Physics 2204
Unit 3: Work, Power and Energy
Worksheet #8: Conservation of Mechanical Energy

Student Name:_____

Energy (E) is defined as the capacity to do work (scalar). The unit for all energy and work is the Joule

Mechanical energy- the energy due to the position of something or the movement of something.

Mechanical Energy can be divided into to categories:

1) Potential Energy (PE)

2) Kinetic Energy (KE)

Conservation Of Mechanical Energy: Energy can't be created or destroyed. It can only be transformed into other types of energy. the TOTAL amount of energy is CONSTANT

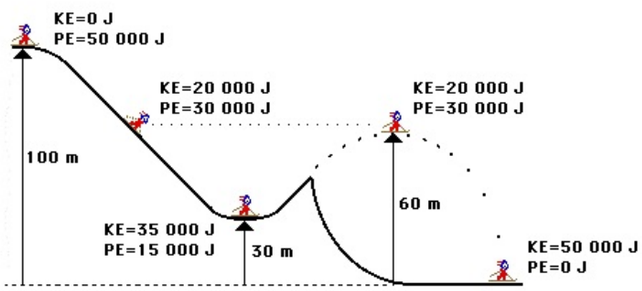
Here we will look at the Law of Conservation of Energy as it applies to mechanical energy only. For a particular object the sum of the potential energy and the Kinetic energy is a constant term. This can be summarized in the following:

$$ME_i = ME_f$$

$$PE_i + KE_i = PE_f + KE_f$$

If no energy is lost due to friction, Mechanical energy is conserved at all points in the motion.

For example: Skiing



Example 1:

Mr. Car Pentar's 2.1 kg lunch-pail slips off the roof of a 4 storey building (height 12.2 m) and falls to the ground. With what speed does it strike the ground?

Example 2:

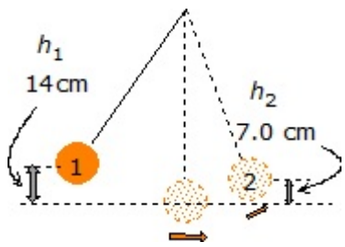
A ball with a mass of 0.95 kg is launched vertically upwards from ground level with an initial speed of 35.0 m/s. What will be the maximum height reached by this ball?

Example 3:

A rock is thrown straight down from the top of a cliff 9.0 m above the water. The initial speed of the rock is 8.0 m/s. With what speed will the rock strike the water?

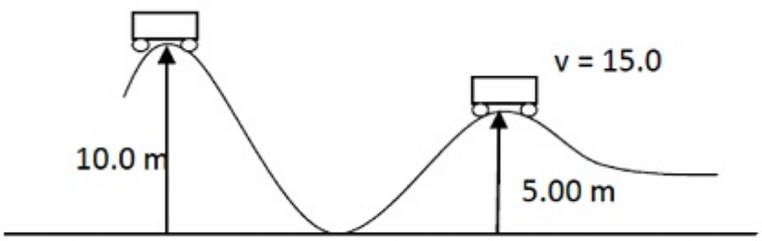
Example 4:

The picture shows a pendulum bob that is displaced to a height of 14 cm (position "1"). How fast will it be moving at position "2" which is 7.0 cm above its lowest position?



Example 5:

A 5.00 x 10^2 kg roller coaster travels at a speed of 15.0 m/s when at a height of 5.00 m above the ground (assume mechanical energy is conserved).



A) Calculate the kinetic energy at 5.00 m.

B) Calculate the gravitational potential energy at 5.00 m.

C) Calculate the speed of the roller coaster when it is at a height of 10.0 m.

PART A: MULTIPLE CHOICE

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided

1. After an energy conversion, you end up with the same total amount of energy as the original amount of potential energy. Which of the following laws explains this rule?

   (A) Law of energy changes
   (B) Law of conservation of energy
   (C) Law of power and energy
   (D) Law of potential energy

2. Which of the following best describes mechanical energy of an object?

   (A) Chemical energy plus its nuclear energy
   (B) Kinetic energy plus its potential energy
   (C) Nuclear energy
   (D) Thermal energy

3. Which of the following laws states that energy cannot be created or destroyed?

   (A) Law of conservation of power
   (B) Law of conservation of energy
   (C) Law of changing energy
   (D) Law of energy changes

4. Which of the following statements is true according to the law of conservation of energy?

   (A) Energy cannot be created
   (B) Energy cannot be destroyed
   (C) Energy can be converted from one form to another
   (D) All of the above

5. In which situation is potential energy converted to kinetic energy?

   (A) A ball rolling on a flat surface is slowed by friction
   (B) A ball rolls slower and slower as it rolls uphill
   (C) A horizontal spring is compressed by a force
   (D) A rock in a sling shot is launched horizontally

6. Which of the following is true at the point where you reach the top of your jump on a trampoline?

   (A) The mechanical energy is zero.
   (B) The potential energy is at a maximum.
   (C) The kinetic energy and potential energy are equal.
   (D) The potential energy is zero.

7. Which one of the following choices is an example of a non-conservative force?

   (A) Elastic spring force
   (B) Electrical force
   (C) Kinetic frictional force
   (D) Gravitational force

8. How is total mechanical energy of a system determined?

   (A) The sum of the kinetic and potential energies in the system
   (B) The product of the net force in the system and the displacement
   (C) The sum of the kinetic and potential energies in the system and the work done by friction
   (D) The sum of the kinetic and potential energies in the system minus the work done by friction

9. How will the energy of an object change as it falls?

	Kinetic Energy	Gravitational Potential Energy
(A)	Decreases	Decreases
(B)	Decreases	Increases
(C)	Increases	Decreases
(D)	Increases	Increases

10. If no friction acts on a diver during a dive, then which of the following statements is true?

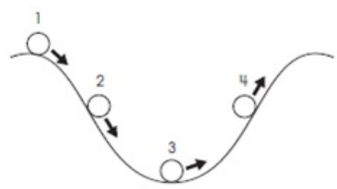
(A) The total mechanical energy of the system increases.
(B) Potential energy can be converted into kinetic energy but not vice versa.
(C) $(KE+ PE)_{beginning} = (KE + PE)_{end}$
(D) All of the above

11. 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

12. A ball is released from rest at position 1. The diagram shows the ball in four positions as it rolls along a track from left to right. In which position does the ball have its minimum gravitational potential energy and maximum kinetic energy?

(A) 1
(B) 2
(C) 3
(D) 4



13. A spring-loaded plunger is used to launch a 1.0 kg car at 4.0 m/s along a frictionless track. The cart goes up a hill to some maximum height h. Which describes, in order, the energy transformations that occur? (Assume no friction)

(A) Elastic potential ⇒ gravitational potential ⇒ kinetic
(B) Elastic potential ⇒ kinetic ⇒ gravitational potential
(C) Gravitational potential ⇒ kinetic ⇒ elastic potential
(D) Kinetic ⇒ elastic potential ⇒ gravitational potential

14. A ball falls from a height h from a tower. Which of the following statements is true?

(A) The potential energy of the ball is conserved as it falls.
(B) The kinetic energy of the ball is conserved as it falls.
(C) The difference between the potential energy and kinetic energy is a constant as the ball falls.
(D) The sum of the kinetic and potential energies of the ball is a constant.

15. You drop a 5.1 kg ball from a height of 2.3 m. Just before it reaches the ground, how much kinetic energy does it have?

(A) 12 J
(B) 23 J
(C) 5.0×10^1 J
(D) 1.2×10^2 J

16. A 2.00 kg ball has a potential energy of 6.40 x 10^3 J at a point above the surface of the earth. The ball is released from rest and strikes the ground. What is its velocity on impact?

(A) 20.0 m/s
(B) -20.0 m/s
(C) 80 m/s
(D) -80 m/s

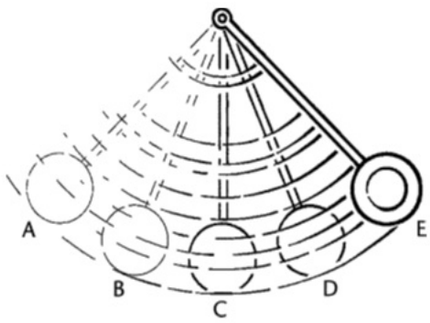
17. A 3.0 kg block falls from rest through a distance of 6.0 m in an evacuated tube near the surface of the earth. What is its speed after it has fallen the 6.0 m distance?

(A) 8.0 m/s
(B) 11 m/s
(C) 13 m/s
(D) 26 m/s

18. A 0.50kg ball is dropped from a third story window which is 2.0 x10^1 m above the sidewalk. What is the speed of the ball just before it strikes the sidewalk?

(A) 5 m/s
(B) 10 m/s
(C) 14 m/s
(D) 20 m/s

Use the diagram below to answer questions 19 to 21:



19. At which point(s) does the pendulum have the most potential energy?

(A) A
(B) E
(C) C
(D) A and E

20. At which point(s) does the pendulum have the most kinetic energy?

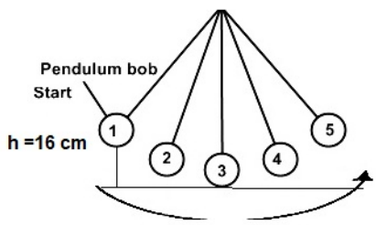
(A) A
(B) E
(C) C
(D) A and E

21. Name two point where the pendulum is increasing in kinetic energy.

(A) A and E
(B) A and C
(C) B and D
(D) B and E

Use the information and picture below to answer questions 22 to 27

A 3.2 kg bob is raised to position 1 which has a height of 16 cm shown below. The pendulum bob continuously oscillates between positions 1 to 5.



22. What is the maximum potential energy of the pendulum?

(A) 5.0×10^{-1} J
(B) 5.0 J
(C) 5.0×10^{1} J
(D) 5.0×10^{2} J

23. Where does the pendulum have maximum potential energy?

(A) 2
(B) 3
(C) 4
(D) 5

24. Where does the pendulum bob have the most kinetic energy?

(A) 2
(B) 3
(C) 4
(D) 5

25. Where is the pendulum bob moving the fastest?

(A) 2
(B) 3
(C) 4
(D) 5

26. What is the maximum speed of the pendulum bob?

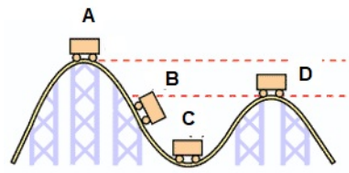
(A) 1.8 m/s
(B) 3.1 m/s
(C) 5.7 m/s
(D) 6.2 m/s

27. If the pendulum bob has 2.3 J of potential energy at position 4, how much kinetic energy does it have?

(A) 2.3 J
(B) 2.7 J
(C) 5.0 J
(D) 7.7 J

Use the picture of the roller coaster shown below to answer questions 28 to 30:

28. Where does the roller coaster have the greatest speed?



(A) A
(B) B
(C) C
(D) D

29. Where does the roller coaster have the lowest potential energy?

(A) A
(B) B
(C) C
(D) D

30. When does the roller coaster's potential energy equal the kinetic energy?

(A) A
(B) B
(C) C
(D) D

31. A skier leaves the top of a slope with an initial speed of 5.0 m/s. Her speed at the bottom of the slope is 13 m/s. What is the height of the slope?

(A) 1.1 m
(B) 6.4 m
(C) 7.3 m
(D) 11 m

32. An engineer is asked to design a playground slide such that the speed a child reaches at the bottom does not exceed 6.0 m/s. Determine the maximum height that the slide can be.

(A) 1.8 m
(B) 2.9 m
(C) 3.2 m
(D) 4.5 m

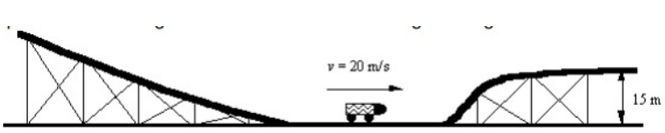
33. A child is sliding down a water slide. By what factor would the height need to be changed in order to double the child's speed at the bottom?

(A) ¼
(B) ½
(C) 2
(D) 4

34. A bicyclist is traveling at a speed of 20.0 m/s as he approaches the bottom of a hill. Neglect the effects of friction and determine the maximum vertical height the bicyclist ascends to.

(A) 3.70 m
(B) 11.2 m
(C) 20.4 m
(D) 40.8 m

35 A roller-coaster car is moving at 20.0 m/s along a straight horizontal track. Predict its speed after climbing the 15.0 m hill shown in the figure. Neglect the effects of friction.



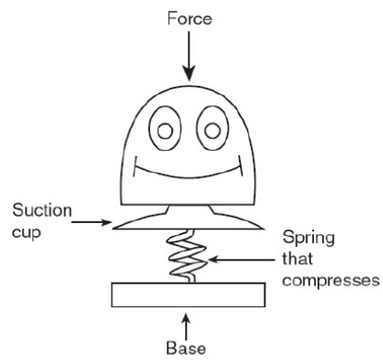
(A) 5.00 m/s
(B) 10.0 m/s
(C) 14.0 m/s
(D) 17.0 m/s

PART B written response

1. A 10.0 g pebble is placed in a sling shot with a spring constant of 200.0 N/m and is stretched back 0.500 m. What is the maximum velocity the pebble will acquire? **Answer is 70.7 m/s**

2. A spring with a spring constant of 350 N/m is compressed a certain distance by a 3.0 kg mass. If the maximum speed of the mass after it is released is 2.0 m/s, calculate the distance the spring was compressed. **Sample 2009**

3. A pop-up toy has a mass of 0.020 kg and a spring constant of 150 N/m as shown. A force is applied to the toy to compress the spring 0.050 m. Calculate whether the toy will hit a 2.1 m high ceiling when it is released. **June 2009**



4. An 80.0 kg stuntman falls from the top of a 70.0 m high building. **June 2011**

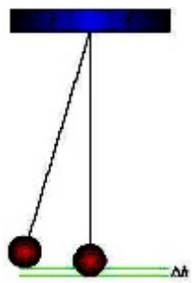
   (i) What is the total mechanical energy of the stuntman when on top of the building?

   (ii) What is the stuntman's speed at a height of 30.0 m above the ground?

5. A spring (k = 125 N/m) is used to launch a 0.15 kg toy straight upwards from the ground. If the spring is compressed 0.080 m, what is the maximum height reached by the toy?

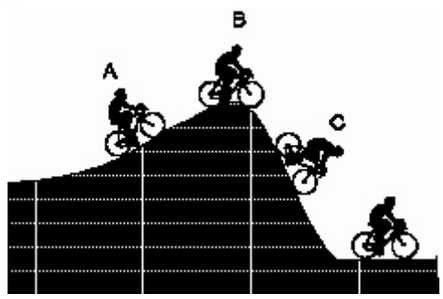
June 2012

6. The picture below a pendulum similar to the one above. Assume that the bob has a mass of 0.20 kg and is displaced to the side, ready to swing. Notice that displacing the bob results in it being lifted slightly by some amount h. Assume that in this instance h = 2.5 cm. You can use conservation of energy to calculate the maximum speed of the bob.

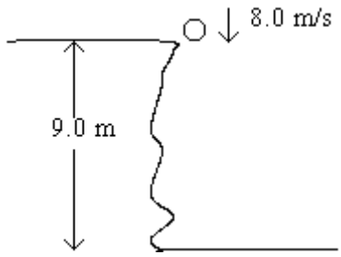


a. Where, in its swing, is the speed a maximum? Explain.
b. When the bob is displaced to the side, what is its PE relative to the bottom of its swing? **Answer is 0.049 J**
c. At the bottom of its swing, all of its energy is KE. Explain.
d. What is the total energy of the bob at the bottom of its swing? **Answer is 0.049 J**
e. Use the answer to part (d), the mass, and the appropriate equation to find the maximum value of v. **Answer is 0.70 m/s**

7. A bike is coasting (not being pedalled) up and over a hill as shown. Describe the energy changes at positions A, B, and C.



8. A rock is thrown straight down from the top of a cliff 9.0 m above the water. The initial speed of the rock is 8.0 m/s. With what speed will the rock strike the water? **Answer is 13.3 m/s**



9. A bullet with a mass of 0.0012 kg is launched vertically upwards at a speed of 402 m/s. If air friction is negligible, find the maximum height reached by the bullet. **Answer is 8245 m**

10. A rock with a mass of 0.30 kg is dropped from a bridge 16.5 m above the water. With what speed will the rock strike the water? **Answer is 18 m/s**

11. A spring with k = 500.0 N/m is drawn back 0.070 m and used to launch a puck with a mass of 0.060 kg. What maximum speed will the puck attain? **Answer is 6.4 m/s**

12. The picture shows a dynamics cart with a mass of 1.40 kg at the bottom of a frictionless ramp. The cart needs to roll up the ramp to just barely make it to the top.

a. Suppose that you wished to use conservation of energy to calculate the initial speed required. **Answer is 4.1 J**
b. Imaging the cart is at rest at the top of the ramp. Calculate the PE relative to the bottom of the ramp. **Answer is 4.1 J**
c. Use your answer from part (a) to calculate the KE that the cart should have at the bottom of the ramp. **Answer is 2.4 m/s**
d. Use your value of KE and mass, along with the appropriate equation, to calculate the speed of the cart at the bottom of the ramp.
e. How is it that the answer from part (c) gives you the speed that the cart must have if it is to just roll to the top of the ramp?

13. A sled with a mass of 40.0 kg and moving at 4.2 m/s strikes a spring with k = 1200 N/m. How far is the spring displaced as the sled comes to a rest? **Answer is 0.80 m**

14. A pendulum has a bob with a mass of 0.077 kg. The bob reaches a maximum speed of 0.60 m/s. Calculate the maximum height that it will rise to. **Answer is 0.018 m**

15. A 10. kg ball is thrown into the air. It is going 3.0 m/s when thrown. How much potential energy will it have at the top? **Answer is 45 J**

16. A 4768-kg roller coaster train full of riders approaches the loading dock at a speed of 17.1 m/s. It is abruptly decelerated to a speed of 2.20 m/s over a distance of 13.6 m. Determine the magnitude of the retarding force which acts upon the roller coaster cars. **Answer is - 50500 N**

17. A 4.00 kg ball is on a 5.00 m ledge. If it is pushed off the ledge, how much kinetic energy will it have just before hitting the ground? **Answer is 196 J**

18. A 25 kg ball is thrown into the air. When thrown it is going 10. m/s. Calculate how high it travels. **Answer is 5.1 m**

19. A 3.0 kg rock sits on a 0.80 meter ledge. If it is pushed off, how fast will it be going at the bottom? **Answer is 4.0 m/s**

20. A catcher's mitt recoils a distance of 12.9 cm in bringing a 142-gram baseball to a stop. If the applied force is 588 N, then what was the speed of the baseball at the moment of contact with the mitt? **Answer is 32.7 m/s**

21. An unknown force is applied to a 12 kg mass. The force acts at an angle of 30.0 degrees above the horizontal. Determine the force acting if the force acts for a horizontal displacement of 22 meters and increases the 12 kg mass's speed from 11 m/s to 26 m/s. **Answer is 180 N**

22. A physics teacher exerts a force upon a 3.29-kg pile of snow to both lift it and set it into motion. The snow leaves the shovel with a speed of 2.94 m/s at a height of 0.562 m. Determine the work done upon the pile of snow. **Answer is 32.3 J**

23. A 250.-gram cart starts from rest and rolls down an inclined plane from a height of 0.541 m. Determine its speed at a height of 0.127 m above the bottom of the incline. **Answer is 2.85 m/s**

24. A 4357-kg roller coaster car starts from rest at the top of a 36.5-m high track. Determine the speed of the car at the top of a loop that is 10.8 m high. **Answer is 22.4 m/s**

25. While on the moon, the Apollo astronauts enjoyed the effects of a small gravity. If Neil Armstrong jumped up on the moon with an initial speed of 1.51 m/s to a height of 0.700 m, what amount of gravitational acceleration did he experience? **Answer is - 1.63 m/s^2**

26. In a wild shot, Bo flings a pool ball of mass m off a 0.68 m high pool table, and the ball hits the floor with a speed of 6.0 m/s. How fast was the ball moving when it left the table? **Answer is 4.8 m/s**

27. A 500.0 kg pig is standing at the top of a muddy hill on a rainy day. The hill is 100.0 m long with a vertical drop of 30.0 m. The pig slips and begins to slide down the hill. What is the pig's speed at the bottom of the hill? **Answer is 24.2 m/s**

28. A 50.0 kg gorilla is sitting on the limb of a tree 4.00 meters above the ground. The gorilla jumps down from the tree limb to the ground. Use the conservation of energy to find the velocity of the gorilla just before hitting the ground. **Answer is 8.85 m/s**

29. A 2.00 kg ball is dropped from the top of a 10.0 m high building. Calculate the potential AND kinetic energies at:

(a) 10.0 m **Answer is PE = 196 J, KE = 0 J**
(b) 8.00 m **Answer is PE = 157 J, KE = 39 J**
(c) 5.00 m **Answer is PE = 98.0 J, KE = 98.0 J**
(d) 0.00 m **Answer is PE = 0 J, KE = 196 J**