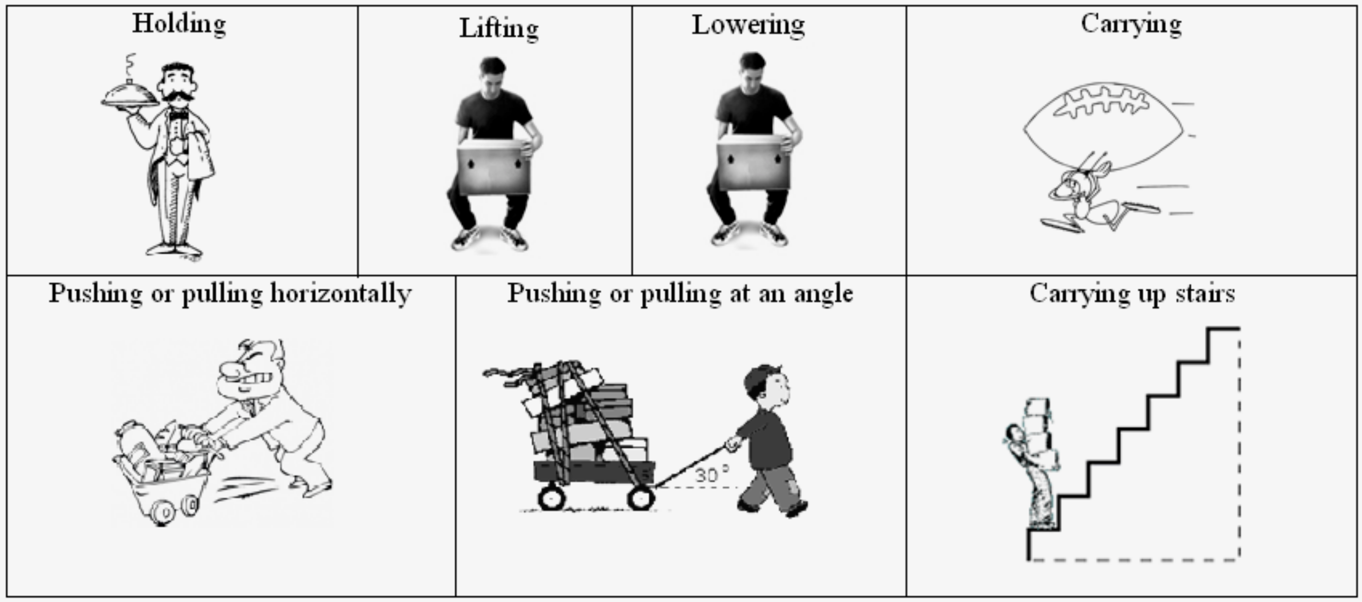
Work and Energy

Sketch vectors for the force and displacement in each activity and then determine if work is done.

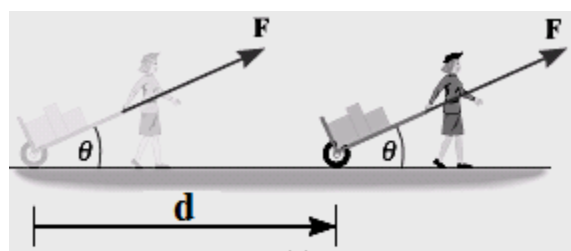


Work:

1)

2)

Formula:



Variable:	**W**	**F**	**d**	**θ**
Quantity:				
Units:				
Type:				

1. Work is a scalar but it can be positive or negative. Explain.

   Positive Work:

   Negative Work:

2. Express the units for work in terms of fundamental units.

Power: a)

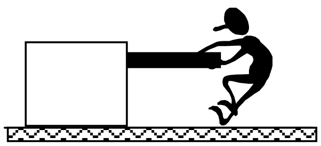
b)

Formula: Alternate Formula:

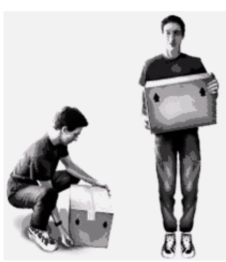
Variable:	**P**	**W**	**t**
Quantity:			
Units:			
Type:			

1. Express the units for power in terms of fundamental units.

2. A student drags a 20.0 kg box horizontally across the floor at a constant speed for a distance of 3.00 meters by applying a force of 100. newtons for 8.0 seconds. Calculate how much work was done and how much power was dissipated.

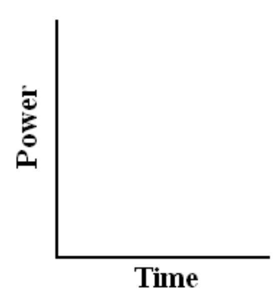


3. The student then lifts the same 20.0 kilogram box 1.50 meters straight up in the air in 4.0 seconds at a constant speed.
   a) Calculate the work he did and the power he used.

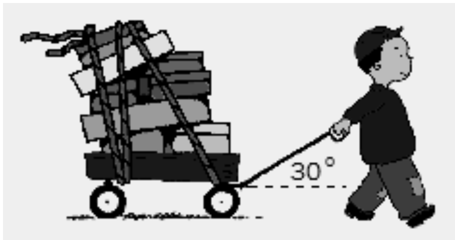


NOTE: When lifting or lowering an object at a constant speed . . .

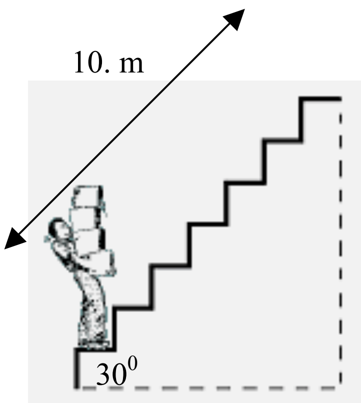
   b) A second student lifted the same box to the same height at a constant speed but in only 2.0 seconds. Compare the work she did and the power she generated to those of the first student.

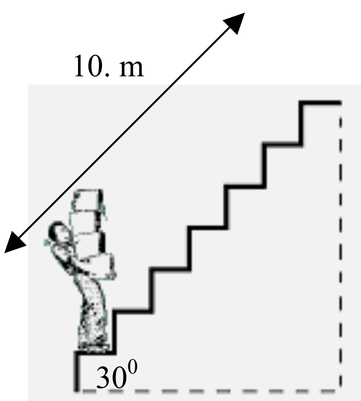


4. If a child drags a 8.0 kilogram wagon for 10. meters by using a force of 20. newtons at an angle of 30.º with the horizontal, how much work does he do?

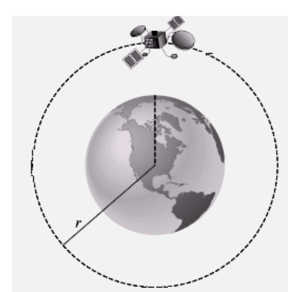


5. A student carries 150. newtons worth of books 10. meters up a flight of stairs which are inclined at an angle of 30^0 from the horizontal. How much work does he do?





6. How much work is done on a 120.-kilogram satellite as it orbits the Earth?

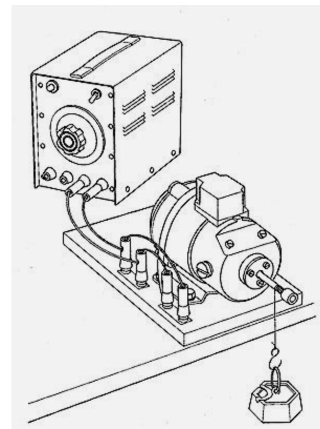


Work and Efficiency

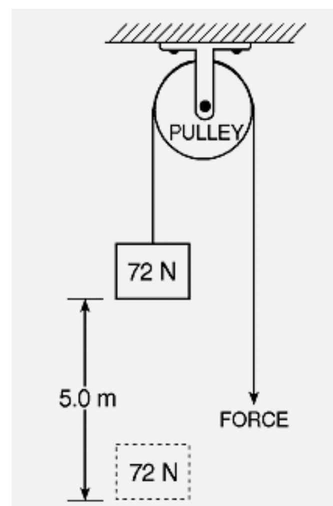
Efficiency:

Formula:

1. An electric motor has an input power of 160 W. In raising a load, 120 W of power are dissipated. What is the efficiency of the motor?



2. A student does 400. J of work using a pulley to raise a 72 N box to a height of 5.0 meters.

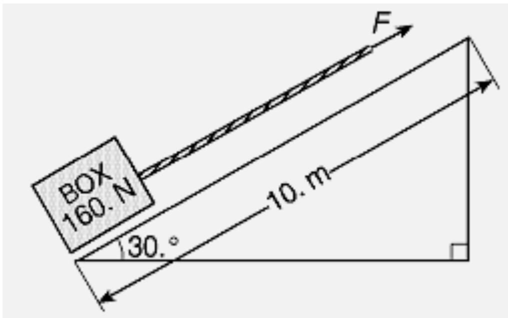


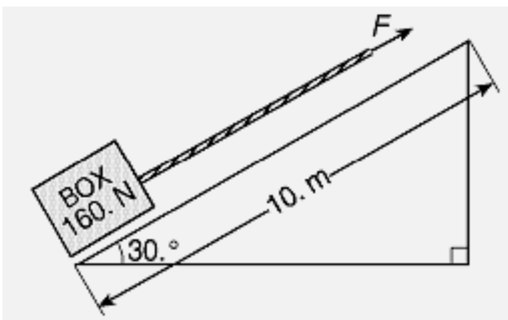
   a) How much work does the student do against gravity?

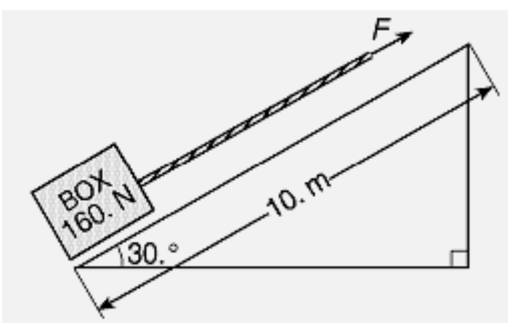
   b) How much work does the student do against friction?

   c) How efficient is this pulley?

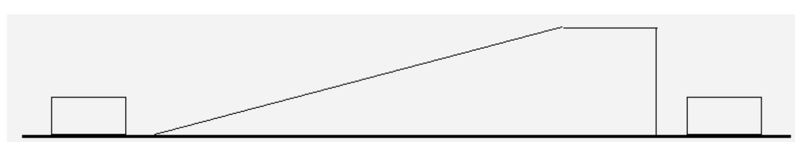
3. A 160.-newton box is pulled to the top of a frictionless ramp at constant speed as shown in the diagram. Calculate the amount of work done.







4. Compare the amount of work needed to get this box to the top of the hill by either lifting it or dragging it up the incline if:

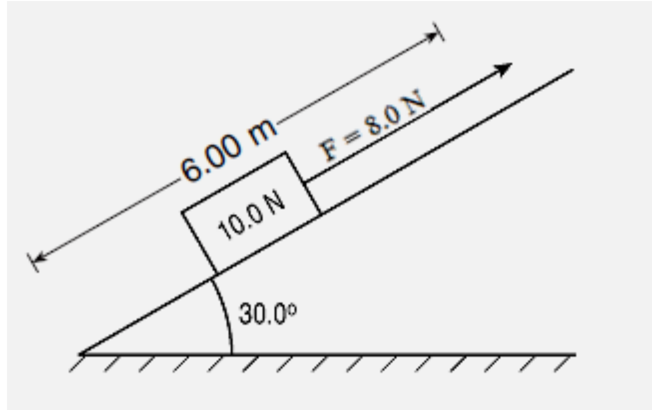


a) the incline is frictionless

b) the incline is not frictionless

Path Independent:

5. An 8.0 newton force is used to pull a 10.0 newton box 6.00 meters up a rough hill at constant speed as shown in the diagram.



a) How much work was done pulling the box up the hill?

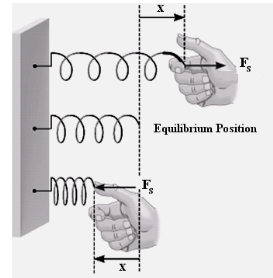
b) How much work was done overcoming gravity?

c) How much work was done overcoming friction?

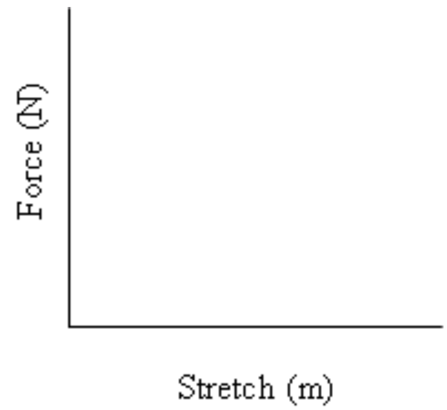
d) How efficient is this process?

Springs

1. Does the force needed to stretch or compress a spring remain constant? Explain.



2. Sketch the expected relationship on the axes at right.



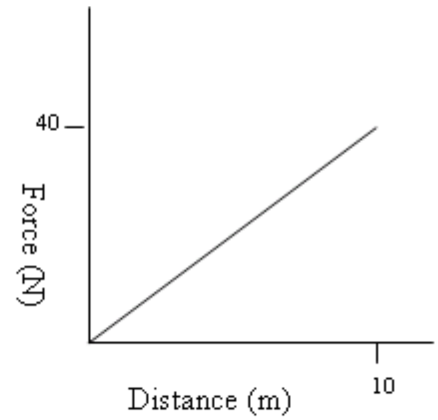
3. What is the significance of the slope of the graph?

4. Sketch on the graph the relationship for a stiffer spring.

Variable:	F_s	k	x
Quantity:			
Units:			
Type:			

5. If it takes 20. newtons of force to compress a spring 8.0 cm, what is its spring constant?

6. The graph at right shows the amount of force needed to stretch a bungee cord a certain distance. Calculate:



a) the spring constant of the bungee cord.

b) the amount of work needed to stretch the bungee cord 10. meters.

NOTE:

c) the area under the curve.

NOTE:

7. How much work is done stretching a spring 0.50 meter if the spring constant is 40. N/m?

Energy

Identify the types of energy displayed in the pictures below, using the concept tree provided.

A

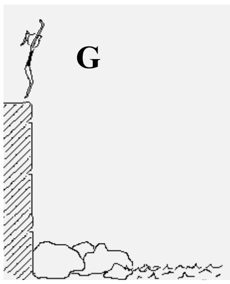

B


C

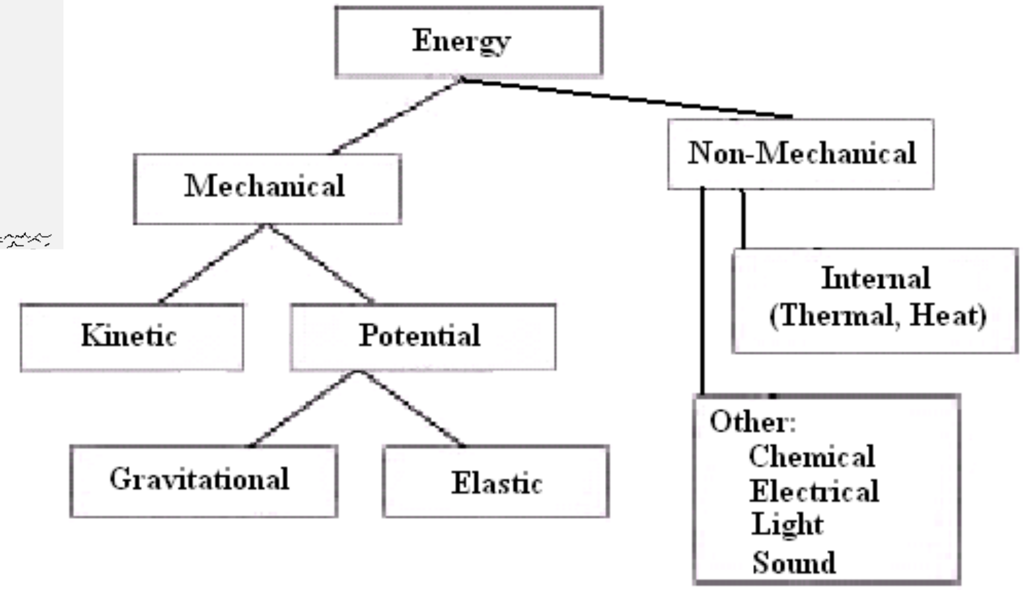

D


E


F


G


H

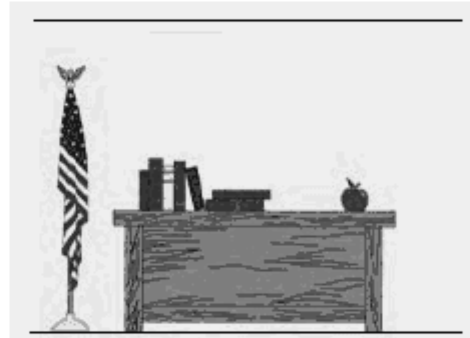



Variable	KE	PE_g	PE_S	Q
Quantity				
Characteristic				
Formula				
Units				
Type				

Mechanical Energy:

Total Energy:

1. a) Estimate the gravitational potential energy of this apple.



Base level (Reference Level, Zero Level):

b) Does PE_g depend on the choice of a base level?

c) When does an object have:

i) Positive PE_g?

ii) Zero PE_g?

iii) Negative PE_g?

d) Does the change in potential energy (ΔPE_g)depend on the choice of a base level?

2. A 900. kilogram car drives off the edge of a 45 meter high cliff at a speed of 25 meters per second. How much energy does the car have at this point?

3. A runner has 800 joules of kinetic energy. If he doubles his speed, how much kinetic energy does he now have?

4. A spring whose spring constant is 125 newtons per meter is compressed 0.50 meter.

   a) Determine how much energy is stored in the spring.

   b) How much force was needed to compress the spring?

5. Sketch the following relationships:

PE_g vs. mass

PE_g vs. speed

KE vs. speed

PE_S vs. stretch

PE_g vs. height

KE vs. mass

PE_S vs. spring constant

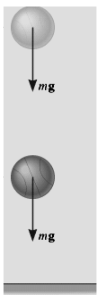
F_S vs. stretch

Conservation of Energy

Transformation:

Transfer:

Describe the energy transformations and energy transfers in each example below:

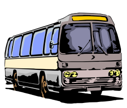


1) Basketball is dropped

Transformation: Transfer:

2) Arrow is shot by archer

Transformation: Transfer:



3) Bus skids to a halt

Transformation: Transfer:

4) Light bulb is lit

Transformation: Transfer:

Conservation of Energy Principle

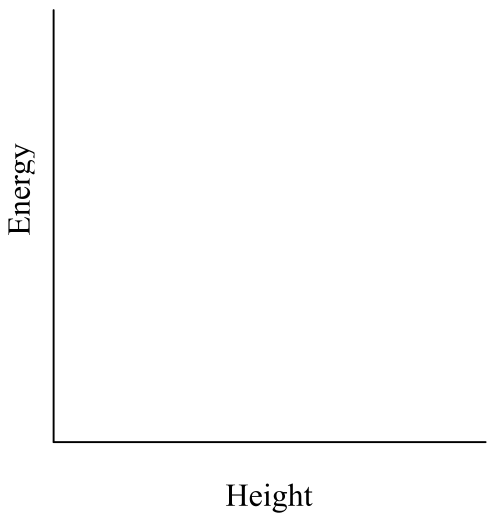
Meaning:

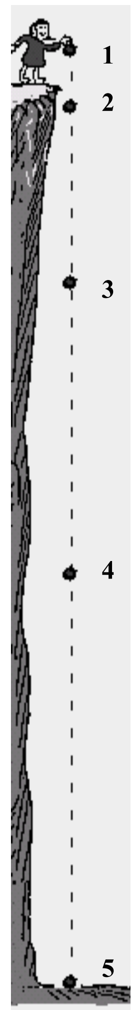
Isolated system:

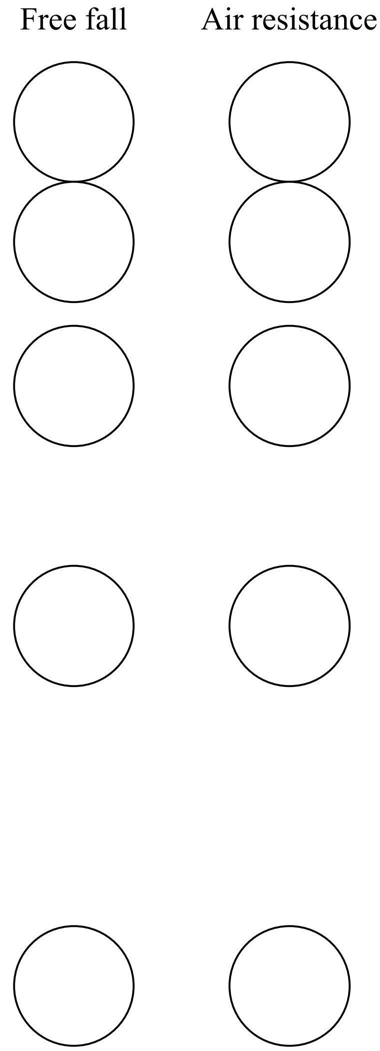
Conservation of Energy

1. a) A student drops a ball from the edge of a cliff. Each snapshot shows where the ball is at the end of each 1.0 second of free fall. Fill in a pie-chart showing the relative amounts of each type of energy the ball has in each snapshot. Neglect air resistance.

   b) Sketch graphs of the kinetic energy, gravitational potential energy, and total energy of the ball as a function of its height above the ground.







   c) Make a statement about the gravitational potential energy and the kinetic energy of the ball as it falls.

   d) Make a statement about the total energy of the ball as it falls.

   e) Discuss the energy of the ball if air resistance is not neglected.

   f) Complete the pie charts above for the case in which air resistance is NOT negligible.

Conservation of Energy Formula:

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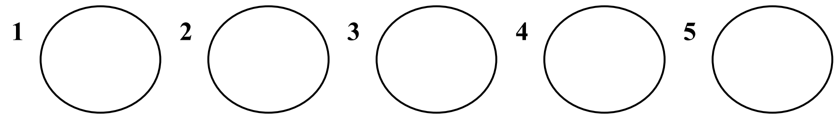
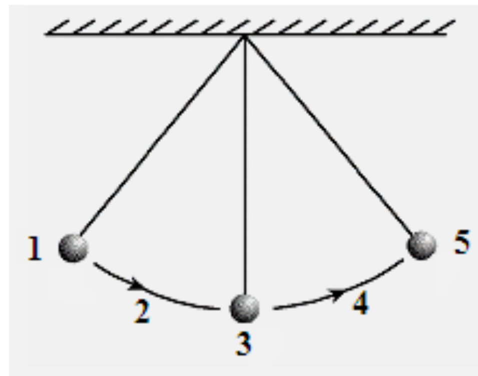
2. A pendulum starts from rest at position 1 and swings freely back and forth.



a) Complete the energy pie charts.

b) A student braves the "bowling ball of death" by releasing it at their nose level. Estimate the speed of the ball at its lowest level.



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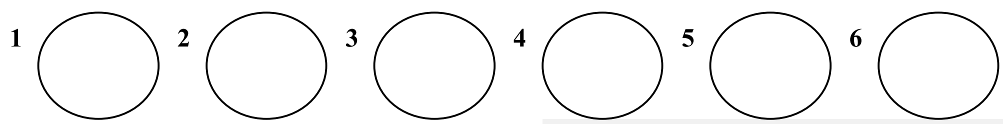
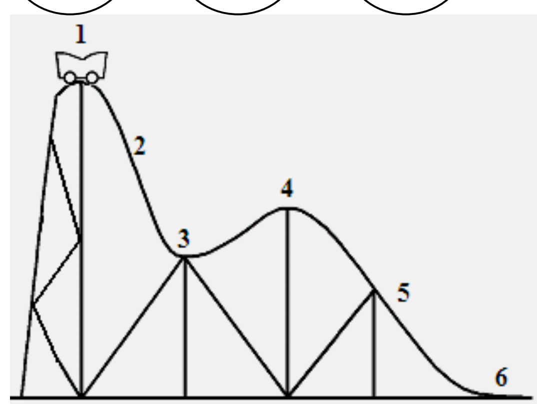
3. A rollercoaster starts from rest and rolls freely downhill, neglecting friction.



a) Complete the energy pie charts.

b) A 750. kg car starts at the top of the 45 meter high first hill and rolls downhill. Calculate how fast it is traveling at position 4 which is 30 meters high..

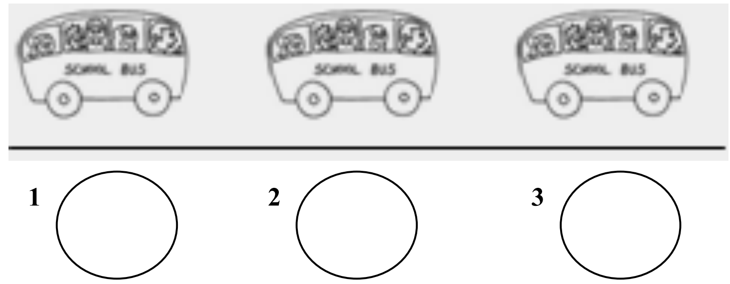


c) Where will the car be traveling the fastest? Why?

4. A moving bus screeches to a halt as the driver slams on the brakes.

   a) Complete the energy pie charts.

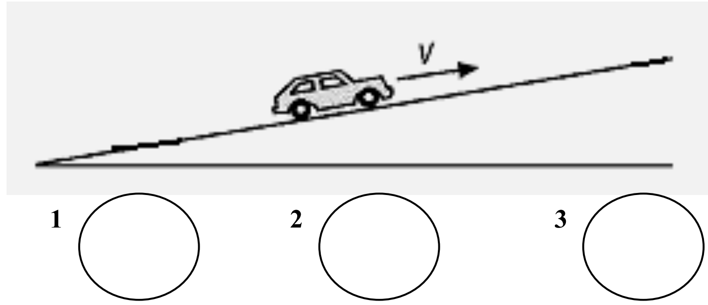
   b) A 5000 kilogram bus traveling at 27 meters per second skids to a stop. How much energy is transformed into internal energy due to friction?



5. a) If the archer pulls back the bowstring 25 centimeters, how fast will the 0.020 kilogram arrow be traveling when it is shot? The bow has a spring constant of 150 newtons per meter.

   b) If the arrow were shot straight up, how high would it go?

6. A car climbing a hill at a steady speed.
   Complete the energy pie charts.



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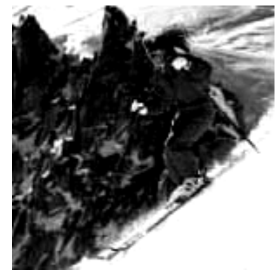
7. A 60. kg skier moving at 5.0 meters per second skis down a hill 45 meters high. If her speed at the bottom of the hill is 20. meters per second, how much energy was lost due to friction? Where did this energy go?



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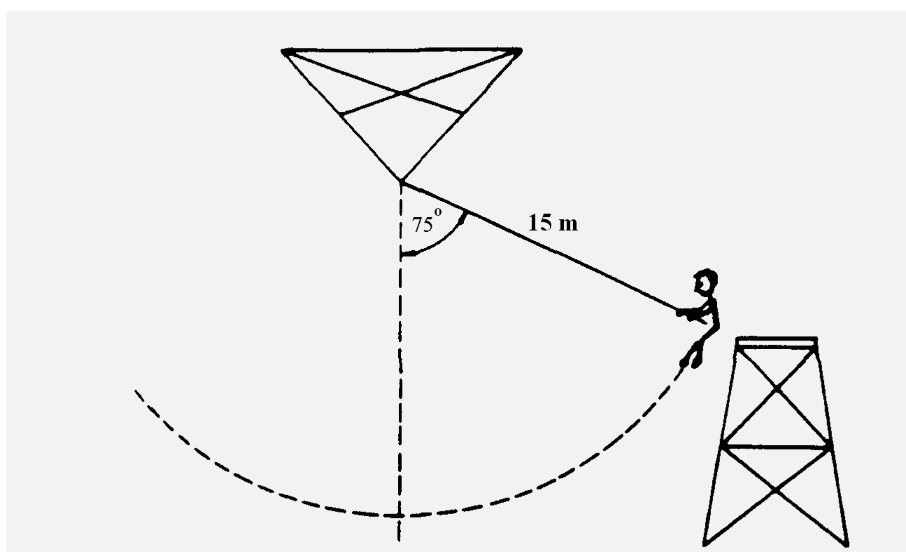
8. A daredevil student jumps off a platform as shown. Determine the speed of the student at the lowest point in the swing.



Demo 1	Demo 2	Demo 3	Demo 4

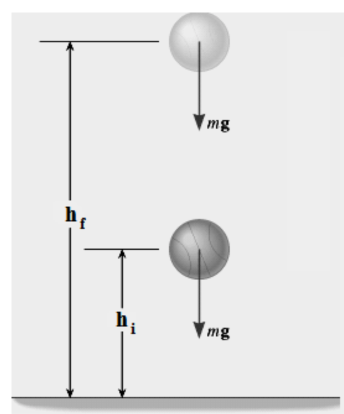
Was energy created in each of the demos above? Explain.

Work-Energy Theorem:

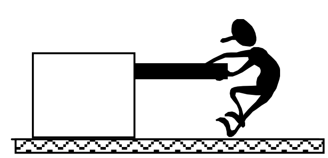
Formula:

Derivation of Energy Formulas

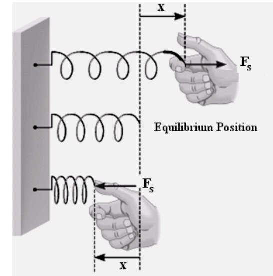
I. Gravitational Potential Energy



II. Kinetic Energy



III. Elastic Potential Energy



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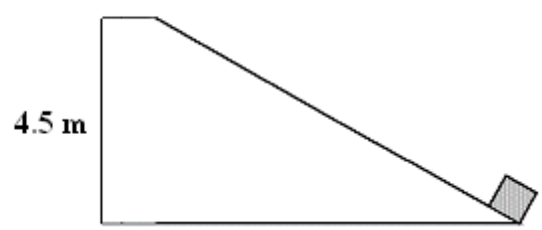
1. A 25 kilogram object is accelerated from rest to a speed of 12 meters per second by a force of 65 newtons. How much work is done by the force?

2. A 5.0 kilogram block slides from rest down a hill with a rough surface. When it reaches the bottom, it has 150 J of kinetic energy. How much work was done overcoming friction as it slid?



3. A 3.0 kg ball is dropped from a height of 10. m. How fast is it going when it hits the ground? Assume an average air resistance force of 20. N acts on the ball as it falls.

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4. A 5.0 kg box is sliding across a rough surface at 2.0 m/s and is brought to rest in 0.40 m. How much work is done by friction in stopping the box? Calculate the force of friction.

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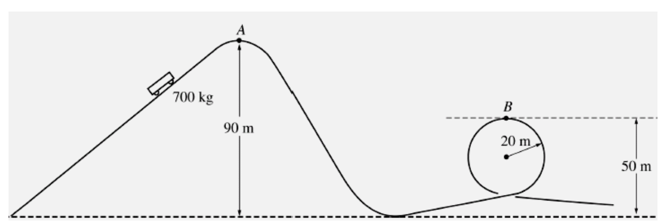
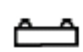
1. A roller coaster ride at an amusement park lifts a car of mass 700 kg to point A at a height of 90 m above the lowest point on the track, as shown above. The car starts from rest at point A, rolls with negligible friction down the incline and follows the track around a loop of radius 20 m. Point B, the highest point on the loop, is at a height of 50 m above the lowest point on the track.



a) Determine the speed of the car at the bottom of the first hill.

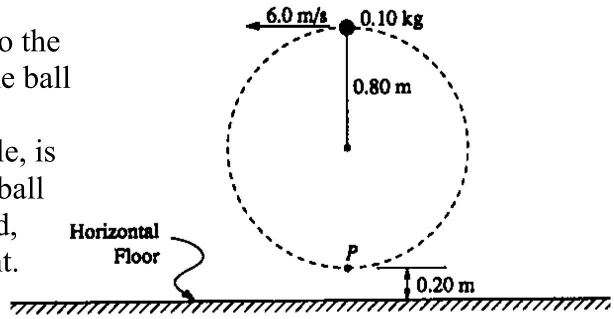
b) Calculate the speed of the car at point B.



c) Calculate the force the track exerts on the car when it is upside down at point B.

Additional Problems

2. A 0.10-kilogram solid rubber ball is attached to the end of a 0.80-meter length of light thread. The ball is swung in a vertical circle, as shown in the diagram. Point ***P***, the lowest point of the circle, is 0.20 meter above the floor. The speed of the ball at the top of the circle is 6.0 meters per second, and the total energy of the ball is kept constant.



a) Determine the total energy of the ball, using the floor as the zero point for gravitational potential energy.

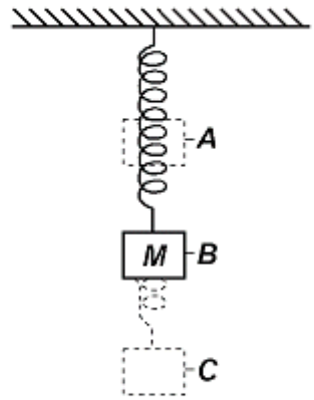
b) Determine the speed of the ball at point ***P***, the lowest point of the circle.

c) Determine the tension in the thread at

i) the top of the circle.

ii) the bottom of the circle.

Mass on a Spring



6. What factors influence the period of a mass bobbing up and down on a spring?

7. Which position is the equilibrium position?

8. At what position(s) is the speed of the mass zero?

9. Where is the mass moving the fastest?

10. Where does the mass have the most potential energy?