls a 0.25-kg softball. The ball starts from rest and leaves the pitcher's hand at a speed of 25m/s. How much work is done on the softball by the hurler's arm?
Given: $m = 0.25kg$
$v_f = 25m/s$
$v_i = 0m/s$

Solution: $$W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$
$$= \frac{1}{2}(0.25kg)(\frac{25m}{s})^2 - \frac{1}{2}(0.25kg)(0)$$
$$= 78.125J$$

5. Jean climbs a fligt of stairs in 1.5min. If she weighs 450N and the stairs is 10m from the ground, how much power will she develop?

Solution: $$P = \frac{W}{t} = \frac{F.d}{t} = \frac{(450N)(10m)}{90\ s} = \frac{50Nm}{s} = 50W$$

Note: Do not to forget to convert the time into seconds

6. A cyclist is trying to leap across two hills by cycling horizontally off the taller hill. The cyclist leaves the taller hill at a speed of 40m/s. Ignoring air resistance, find the final speed with which the cyclist strikes the ground on the other hill.

Given:

$v_i = 40m/s$

$y_i = 50m \rightarrow height\ of\ the\ taller\ hill$

$y_f = 20m \rightarrow height\ of\ the\ smaller\ hill$

Unknown: final velocity, v_f

Solution:

Using the principle of Conservation of Energy:

$$E_f = E_i \quad \rightarrow \quad K_f + U_f = K_i + U_i$$

Where: $K = \frac{1}{2}mv^2 \quad and \quad U = U_{grav} = mgy$

$$\frac{1}{2}mv_f^2 + mgy_f = \frac{1}{2}mv_i^2 + mgy_i$$

$$v_f = \sqrt{v_i^2 + 2g(y_i - y_f)}$$

$$v_f = \sqrt{(40m/s)^2 + \left[2\left(\frac{9.8m}{s^2}\right)(50m - 20m)\right]}$$

$$v_f = 46.78m/s$$

7. The speed of the hockey puck decreases from 45m/s to 44.67m/s in coasting 16m across the ice. Find the coefficient of kinetic friction, μ_k between the puck and the ice.

Given:

$v_i = 45m/s$

$v_f = 44.67m/s$

$d = 16m$

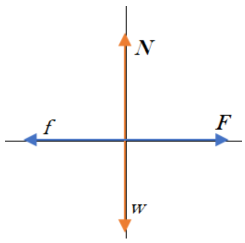
Solution:

We can solve the kinetic friction, μ_k from the formula of friction: $f = \mu_k N$

Looking at the FBD of the system, we see that

$N = w = mg \quad \rightarrow N = mg$

and $F = f$



Using the Work-Energy Theorem: $W = K_f - K_i$

where: $W = F.d$

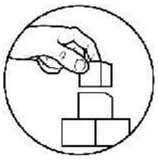
$$F.d = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Note that: $F = f = \mu_k N = \mu_k mg \rightarrow F = \mu_k mg$

$$(\mu_k mg)d = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

We can cancell out m from both sides. We get:

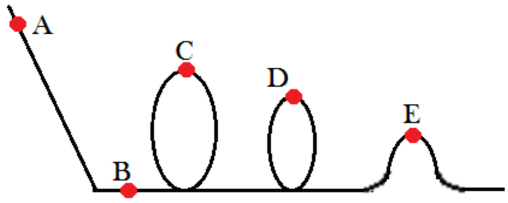
$$\mu_k = \frac{\frac{1}{2}(v_f^2 - v_i^2)}{gd} = \frac{\frac{1}{2}\left((44.67m/s)^2 - (45m/s)^2\right)}{(9.8m/s^2)(16m)} = 0.1$$



What's More

You need to be more ENERGYtic to answer this!

Direction: Do as instructed.



1. Consider the diagram at the right in answering the next three questions. Five locations along a roller coaster track are shown. Assume that there are negligible friction and air resistance forces acting upon the coaster car.

   a. Rank the five locations in order of increasing PE (smallest to largest PE). Use < and or = signs

   b. Rank the five locations in order of increasing KE (smallest to largest KE). Use < and or = signs.

   c. Complete the relationship of the potential energy between the pair of points given: Use <, > and or = signs.

      i. A ____ C　　ii. E ____ A　　iii. D ____ C

      iv. D ____ E　　v. C ____ B　　vi. B ____ A

2. Read each of the following statements and identify them as having to do with kinetic energy (KE), potential energy (PE) or both (B).

KE, PE or B?	Statement:
	1. If an object is at rest, it certainly does NOT possess this form of energy.
	2. Depends upon object mass and object height.
	3. The energy an object possesses due to its motion.
	4. The amount is expressed using the unit joule (abbreviated J).
	5. The energy stored in an object due to its position (or height).
	6. The amount depends upon the arbitrarily assigned zero level.
	7. Depends upon object mass and object speed.
	8. If an object is at rest on the ground (zero height), it certainly does NOT possess this form of energy.

Excerpted from The Physics Classroom, 2009

What I Have Learned

Time to recharge – I need more ENERGY.

Direction: Solve the following problems systematically. Show all your solutions clearly.

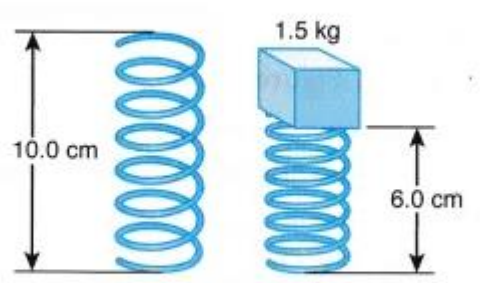
1. Complete the paragraph by supplying the correct value needed. Show your solutions.

   An object starts from rest with a potential energy of 600 J and free-falls towards the ground. After it has fallen to a height of one-fourth of its original height, its total mechanical energy is ______ J, its potential energy is ____ J, and its kinetic energy is _____ J.

2. A glider is gliding through the air at a height of 416 meters with a speed of 45.2 m/s. The glider dives to a height of 278 meters. Determine the glider's new speed.

3. Bart runs up a 2.91-meter high flight of stairs at a constant speed in 2.15 seconds. If Bart's mass is 65.9 kg, determine the Work which he did and his Power rating.

4. The figure shows a spring before and after being compressed.
   a. Calculate the force constant of the spring.
   b. What is the elastic potential energy stored in the compressed spring?



Summary

- Exerting Force on an object does not always imply that Work is done. In Physics, three conditions must be satisfied for Work to be done. In summary, Work is being done only when all the following conditions are satisfied:
  1. There is Force applied on an object.
  2. The object moves to a distance d as the Force is applied.
  3. The Force applied has a parallel component with the object's motion.

  Mathematically: $W = Fdcos\theta$ SI Unit of Work: Joules = 1Nm

  where:

  F is the force applied on the object
  d is the distance the object moved and
  θ is the angle between F and d

- An object or a person can exert force of Energy. When a body possesses Energy, it can do Work. Thus Energy is simply defined as the capacity to do Work.
  The unit of Energy and Work are the same – Joules.

- There are many forms of Energy and one of those is Mechanical Energy. Mechanical Energy is the sum of Kinetic and Potential Energy. $ME = KE + U$

- Kinetic Energy, KE, is the energy possess by moving objects. $KE = \frac{1}{2}mv^2$

- Potential Energy, U is simply defined as stored energy. There are two types of Potential Energy discussed in this module namely: Gravitational PE and Elastic PE.

- Gravitational Potential Energy, U_{grav}, is the energy possessed by an object by virtue of its position. Mathematically: $U_{grav} = mgy$

- Elastic Potential Energy, U_{el} is the energy acquired by elastic objects when work is done by it so that it is compressed or stretched from its equilibrium position. $U_{el} = \frac{1}{2}kx^2$

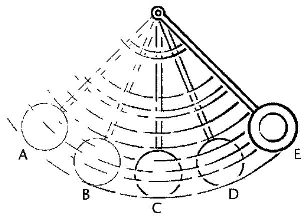
- The change in Kinetic Energy of the object is equal to the Work done on it. This is called the Work-Energy Theorem and is mathematically expressed as $W = \Delta K$

- Energy can neither be created nor destroyed, but it can be changed from one form to another. This is the law of conservation of energy. In the conservation of Mechanical Energy, the sum of the kinetic energy and potential energy in an isolated system is constant. $\sum E_i = \sum E_f \quad \leftrightarrow \quad K_i + U_i = K_f + U_f$

Assessment: (Post-Test)

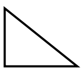
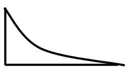
Multiple Choice. Answer the question that follows. Choose the best answer from among the given choices.

For numbers 1 to 4, refer to the figure given.

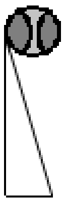
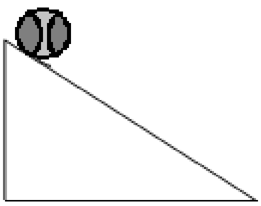
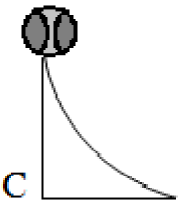


1. At what point in its motion is the kinetic energy of the pendulum bob maximum? A. A B. B C.C D. D
2. At what point in its motion is the kinetic energy of the pendulum bob minimum? A. E B. C C. A D. B
3. At what point in its motion is the potential energy of the pendulum bob minimum? A. A B. B C.C D. D
4. At what point in its motion is the potential energy of the pendulum bob maximum?
   A. E B. C C. A D. B
5. In a marathon, the winner and the runner-up have the same mass. Compared with the runner-up, the winner has more
   a. energy b. force c. power d. work
6. Which event does NOT describe potential energy being changed into kinetic energy?
   A. A box sliding down a ramp. B. A mango falling from a crate.
   C. A pen spring being compressed. D. A stretched rubber band got loosened.
7. Which event illustrates the direct transformation of potential to kinetic energy?
   A. A basketball player catches a flying ball.
   B. A Kalesa moves from rest.
   C. Kathy's arrow is released from its bow.
   D. The spring mechanism of a toy is rotated until it locked.
8. 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.
9. The potential energy of a 4-kg object on top of a hill is 72 J. What is its velocity in m/s just before it hits the ground?
   A. 36 B. 18 C. 6 D. 3
10. In order to do work, energy is
    A. transferred or converted B. used up
    C. lost D. lost or transferred
11. A man carries a load of 500 N to a distance of 100 m. The work done by him is
    A. 5 N B. 50,000 Nm C. 0 D. 1/5 N
12. Power is a measure of the _______
    A. rate of change of momentum B. force which produces motion
    C. change of energy D. rate of change of energy
13. When angle between force and displacement is 90° then work done is
    A. 0 J B. 1 J C. 10 J D. 50 J
14. What power is needed to lift a 49-kg person a vertical distance of 5.0 m in 20.0 s? A 12.5 W B. 210 W C. 120 W D. 25 W
15. Greg applies a force of 100 N to move a box 5 meters. How much work did he do?
    A. 100 J B. 5 J C. 500 J D. 500 N

16. If you push on a 300 kg rock with a force of 1,000 N for 10 s, and it doesn't move, how much work have you done on the rock?
    A. 0 J   B. 10,000 J   C. 300,000 J   D. 3,000,000 J
17. As a baseball flies through the air after being hit, which of the following types of energy does it have?
    A. potential energy   C. mechanical energy
    B. kinetic energy   D. chemical energy
18. Which would ALWAYS be true of an object possessing a potential energy of 0 joules?
    A. It is on the ground.   B. It is at rest.
    C. It is moving on the ground   D. It is moving.
19. The amount of work that can be done by a 8000-W machine in 12 seconds is
    A. 667 J   B. 96,000 J   C. 800 J   D. 960 J
20. If an engine does 783 J of work in 9 seconds, its average power is
    A. 87 W   B. 774 W   C. 7047 W   D. 792 W
21. What is the kinetic energy of a 4 kg rock falling through the air at 5 m/s?
    A. 10 J   B. 50 J   C. 20 J   D. 200 J
22. How much power does it take to lift a 1,000 N load 10 m in 20 s?
    A. 5 W   B. 500 W   C. 2,000 W   D. 200,000 W
23. If you increase _________ and __________ then you will increase the objects amount of potential energy.
    A. mass, height   B. mass, acceleration
    C. mass, velocity   D. mass, speed
24. If you push identical boxes from the bottom of each ramp to the same height at the top, which ramp would require you to do the most work on the box? Ignore friction.

    A.    B.    C.    D. all the same

25. All of the identical balls start at the same height. Which will have the highest velocity when it reaches the bottom of its ramp? Ignore friction.

    A    B    C    D. all the same

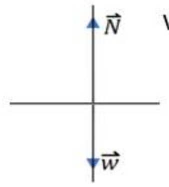
Key to Answers

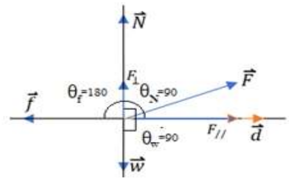
Lesson 1

Pre-test

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

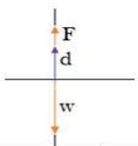
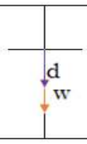
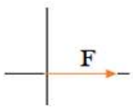
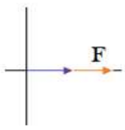
What's New

1. 

2. 

3. With √: a, b,c

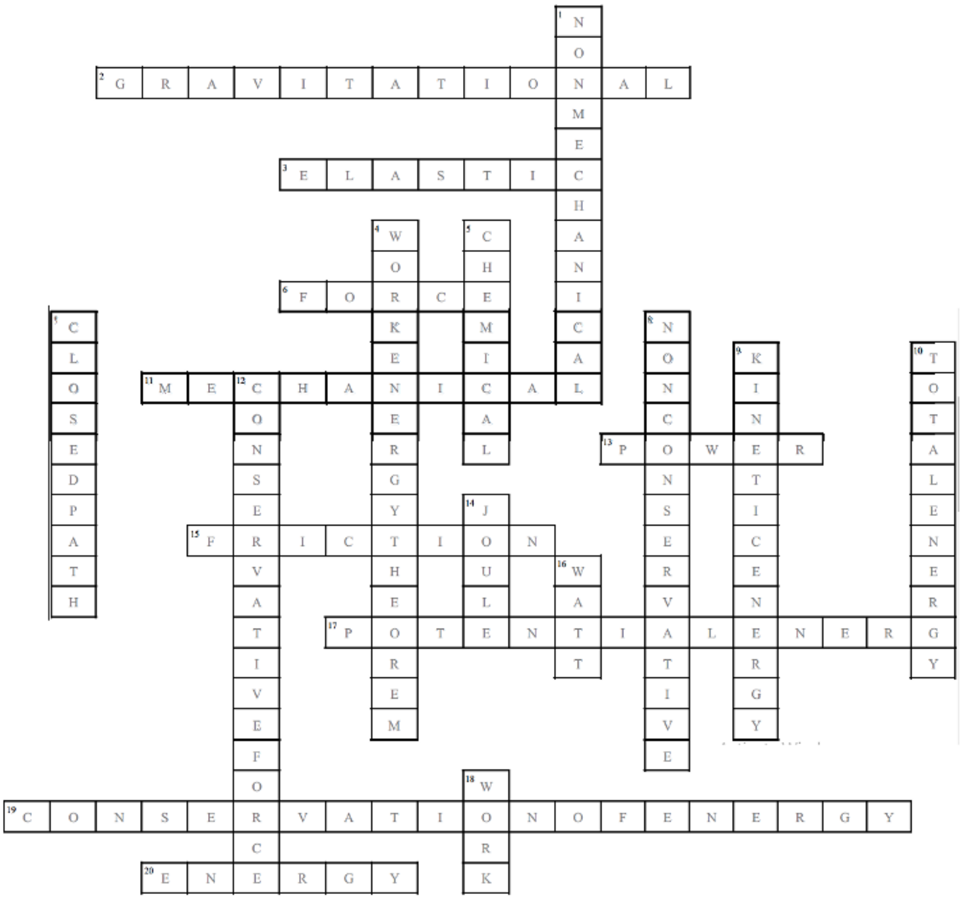
What's More

Scenario	FBD (include the displacement)	Is there Work Done? (Yes/No)	Justification
1. You go up a flight of stairs		YES	-with displacement -with component of the Force parallel to the object's motion
2. You tug a stubborn carabao which refuses to budge		NO	No displacement
3. A ripe mango falls from the tree		YES	with displacement -with component of the Force parallel to the object's motion
4. You pushed against an immovable concrete wall for 5 minutes		NO	No displacement
5. You push your classmate on a swing		YES	with displacement -with component of the Force parallel to the object's motion

What I have learned

1. There is Force applied on an object.
   The object moves to a distance d as the Force is applied.
   The Force applied has a parallel component with the object's motion.
2. Answers vary
3. W=mgy (answers vary depending on the student's weight)
4. A. W=Fd=(100N)(10m)=1000J   B. W=mgy=(50kg)(9.8m/s2)(10m)=5,000J

Lesson 2
What's New



What's More

1. A. B < E < D < C < A
   b. A < C < D < E < B
   c. A>C; E<A; D<C; D>E; C>B; B<A
2. 1. KE 2. PE 3. KE 4. B 5. PE 6. PE 7. KE 8. B

What I have learned

1. 600J; 150J; 450J
2. v = 68.9 m/s
3. W=1879.3J P=874W
4. K=367.5N/m U_{el}=0.294J

Assessment:

1. C
2. A/C
3. C
4. A/C
5. C
6. C
7. C
8. B
9. C
10. A
11. C
12. D
13. A
14. C
15. C
16. A
17. B
18. A
19. B
20. A
21. B
22. B
23. A
24. D
25. D

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