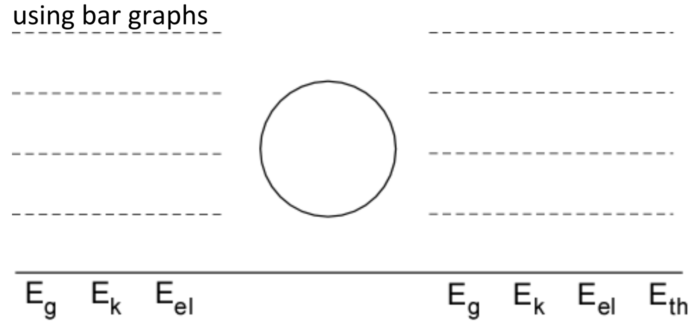
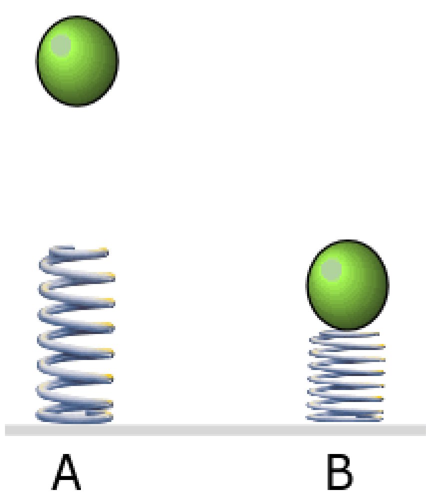
Practice 6.4. Energy Bar Graphs I

1. You have the following situation: a rope pulls a skier, initially at rest, up a hill with no friction. Initial state: a skier is at rest at the bottom of a hill. Final state: the skier is moving at moderate speed at the top of the hill.

System: include the skier and Earth, but exclude the rope pulling on the skier.

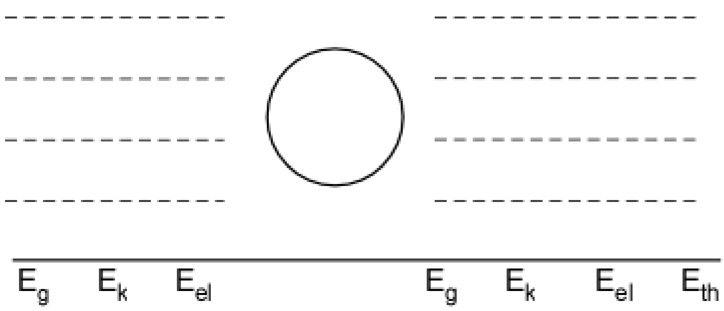
a) Draw a sketch showing the initial and final states	c) Analyze the energy transfers and transformations using bar graphs 
b) what type of system is it ? (circle one) closed open	d) Analyze the energy transfers and transformations using pie charts.

2. A ball is dropped (initial velocity is zero) from a certain height onto a vertical spring that is initially uncompressed. Ignore air resistance.

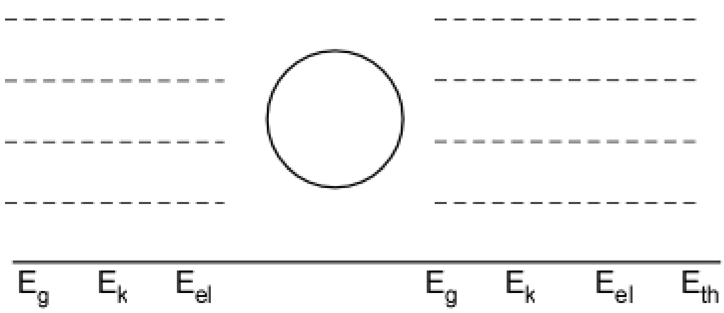
 	Initial state A: ball is dropped from a certain height (just before the ball starts moving) Final state B: the spring is fully compressed and the ball is not moving anymore

On the diagrams provided below, draw energy bar graphs for the following chosen systems and write the law of conservation of energy using an equation:

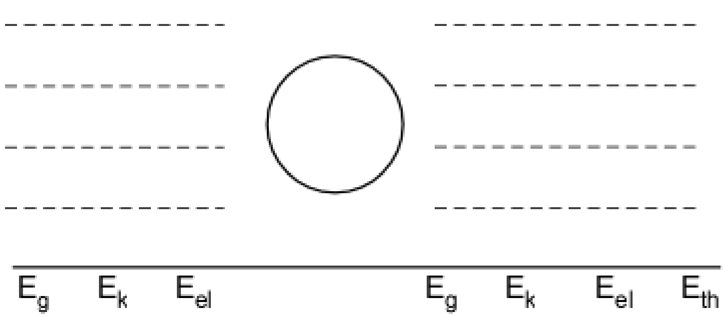
a) ball + spring + earth



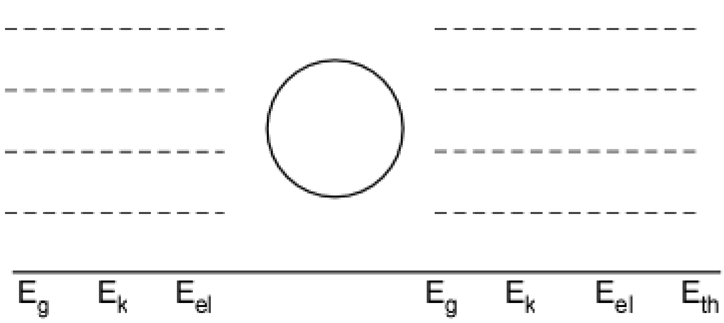
b) ball + spring



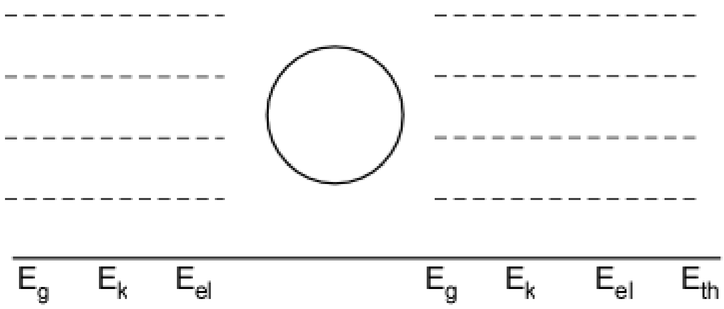
c) ball + earth only



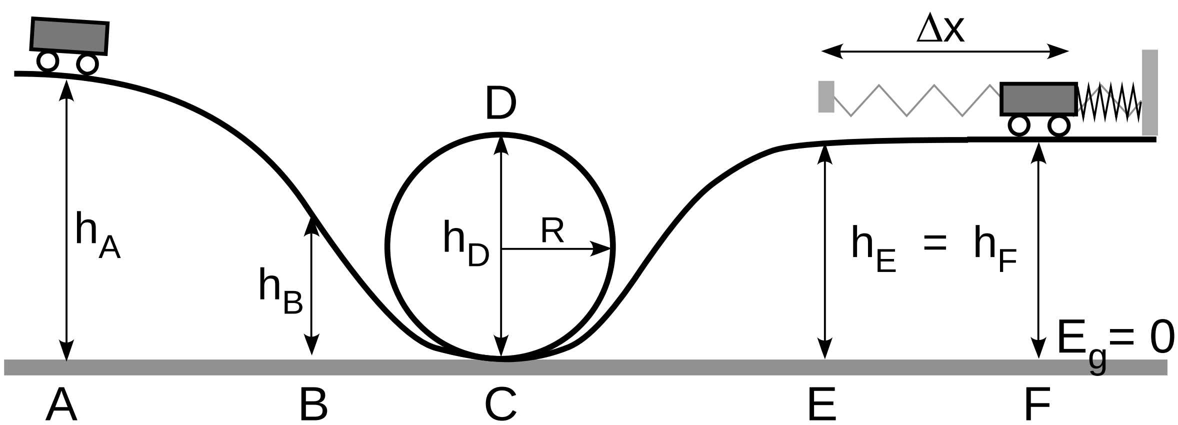
d) ball only



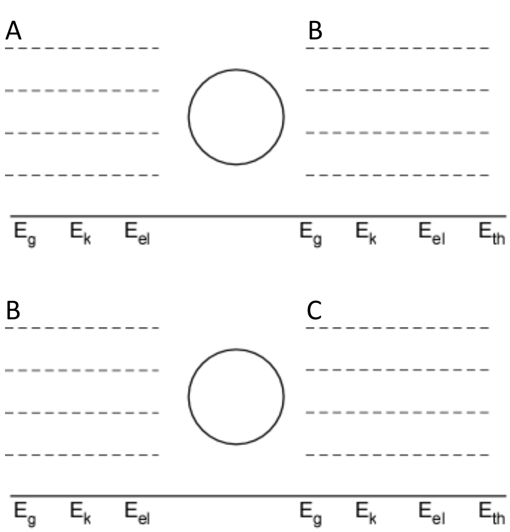
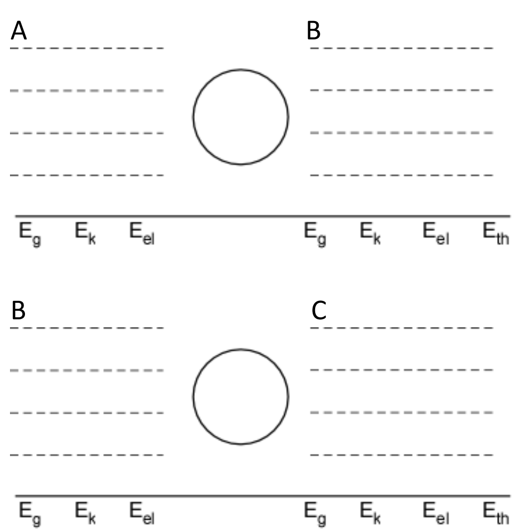
e) spring only

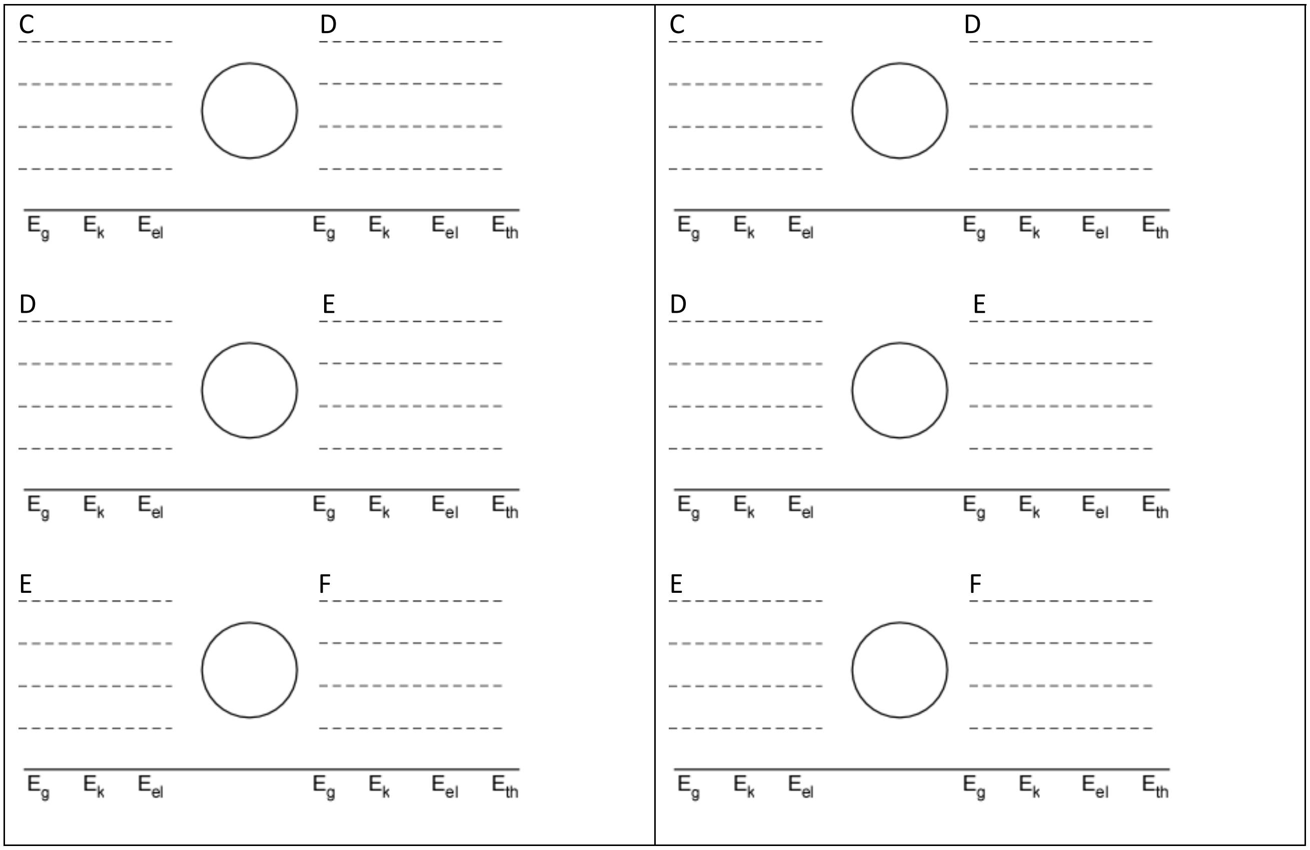


4. A rollercoaster car starts from rest from the top of a very high hill as shown in the figure below.

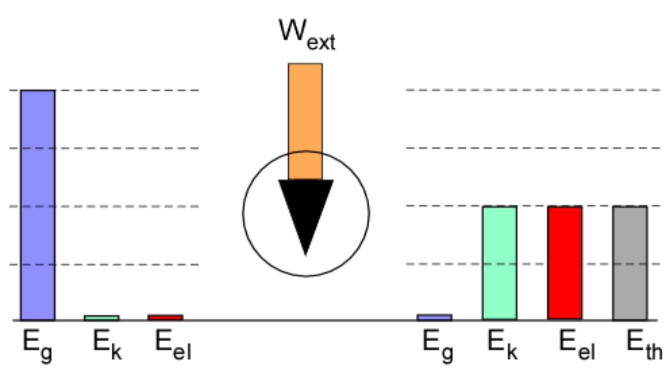


After exiting the loop-the-loop, the car goes up a second (smaller) hill where it encounters a spring that when fully compressed brings the car at a stop. On the diagrams provided below draw energy bar graphs for positions A, B, C, D, E, and F when the system is:

a) car + earth + ground + spring and there is no friction or air resistance. 	b) car + earth + spring and there is friction between the car and the ground. 



5. Below you are given an energy bar chart for a process. Describe a situation that would fit the energy bar graphs, and then sketch a process (including the system, its initial and final state). There are many possible choices.



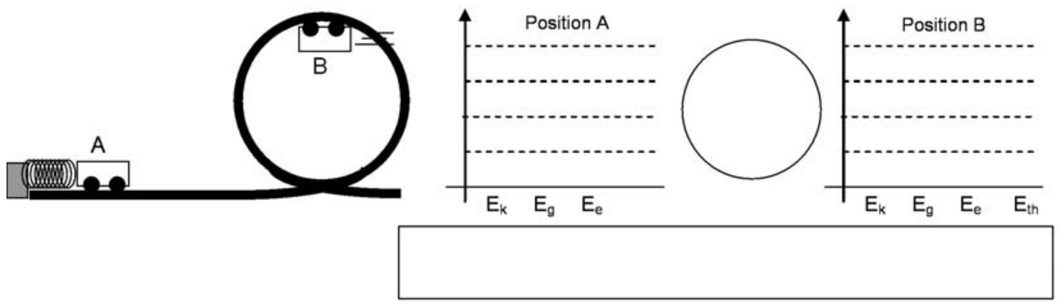
Practice 6.5. Energy Bar Graphs II

Note: Use this practice for honors classes

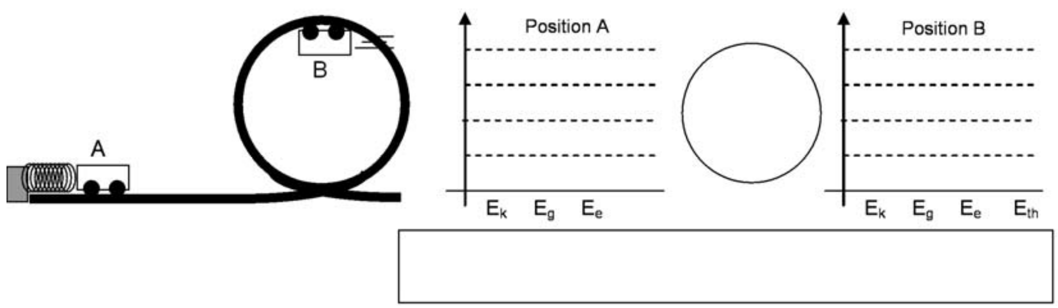
For each situation shown below:

a) Underline/highlight/circle the system in question. (Always include the earth in your system).
b) Show your choice of zero point for the gravitational potential energy.
c) Label initial and final positions on the picture provided.
d) Complete the energy bar graphs for position A, the energy flow diagram from position A to position B, and the energy bar graphs for position B.
e) Write the energy equation in the box provided.

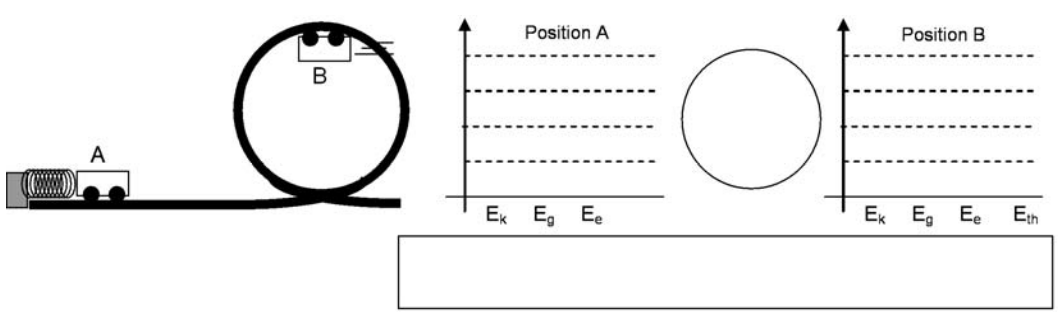
1. In the situation shown below, a spring launches a roller coaster cart from rest on a frictionless track into a vertical loop. Assume the system consists of the cart, the earth, the track, and the spring,



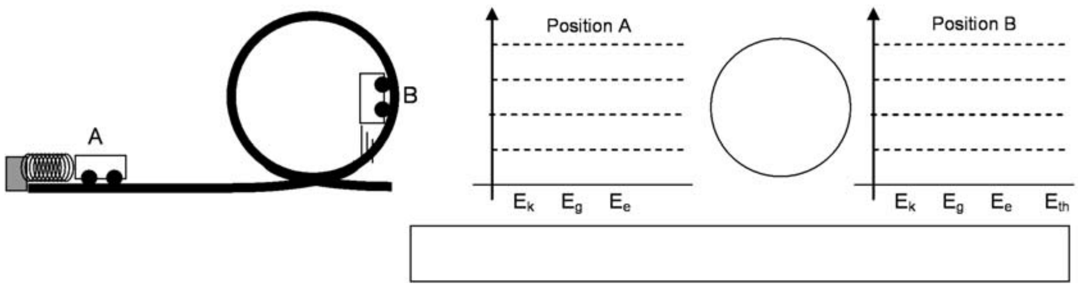
2. Repeat problem 1 for a frictionless system which includes the cart, the earth, and the track, but not the spring.



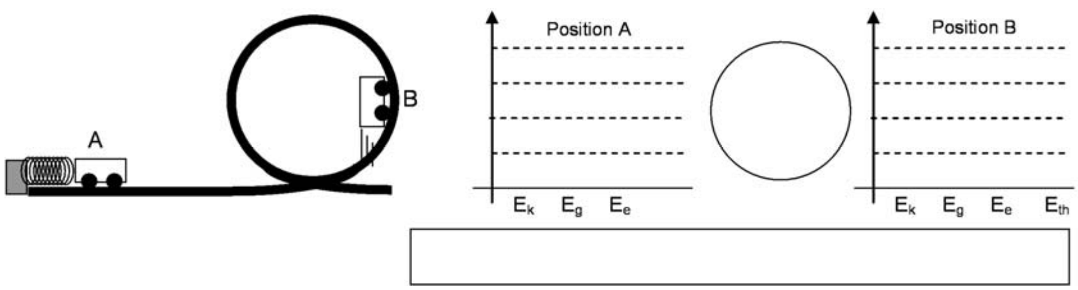
3. Repeat problem 1 for the same system, but assume that there is friction between the cart and the track.



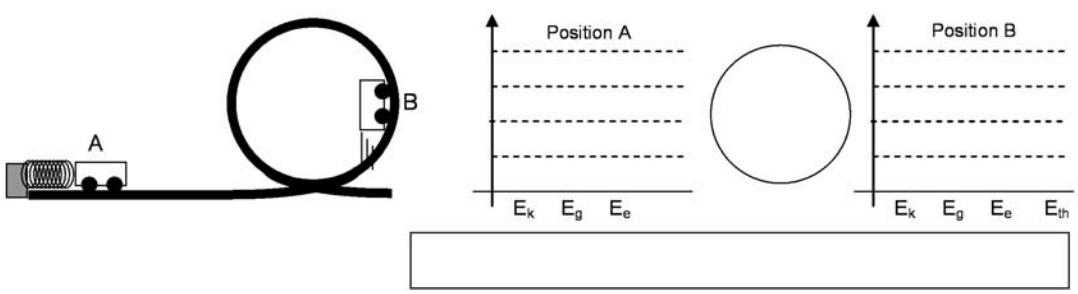
4. This situation is the same as problem 1 except that the final position of the cart is lower on the track. Make sure your bars are scaled consistently between problem 1 and 4. Assume the system consists of the cart, the earth, the track, and the spring.



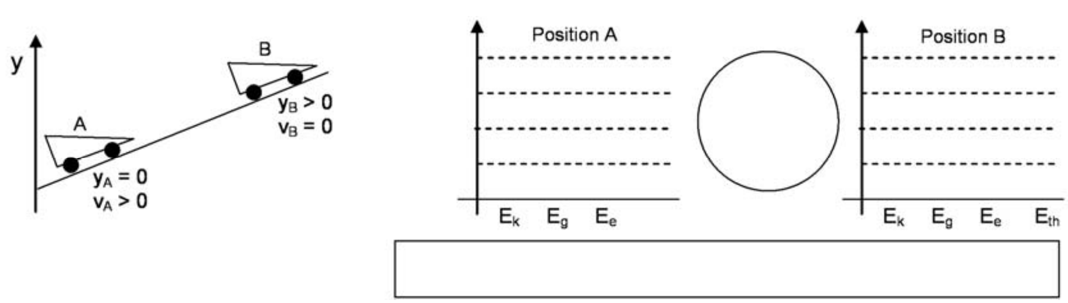
5. Repeat problem 4 for a frictionless system which includes the cart, the earth, and the track, but not the spring.



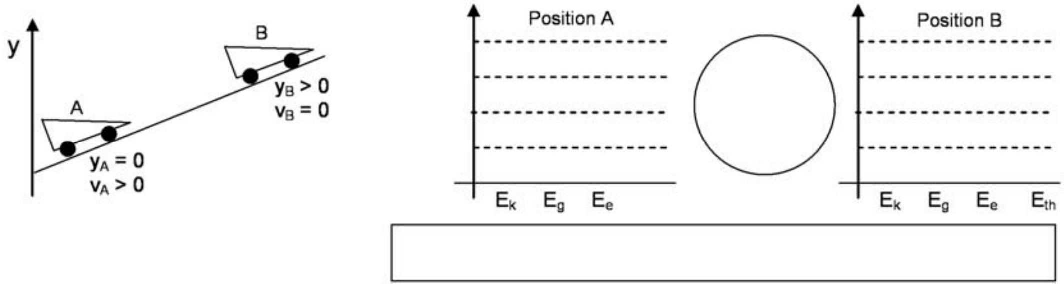
6. Repeat problem 4 for the same system, but assume that there is friction between the cart and the track.



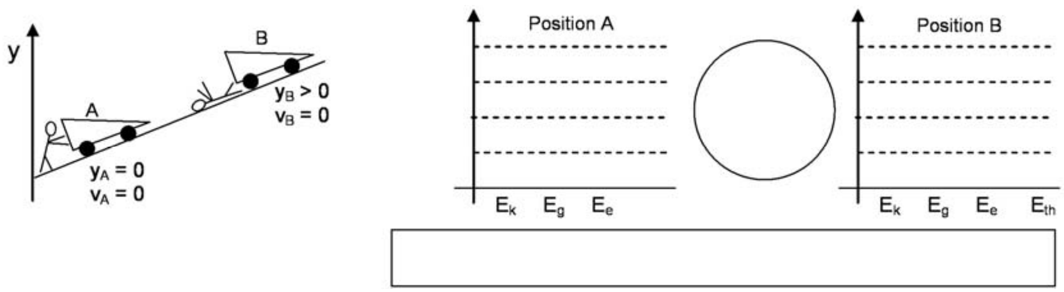
7. A moving car rolls up a hill until it stops Do this problem for a system that consists of the car, the road, and the earth. Assume that the engine is turned off, the car is in neutral, and there is no friction.



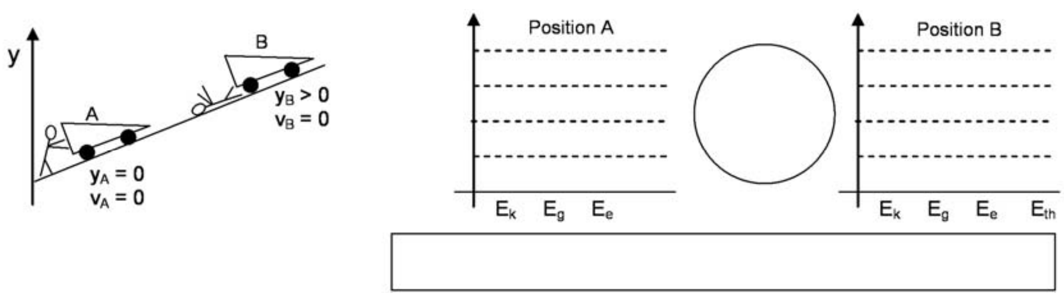
8. Repeat problem 7 for the same system with friction.



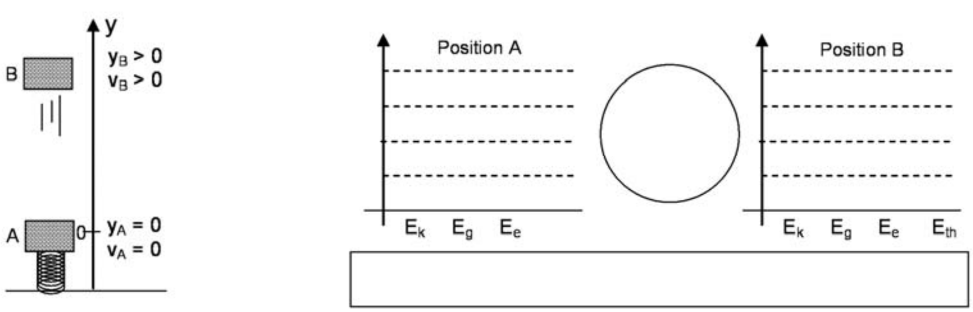
9. A person pushes a car, with the parking brake on, up a hill. Assume a system that includes the car, the road, and the earth, but does not include the person.



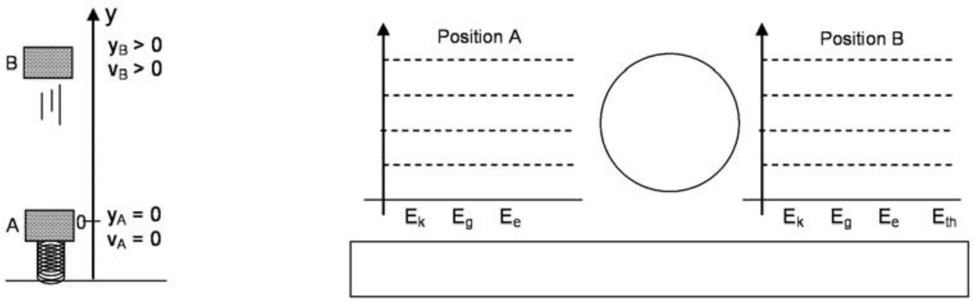
10. Repeat problem 9 for a system that does not include the earth. Think carefully about the energies in your system.



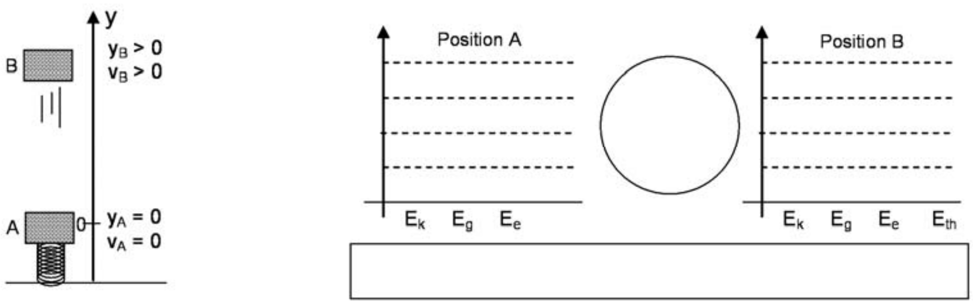
11. A load of bricks rests on a tightly coiled spring, then is launched into the air. Assume a system that includes the spring, the bricks and the earth. Do this problem without friction.



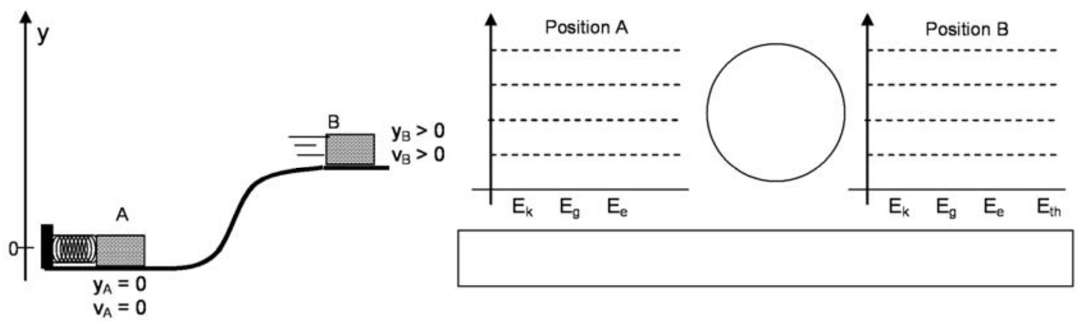
12. Repeat problem 11 with friction.



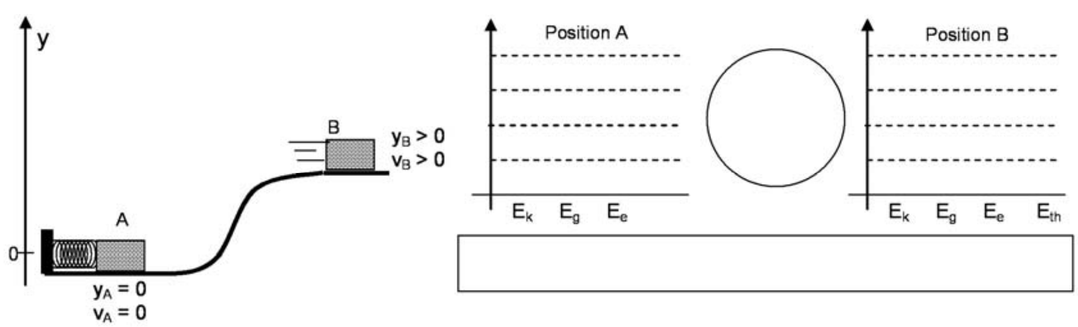
13. Repeat problem 11 for a system that does not include the spring.



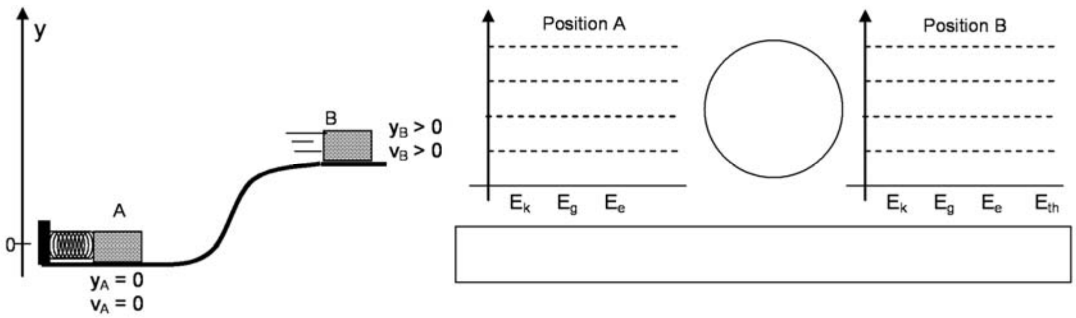
14. A crate is propelled up a hill by a tightly coiled spring. Analyze this situation for a frictionless system that includes the spring, the hill, the crate, and the earth.



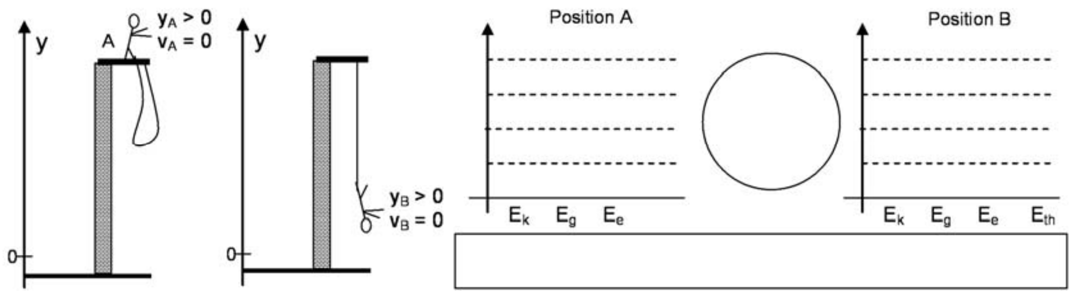
15. Repeat problem 14 with friction.



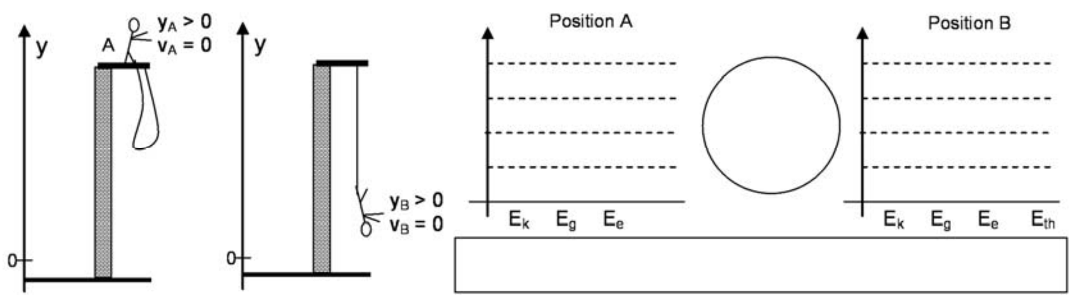
16. Repeat problem 14 for a system that does not include the spring.



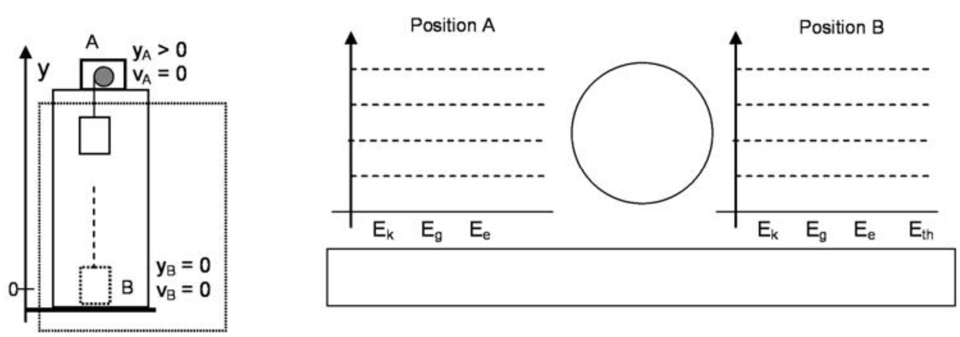
17. A bungee jumper falls off the platform and reaches the limit of stretch of the cord. Analyze this situation for a frictionless system that consists of the jumper, the earth, and the cord.



18. Repeat problem 17 if the cord is not part of the system. Make your own bar graphs.

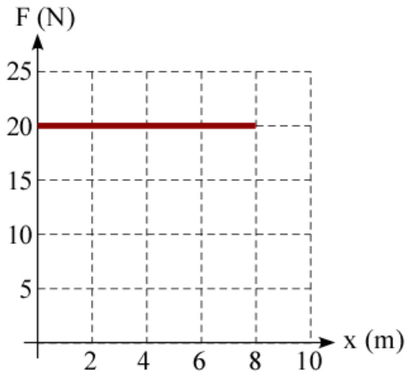
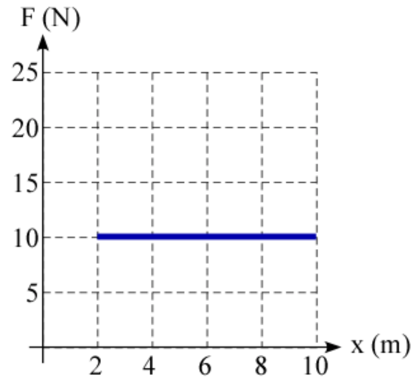
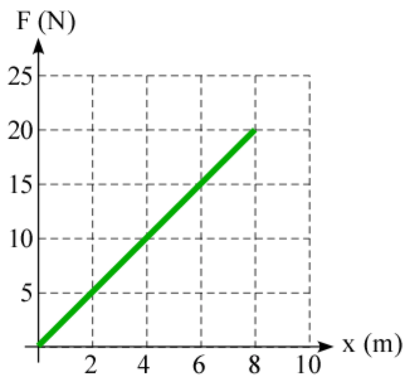
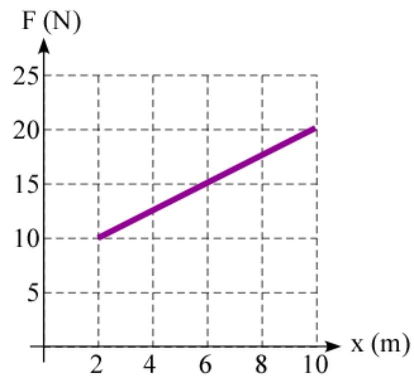


19. An elevator, initially at rest, begins to move and is then brought to rest as it reaches the ground floor. The system consists of everything within the "system boundary" rectangle shown in the diagram.

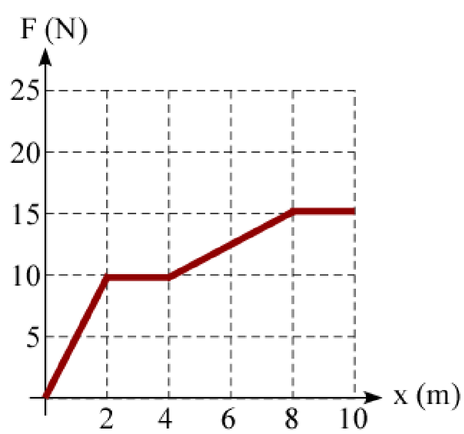


Practice 6.6. Calculating Work

1. Calculate the work done by each of the forces represented graphically below.

A	B
	
W =	W =
C	D
	
W =	W =

2. Jimmy is trying to move a very heavy box. He cannot push with a constant force continuously. The force applied by Jimmy to move the box is given as a function of the box's position in the graph below. Calculate the work done by Jimmy when pushing the box
   a) the first 2 meters.
   b) the first 4 meters
   c) from x = 4 m to x = 8 m
   d) the entire distance, Δx = 10 meters.



3. For each situation described below
   a) Draw a before and after diagram (initial and final state) for the system.
   b) Identify all the forces acting on it.
   c) Determine if work done by these forces is positive, negative or zero.

A. An elevator moving upward.	B. An elevator moving downward.
C. You push a heavy box across a rough floor.	D. You drag a heavy chair across a rough floor.
E. You slide down a hill.	F. A ball is thrown straight upward. Consider the ball after it left your hand until it reached its maximum height.

4. Will is pulling on a box of mass 2 kg with a constant horizontal force of 20 N. As a result, the box moves a horizontal distance of 10 m. Consider that there is no friction between the box and the surface.
   a) Make a before and after drawing of your problem and identify all the forces acting on the box.

   b) Calculate the work done by Will on the box.

   c) Calculate the work done by the earth on the box.

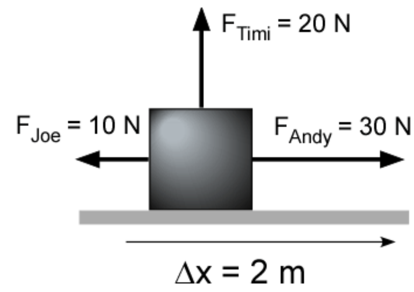
5. A 0.3 kg rock is falling through the air from a height of 10 m. Neglect air friction.
   a) Make a before and after drawing of your problem.

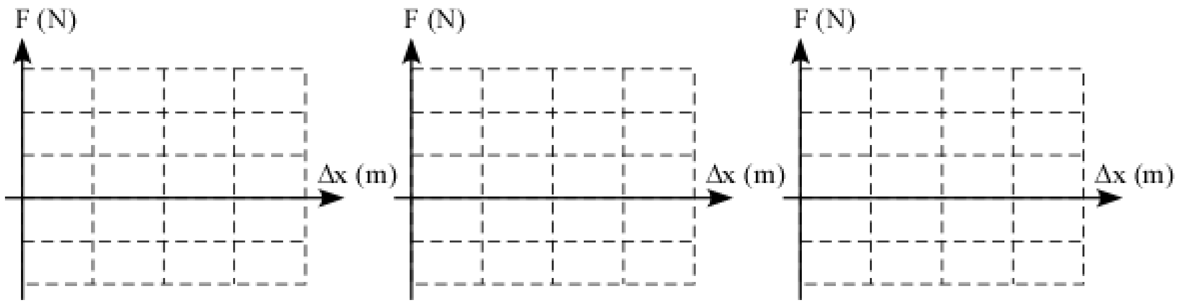
   b) What forces act on the rock?

   c) Make a graph of the net force acting on the rock as a function of its height. In one case choose the positive direction of motion vertically upward and in the other case vertically downward.

   d) Calculate the net work done on the rock using both graphs. Explain your answers.

6. A very heavy box is resting on a frictionless floor. Andy, Joe and Timi decide to try and move the box. Each one of them applies a force as shown in the diagram below. Under the combined action of these forces, the box moves 2 m to the right.
   a) Draw a force vs displacement graph for each one of the three applied forces on the graphs provided below.





   b) Calculate the work done by each force.

   c) Calculate the total work done on the box (sum of all work done by all forces).

7. Joe is rearranging the furniture in his room. He wants to move his desk from one corner of the room to another. He pushes with a constant horizontal force of 50 N on the desk and moves it a horizontal distance of 8 m. Then he realizes he does not like how the desk looks like on that corner and pushes it back with the same constant force toward the other corner but only half way, because he got tired. Draw a graph of F (force applied by Joe) vs x and calculate the work done by Joe in moving his desk.

8. Bill is playing with a 0.4 kg ball; he throws the ball up in the air from a height of 1 m. The ball reaches a maximum height of 15 m and then it starts falling back towards the ground.
   a) Draw energy bar graph diagrams for the ball + Earth system at the following positions: after the ball just leaves Bill's hand, the ball moves upward and it reaches half of its height, the ball is at the maximum height, the ball moves downward just before it hits the ground .
   b) Draw an F vs y graph and calculate the net work done by the force of gravity on the ball from the moment Bill throws it in the air till the moment the ball hits the ground.

9. Timi and Andy have a tug-of-war over a 0.5 kg box of chocolates found on a horizontal table with no friction. Andy is pulling on the box with a force of 10 N to the right and Timi is pulling on the box with a force of 12 N to the left.
   a) In which direction is the box moving?
   b) What is the resultant force acting on the box?
   c) What is the acceleration of the box?
   d) What distance is the box moving in 5 seconds?
   e) What is the work done by Andy on the box? (use two different ways to calculate).
   f) What is the work done by Timi on the box? use two different ways to calculate).
   g) What is the total work done on the box? (use two different ways to calculate).

Practice 6.7. Work and Gravitational Potential Energy

Problem 1

Will is pulling on a box of mass 2 kg with a constant horizontal force of 20 N of a frictionless horizontal surface. As a result, the box moves a horizontal distance of 10 m, from position A to position B.

a) Make a drawing of your problem for your system (box only) in states A and B and identify all the forces acting on the box only in each state.

b) Is there a net force acting on the box? If yes, what is the direction of this force? Explain how you found it.

c) Calculate the work done by the force Will applies to the box.

d) Calculate the work done by the force of gravity (applied by the Earth) on the box.

e) Calculate the work done by the normal force (applied by the ground) on the box.

f) Calculate the work done by the net force acting on the box. Hint: this work is also called “net work” or “sum of all work done by all forces acting on the object”.

g) Consider that your system is made up of the box and earth. Draw a bar graph for the system.

h) Is there energy transfer in or out of your system?

i) What is the total energy of your system made up of in state A?

j) What is the total energy of your system made up of in state B?

k) What happens to the total energy of your system from state A to state B?

l) Using your bar graph, write the mathematical expression for the conservation of energy for your system.

m) By how much did the total energy of your system change when going from state A to state B? Give a numerical answer.

Problem 2

A 0.3 kg rock is dropped from a height of 10 m (state A) and is falling through air (with no air resistance) until it just hits the ground (state B). Take g = 10 m/s^2.

a) Make a drawing of your problem for your system (rock only) for states A and B. Make sure you draw all the forces acting on the rock.

b) What is the net force acting on the rock?

c) Calculate the net force acting on the rock.

d) Calculate the work done by the net force acting on the rock.

e) Draw a bar graph for your system (rock only) in state A and state B.

f) Is there energy transfer in or out of your system?

g) What is the total energy of your system made up of in state A?

h) What is the total energy of your system made up of in state B?

i) What happens to the total energy of your system from state A to state B?

j) Using your bar graph, write the mathematical expression for the conservation of energy for your system.

k) By how much did the total energy of your system change when going from state A to state B? Give a numerical answer.

l) What is the kinetic energy of your system when the rock hits the ground?

m) Now consider that your system is made up of the rock and Earth. Draw a bar graph for your system going from state A to state B.

n) Is there energy transfer in or out of your system?

o) What is the total energy of your system made up of in state A?

p) What is the total energy of your system made up of in state B?

q) What happens to the total energy of your system from state A to state B?

r) Using your bar graph, write the mathematical expression for the conservation of energy for your system.

s) What is the total energy of your system in state B? Give a numerical answer.

t) What is the gravitational potential energy of your system in state A? Give a numerical answer.

u) What is the gravitational potential energy of your system in state B?

v) How does the change in gravitational potential energy compare with the work done by the force of gravity?

Problem 3

A block of mass m = 2 kg is pulled up an inclined frictionless plane by a constant force F = 16 N such that the block is moving with constant speed from position A to position B. The distance traveled by the box along the inclined plane from point A to point B is 5 m, and the change in height from point A to point B is 4 m. Take g = 10 m/s2.

a. Make a drawing of your problem for your system (block only) for states A and B. Make sure you draw all the forces acting on the block

b. What is the net force acting on the block?

c. Calculate the work done by the applied force F on the block.

b) Calculate the work done by the normal force on the block. Justify your answer.

c) Calculate the work done by the force of gravity Fg acting on the block. Justify your answer.

d) Draw a bar graph for your system (block only) in state A and state B.

e) Is there energy transfer in or out of your system?

f) What is the total energy of your system made up of in state A?

g) What is the total energy of your system made up of in state B?

h) What happens to the total energy of your system from state A to state B?

i) Using your bar graph, write the mathematical expression for the conservation of energy for your system.

j) By how much did the total energy of your system change when going from state A to state B?

k) Now select your system to be block and earth. Draw a bar graph for your system in state A and state B.

l) Is there energy transfer in or out of your system?

m) What is the total energy of your system made up of in state A?

n) What is the total energy of your system made up of in state B?

o) What happens to the total energy of your system from state A to state B?

p) Using your bar graph, write the mathematical expression for the conservation of energy for your system.

q) By how much did the total energy of your system change when going from state A to state B?

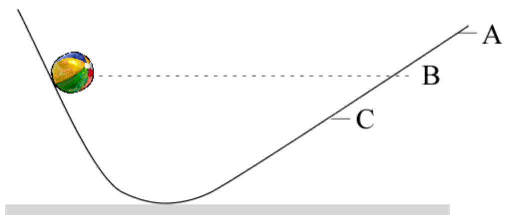
r) What is the gravitational potential energy of your system in state B?

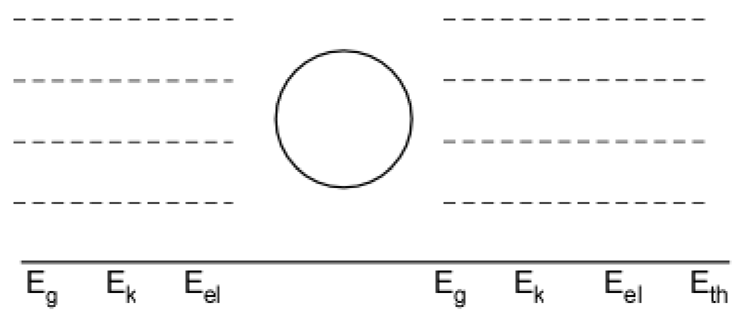
s) Will your answer change if the ramp is made longer or shorter but the height is kept the same? Explain.

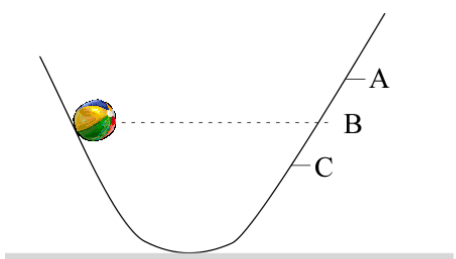
t) How does the change in gravitational potential energy of your system compare with the work done by the gravitational force?

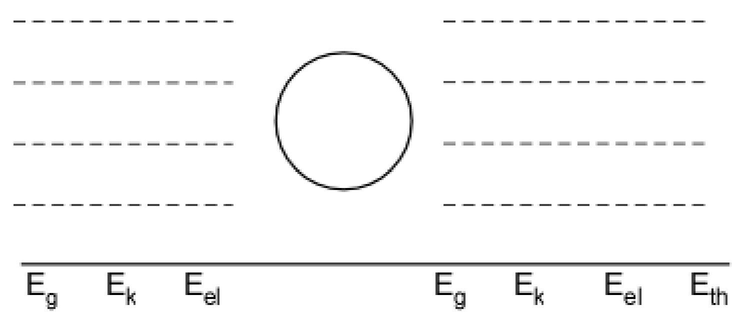
Practice 6.8. Gravitational Potential Energy

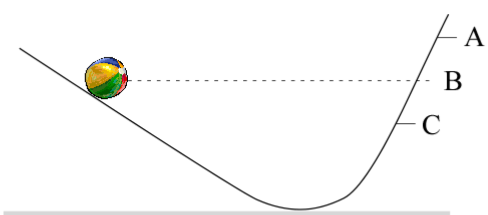
1. Shown below are three frictionless tracks. A ball is released from rest at the position shown on the left. To which point does the ball move on the right before stopping and reversing its motion? Draw an energy bar graph for each case. In every drawing, point B is at the same height with respect to the ground as the release point for the ball, A is above and C is below. Your system is the ball and Earth.

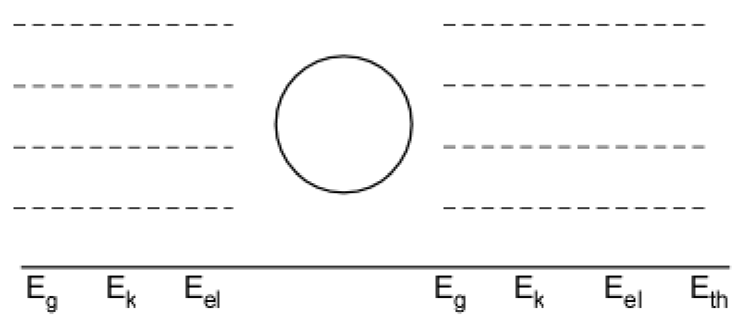






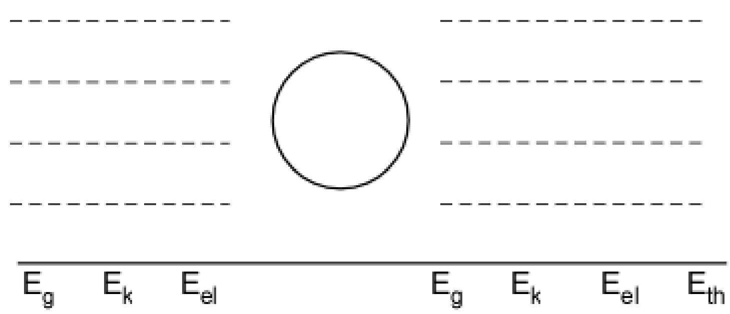






2. Draw energy bar graphs to show the energy transformations for the situations described below.

A. A car runs out of gas and coasts up a hill until finally it stops.



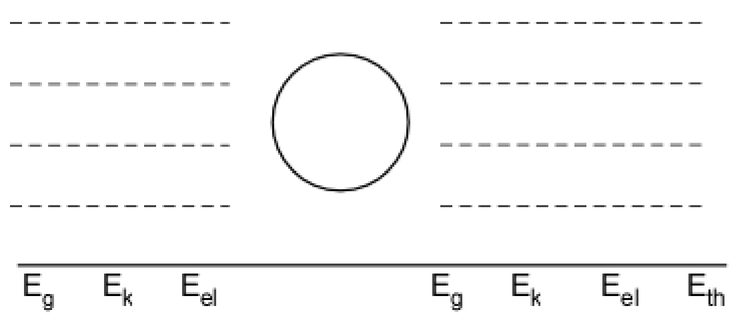
System:

Initial position:

Final position:

Zero of E_g:

B. A pendulum bob is held out horizontally and released from rest. A short time later it swings through its lowest point.



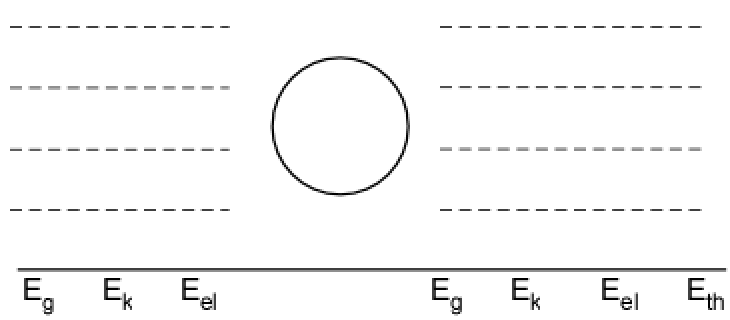
System:

Initial position:

Final position:

Zero of E_g:

C. A sled starts from rest at the top of a snow covered hill, slides without friction through a valley, and just barely makes it to the top of an adjacent hill.



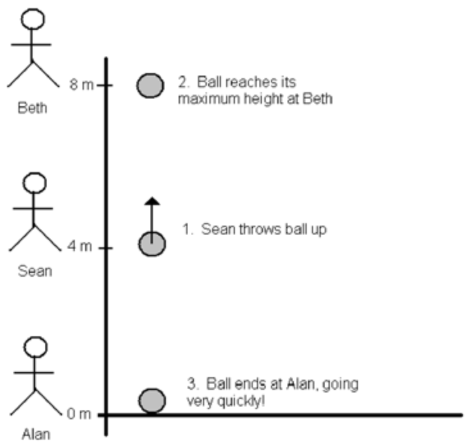
System:

Initial position:

Final position:

Zero of E_g:

3. Sean, Alan, and Beth are preparing for a physics competition. They are all in the same building. They play with a ball: Sean throws a 0.3 kg ball upward from his window which is 4 m above the ground. The ball rises to a height of 8 m, reaching Beth's window, before starting to fall back toward the ground where Alan is. Each one of the three students measures the position of the ball but each uses a different origin for the coordinate system: Sean considers the zero for the gravitational potential energy at the point of release of the ball, Beth considers the zero for the gravitational potential energy at the point of maximum height when the ball reached her window, and Alan considers the zero for the gravitational potential energy on the ground where he was. Each one must calculate the initial (when it was released) and final (just before it hits the ground) gravitational potential energy of the ball, as well as the change in gravitational potential energy.



a) Calculate the gravitational potential energy for the initial (when it was released) and final (just before it hits the ground) state of the ball + earth system and fill in the table below with the data.

	E_g initial	E_g final	ΔE_g
Sean			
Beth			
Alan			

b) Draw qualitative energy bar graphs for the ball + earth system indicating the zero of the gravitational potential energy for Sean, Alan and Beth.

Sean

Alan
Beth

c) What can you conclude about the change in the gravitational potential energy of the ball + earth system? Does it matter where one chooses the zero for the gravitational potential energy?

Practice 6.9. Energy in Springs

1. Students in Ms. Dweik's class and Mr. Steinhoff's class are trying to identify the weakest and the strongest springs in their classrooms. Students in both classes collected the following data for the three springs they had in their classroom:

Ms. Dweik's class

Spring Extension Δx (cm)	Spring 1 Force (N)	Spring 2 Force (N)	Spring 3 Force (N)
0.5	10	50	2
1.0	20	100	4
1.5	30	150	6
2.0	40	200	8
2.5	50	250	10
3.0	60	300	12
3.5	70	350	14

Mr. Steinhoff's class

Spring Extension Δx (cm)	Spring 1 Force (N)	Spring 2 Force (N)	Spring 3 Force (N)
0.5	125	0.3	220
1.0	250	0.6	440
1.5	375	0.9	660
2.0	500	1.2	880
2.5	625	1.5	1100
3.0	750	1.8	1320
3.5	875	2.1	1540

Using the data from the table:

a) Determine which spring is the strongest and which one is the weakest in each classroom. Which class has the strongest spring? Which class has the weakest spring? How do you know?

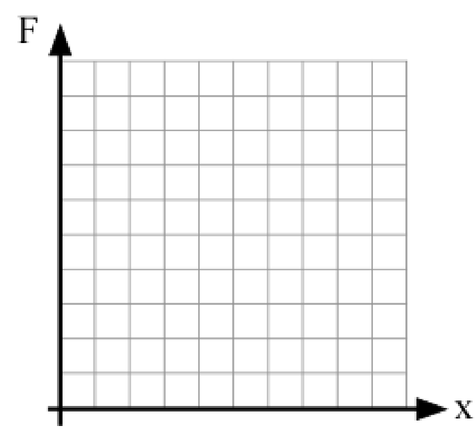
b) Calculate the spring constant for each spring (explain how you calculated it, either mathematically or from a graph).

c) Calculate how much energy can be stored in spring 2 (for each class) when stretched 1.2 cm.

d) Calculate how much energy is required to stretch spring 2 (in each class) an additional 1.2 cm. Explain your answer.

2. Hannah has a spring with a spring constant k_1 = 100 N/m and Claire has a spring with a spring constant k_2 = 200 N/m.
   a) Who must apply a bigger force to stretch the spring 10 cm?

   b) What is the value of that force?

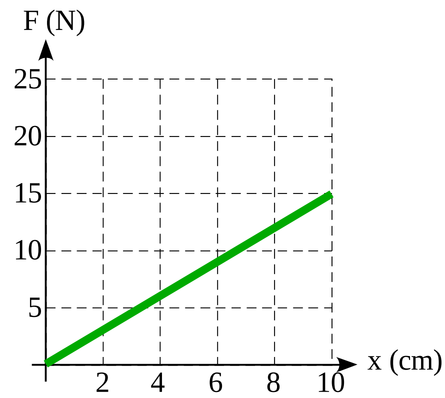


   c) Draw a graph for the force vs stretch.

   d) How much energy is stored in the springs when they are stretched 10 cm?

   e) If Hannah wants to stretch the first spring an additional 10 cm, how much energy must she transfer into the spring? How is this energy transferred into the spring?

3. David stretches a spring 15 cm by applying the force represented in the graph below. Using the graph:



a) Find the work done by David to stretch the spring 3 cm.

b) Find the elastic potential energy stored in the spring when it is stretched 3 cm.

c) Find the work done by David to stretch the spring an additional 3 cm, from 3 cm to 6 cm.

d) Find the elastic potential energy transferred into the spring when it was stretched an additional 3 cm.

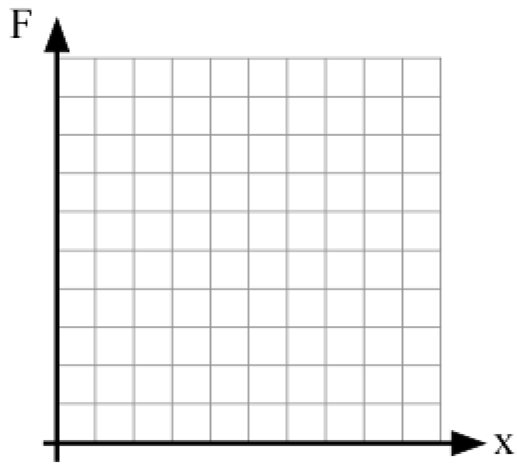
e) Find the work done by David to stretch the spring 15 cm.

f) Find the total elastic potential energy stored in the spring when it is completely stretched.

4. Suppose that during the Elastic Energy Lab one group in Mr. Dedrick's class found that the force applied to stretch the spring from its equilibrium is described by the expression $F_e = 1000 \cdot \Delta x$ (with force measured in Newton).

   a) Construct a graphical representation of force vs. deformation (make the maximum deformation 0.25 m).

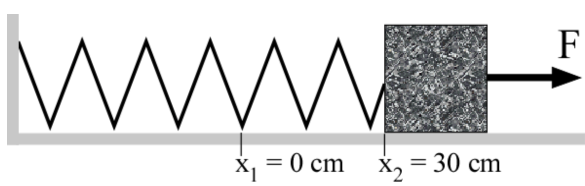
   b) Using the graph, determine the amount of energy stored in the spring while stretching it from x = 0 to x = 10 cm.



   c) Using the graph, determine the amount of energy stored in the spring while stretching it from x = 15 cm to x = 25 cm.

   d) In which case was more work done to stretch the spring, from 0 to 10 cm, or from 10 to 20 cm? How would you explain this answer?

5. The spring at right has a spring constant k = 10 N/m and it is connected to a block. A force F, as shown in the figure below, pulls on the block such that the block moves to the right.

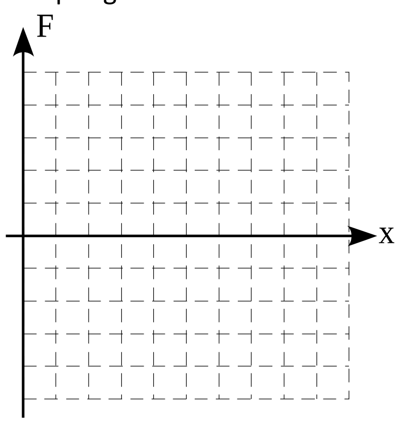


   a) As the block moves to the right, the spring stretches. Fill in the table with data for the elastic force in the spring.

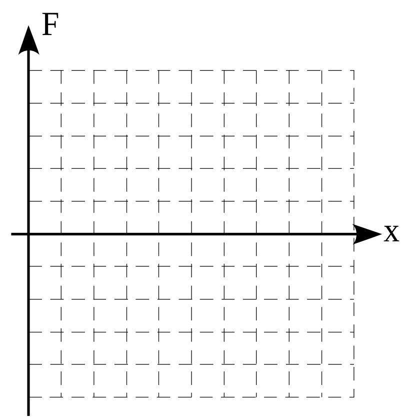
Deformation = Δx	Force: $F_e = - k \cdot \Delta x$
0 cm	
5 cm	
10 cm	
15 cm	
20 cm	
25 cm	
30 cm	

b) Draw all the forces acting on the block (sketch a force diagram) when the block is displaced 0.30 m horizontally to the right, and held motionless. What force does the spring exert on the block? (Assume a frictionless surface.)

c) On the graph provided below, draw the elastic force vs Δx, using the data from the table at (a) and calculate the work done by the spring when stretched 30 cm.



d) The force holding the block motionless is now removed. The spring pulls the block towards the left (toward its unstretched position). On the graph below draw the elastic force in the spring vs Δx until the spring is not stretched anymore and calculate the work done by the spring when stretched 30 cm.



e) How much energy was stored in the spring when it was stretched 30 cm?

f) How much work is done by the elastic force to bring the block back to its initial position?

g) Compare the work done in extending the spring with the work done in bringing it back to the unstretched position. Explain.

6. A ball of mass m = 0.2 kg is released from a height of 10 m with respect to the top of a vertical spring placed on the ground. The ball falls on the spring and compresses it a distance of 0.5 m before coming to rest.

a) Draw a schematic diagram of the problem for the initial (ball just released) and final (spring fully compressed) state of the ball + spring + earth system in the box at right.

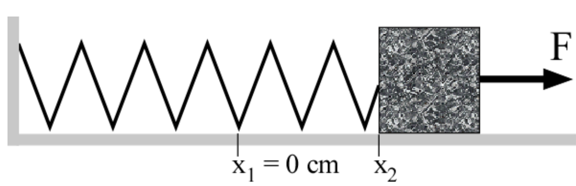
b) Draw an energy bar graph diagram for the system.

c) Calculate the gravitational potential energy of the ball when it is released.

d) Calculate the elastic potential energy stored in the fully compressed spring.

e) Calculate the elastic constant for the spring.

7. The spring below has a spring constant k = 20 N/m and it is connected to a block. A force F, as shown in the figure below, pulls on the block such that the block moves to the right.



a) The box is pulled to the right with a force F until its position is x_2 and the block is not moving. Draw a force diagram for the block above when the spring is stretched, yet the block is stationary.

b) The force of friction between the box and the surface is 4.00 N. The maximum value of the force applied F is 10 N. What is the maximum distance that the spring can be stretched from equilibrium before the block begins to slide back?

c) Calculate the work done by the elastic force on the block when the block is moved from x_1 = 0 cm to x_2 = 30 cm.

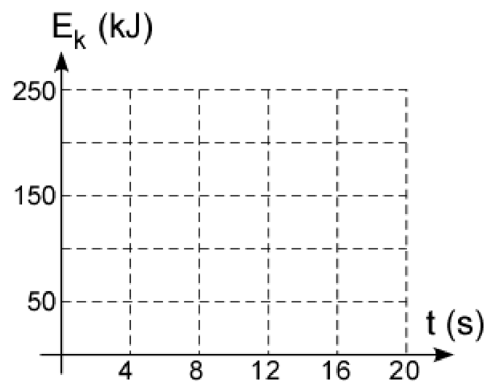
d) Calculate the work done by the force of friction when the block is moved from x_1 = 0 cm to x_2 = 30 cm.

e) Calculate the energy stored in the spring when stretched 30 cm.

Practice 6.10. Kinetic Energy

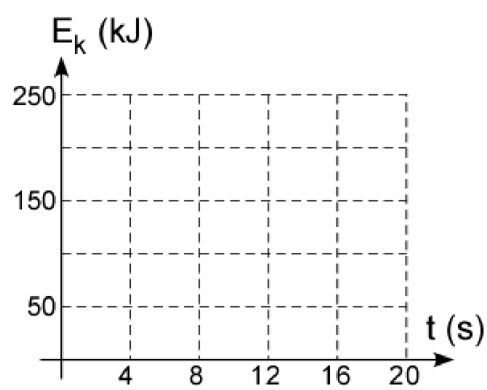
1. A 1000 kg car accelerates uniformly from 0 m/s to 20 m/s in 20 s. Find:
   a) the car's acceleration
   b) the speed of the car every 2 seconds for the first 20 seconds and fill in the values in the table provided.
   c) the kinetic energy of the car every 2 seconds, fill in the values in the table provided and plot the kinetic energy on the graph provided.

Time (s)	Speed (m/s)	Kinetic Energy (J)	Kinetic Energy (kJ)
0			
2			
4			
6			
8			
10			
12			
14			
16			
18			
20			



2. A 1000 kg car moving at 20 m/s breaks to a halt with uniform acceleration in 4 s. Find:
   a) the car's acceleration
   b) the speed of the car every second for the first 4 seconds and fill in the values in the table provided.
   c) the kinetic energy of the car every second, fill in the values in the table provided and plot the kinetic energy on the graph provided.

Time (s)	Speed (m/s)	Kinetic Energy (J)	Kinetic Energy (kJ)
0			
2			
4			
6			
8			
10			
12			
14			
16			
18			
20			



3. Doug is playing with his slingshot. He pulls back on the slingshot stretching it by 20 cm. Knowing that the elastic constant of the rubber band for the slingshot is 200 N/m, find the velocity of the small plastic ball (mass 0.05 kg) when it leaves the slingshot. Draw energy bar graphs to show energy transformations or transfers for the slingshot + ball + earth system.

4. Kelsey is doing dishes. Suddenly, one of the plates (mass m = 0.35 kg) slips from her hands and drops to the floor. The height from which the plate drops is 1 m.
   a) Draw a bar graph analysis for the energy of the plate + earth system.

   b) Calculate the total energy of the plate at the moment Kelsey drops it.

   c) What is the total energy of the plate just before it hits the floor?

   d) What is the speed with which the plate hits the floor?

5. From a 6.78 m high bridge, Sarah throws a small stone (mass m = 0.25 kg) into the water below with an initial velocity of 2 m/s. The stone hits the water with a velocity of 11.7 m/s. In all calculations use g = 9.8 m/s^2. There is no air resistance.
    a) Calculate the kinetic energy of the stone at the moment when Sarah throws it.

    b) Calculate the kinetic energy of the stone when it hits the water.

    c) Calculate the work done by the net force acting on the stone.

    d) Calculate the change in gravitational potential energy for the stone.

    e) Compare the change in gravitational potential energy with the work done by the force of gravity acting on the stone. Can you explain your answer?

Practice 6.11. Conservation of Energy Problems

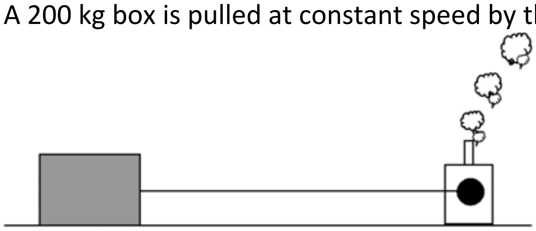
1. An 8.00 kg cart is moving at 5.00 m/s when it hits a spring of spring constant 50.0 N/m. When the cart has come to rest, how much is the spring compressed? Ignore friction and air resistance.

2. A 20.0 kg cart, initially at rest, rolls down a hill. a) What is the speed of the cart when it is 5.00 meters lower than its initial position? B) Assuming that 10% of the energy is dissipated by friction, what is the speed of the cart when it is 5.00 meters lower than its initial position? Ignore friction and air resistance.

3. A 500 g block is placed on a spring of spring constant 100 N/m, compressing it 0.300 m. If the block is released from rest, what is the greatest height reached by the block with respect to the release point? Ignore friction and air resistance.

4. A 25 g bullet traveling at 350 m/s strikes a fixed block of wood. The block of wood exerts an average force of 50,000 N on the bullet. How far into the wood does the bullet go? Ignore friction and air resistance.

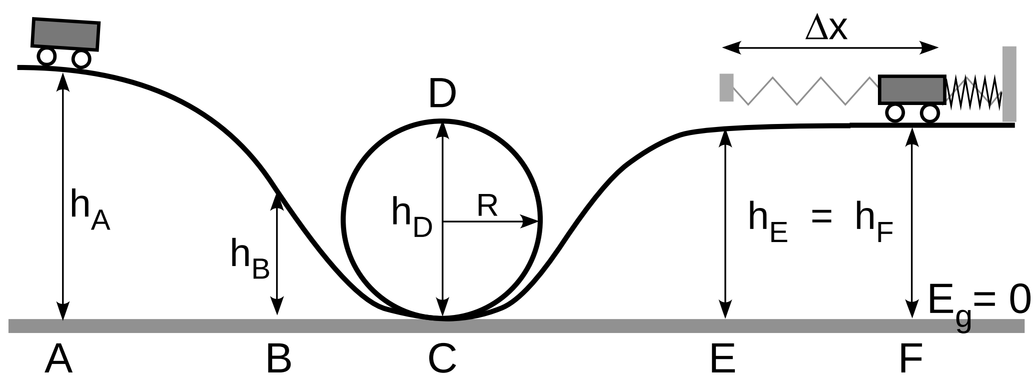
5. A 200 kg box is pulled at constant speed by the little engine pictured to the right.



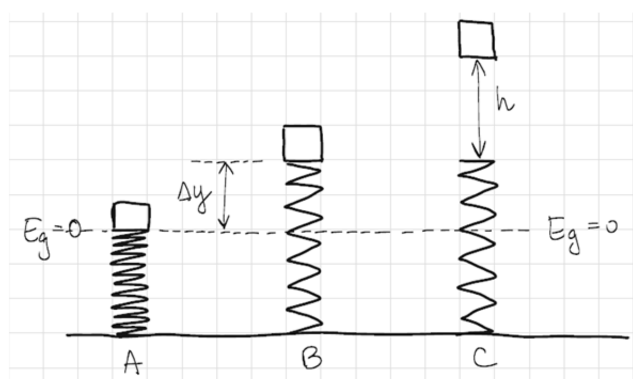
The box moves a distance of 2.50 m across a horizontal surface. A frictional force of 400 N opposes the motion of the box. Ignore friction and air resistance.

a) Draw a force diagram of all relevant forces acting on the box.
b) Construct a qualitative energy bar graph/flow diagram for this situation. Be sure to specify your system.
c) How much energy is transferred to the system by the engine?
d) What type of motion would occur if the engine pulled with a force of 500 N?
e) Modify your force diagram and apply Newton's 2nd Law to find the acceleration.
f) How far could the box be pulled at constant velocity by using 8,000 J of energy?

6. A 200 kg rollercoaster car starts from the top of a 180 m high hill. Start the problem by drawing an energy bar graphs for each one of the positions indicated on the figure below (A, B, C, D, E, and F). Picture is not drawn to scale. Ignore friction and air resistance.
   a) Calculate the speed of the car when it is 75 m above the ground (position B).
   b) What is the speed of the car when it reaches the ground (position C)?
   c) The car must go around a loop-the-loop. If its speed at the top of the loop (position D) is 30 m/s, calculate the radius of the loop-the-loop.
   d) After exiting the loop-the-loop, the car goes up a hill and reaches its top with a speed of 45 m/s. How high is that hill (position E)?
   e) In order to stop the car, at the top of the hill there is a spring with a spring constant of 4050 N/m. How much does the car compress the spring before stopping?
   f) And just for kicks: what is the acceleration of the car during the stopping distance? Would you ride on such a rollercoaster?



7. A 0.4 kg box is placed on a vertical spring of spring constant k = 20000 N/m and pushed down until the spring is compressed by 5 cm, as shown in the figure below. Start the problem by drawing an energy bar graph for each one of the positions indicated (A, B, and C). Ignore friction and air resistance.
   a) You let go of the box. Calculate the speed of the box when it leaves the spring (position B).
   b) What is the maximum height (with respect to the release point) that the box reaches (position C)?



Practice 6.12. Energy: Putting it together!

1. A baseball (m = 140 g) traveling at 30.0 m/s moves a fielder's glove backward 35.0 cm when the ball is caught.
   a) Construct an energy bar graph of the situation, with the ball as the system.
   b) What was the average force exerted by the ball on the glove?

2. A 60.0 kg student jumps from the 10.0 meter platform at Washington University's swimming complex into the pool below.
   a) Determine her E_g at the top of the platform.
   b) How much E_k does she possess at impact? What is her velocity at impact?
   c) Repeat steps a and b for a 75.0 kg diver.
   d) If the first diver jumped from a platform that was twice as high, how many times greater would be her velocity at impact?
   e) How much higher would the platform have to be in order for the first diver's velocity to be twice as great?

3. A spring whose spring constant is 850 N/m is compressed 0.400 m.
   a) What is the maximum speed it can give to a 500 g ball?
   b) If the spring were compressed twice as much, how many times greater would the velocity of the ball be?

4. A bullet with a mass of 10.0 g is fired from a rifle held horizontally that has an 85.0 cm long barrel.
   a) Assuming that the force exerted by the expanding gas to be a constant 5500 N, what speed would the bullet reach?
   b) Do an energy pie chart analysis of the situation, with the entire gun and bullet as the system.

5. A 24.0 kg child descends a 5.00 m high slide and reaches the ground with a speed of 2.80 m/s.
   a) How much energy was stored as internal energy due to friction in the process?
   b) Do a pie chart analysis of this situation, using an accurate % of the pie to represent the amount of E_{int} in the process.

Practice 6.13. Power

1. A 60.0 kg box is lifted straight upward by a rope, a distance of 10.0 meters, at constant speed. How much power is required to complete this task in 5.00 seconds?

2. Hulky and Bulky are two workers being considered for a job at the UPS loading dock. Hulky boasts that he can lift a 100 kg box 2.00 meters vertically, in 3.00 seconds. Bulky counters with his claim of lifting a 200 kg box 5.00 meters vertically, in 20.0 seconds. Which worker has a greater power rating?

3. A 1994 Ford Mustang is driving down a road with a constant speed of 30.0 m/s. The engine must exert a 5000 N force to maintain this speed.
   a) What is the power rating of the engine?
   b) How does the Mustang's power rating compare to the 220 hp Dodge Stealth engine?

4. An 82.0 kg hiker climbs a mountain. During a two hour period, the hiker's vertical elevation increases by 540 meters.
   a) Calculate the climber's increase in gravitational potential energy.
   b) Find the power generated to increase the hiker's E_g.

5. How long would it take a 7.50 kW motor to raise a 500 kg piano to an apartment window 10 meters above the ground?

6. The trains on the Batman rollercoaster at Six Flags are raised from 10.0 m above ground at the loading platform to a height of 60.0 m at the top of the first hill in 45.0 s. Assume that the train (including passengers) has a mass of 2500 kg. Ignoring frictional losses, what would be the minimum power rating required for the motor to accomplish this task?

7. Your electric utility company sends you a monthly bill informing you of the number of kilowatt-hours you have used that month.
   a) Is the utility charging you for energy or power? Explain.
   b) How many joules does your 1600 W blow dryer transfer if you dry your hair in 5.0 min?
   c) Convert this energy to calories, Calories, kW-hrs, ergs, btu, GeV, and ft-lbs.
   d) Convert the power rating of the blow dryer to horsepower, ft-lbs/s, and ergs/millennium.
   e) If the electric company charges $0.07/kW-hr, and you use your blow dryer for 30.0 minutes per day every day, what will you be charged for one year of blow dryer use?

Practice 6.1. Physical systems, states, processes

For each one of the images below, identify a system, an initial and final state for the system, and the energy transformations in the system. Draw a dotted line around your system to illustrate it. Ignore friction and air resistance.

	**Example**: A pitcher throws a baseball. The ball leaves his hand. *System*: baseball + earth *Initial state*: when it leaves the pitcher's hand *Final State*: when it hits the ground *Energy transformations*: from kinetic and gravitational potential energy to kinetic only.
	A. A roller coaster moves from the top of the loop to the bottom. System: Initial state: Final State: Energy transformations:
	B. A bow is stretched from its unstretched position. System: Initial state: Final State: Energy transformations:
	C. Water shoots up in the air from ground level. System: Initial state: Final State: Energy transformations:

Identify the system, initial and final state, and energy transformation in each of the following examples:

<table>
<tr>
<td>A. A ball is dropped from the top of a very tall building

System:

Initial state:

Final State:

Energy Transformation:</td>
<td>B. An airplane takes off on a runway.

System:

Initial state:

Final State:

Energy Transformation:</td>
</tr>
<tr>
<td>C. A rock is shot from a slingshot.

System:

Initial state:

Final State:

Energy Transformation:</td>
<td>D. Starting from rest, a pole vaulter runs, plants his pole, vaults over the bar, and lands on a thick mattress.

System:

Initial state:

Final State:

Energy Transformation:</td>
</tr>
<tr>
<td>E. A moving ball collides with a stationary ball: after collision, both balls are moving.

System:

Initial state:

Final State:

Energy Transformation:</td>
<td>F. A heavy bag attached to an unstretched spring hanging from the ceiling is let go. The spring stretches and it comes to rest just above the ground.

System:

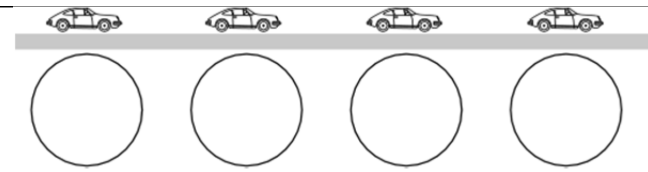
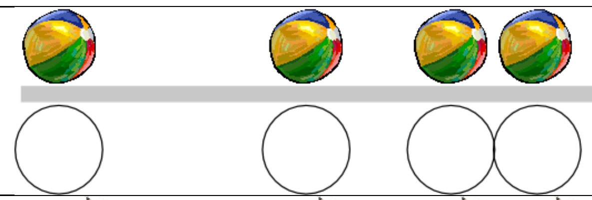
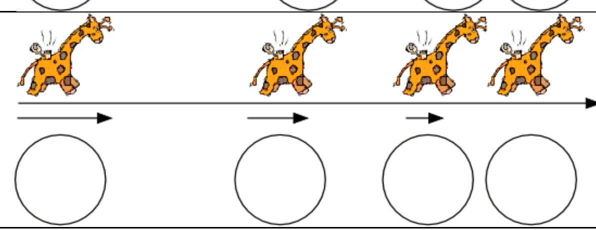
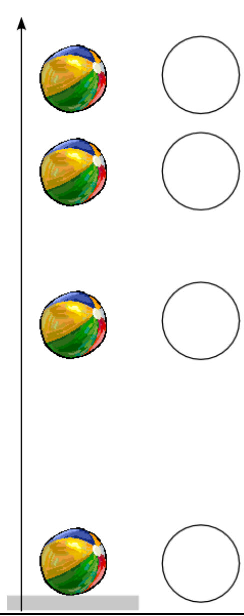
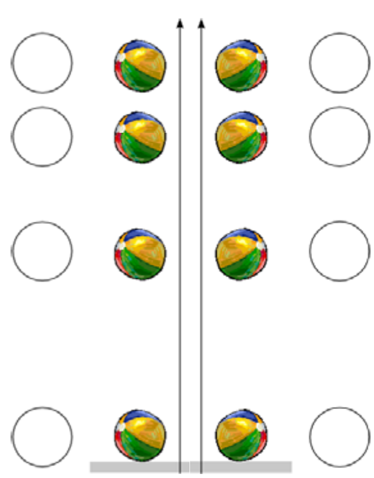
Initial state:

Final State:

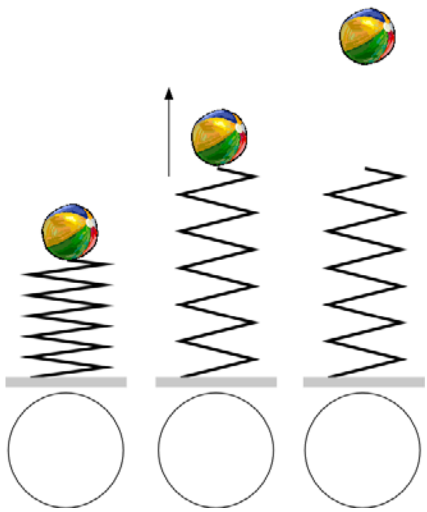
Energy Transformation:</td>
</tr>
</table>

Practice 6.2. Energy Pie Charts I

1. Use pie charts to analyze the energy changes in each situation given below. Follow the rules listed below:
   a) Choose your system such that no energy transfers are occurring to or from your system. Clearly write who your system is in the space provided.
   b) Draw a motion diagram for the object (above or near the picture provided).
   c) Carefully label the pies to correspond with the arrangement of the objects in your system. (A, B, C, etc.)
   d) Analyze the energy transformations within your system. The pies should be accurately divided and labeled with the energy storage mechanisms involved.

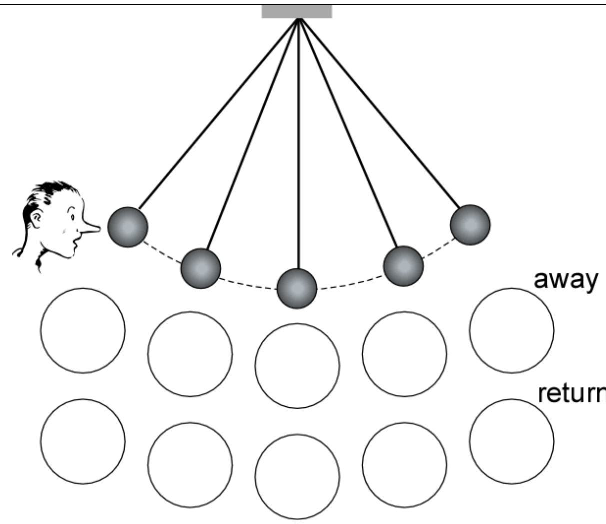
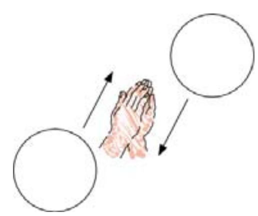
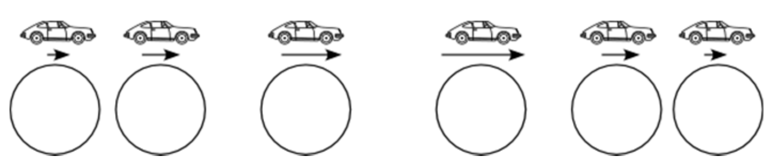
A. A car is driven down the street at a constant speed. Ignore friction. System:	
B. A ball moving with an initial velocity *v*, rolls on a very rough floor until it comes to a stop. System:	
C. A wind-up toy giraffe is moving such that it across a table slowing down until it comes to a stop. There is friction with the table. System:	
D. A ball is dropped to the floor from a certain height. Ignore air resistance. System: 	E. A ball is thrown up in the air and then falls back down. Ignore air resistance. System: 

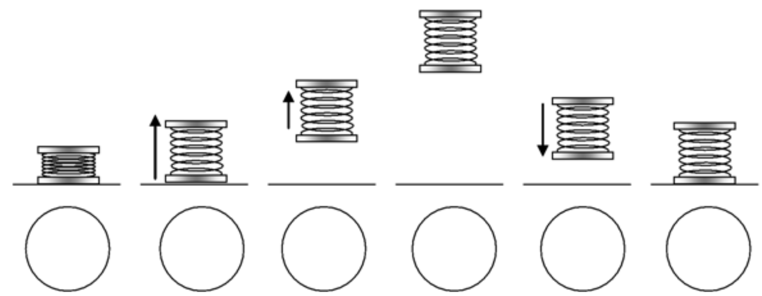
2. A ball rests on a compressed spring. The spring is let go, and it extends and pushes the ball upwards. The last image is the ball at its maximum height. The system to consider is ball + spring + earth. Ignore air resistance.
   a) Draw a motion diagram for the ball.
   b) Do a pie chart for each position of the ball and explain the energy transformations involved.



Practice 6.3. Energy Pie Charts II

1. Use pie charts to analyze the energy changes in each situation given below. Follow the rules listed below:
   a) Choose your system such that no energy transfers are occurring to or from your system. Clearly write who your system is in the space provided.
   b) Draw a motion diagram for the object (above or near the picture provided).
   c) Carefully label the pies to correspond with the arrangement of the objects in your system. (A, B, C, etc.)
   d) Analyze the energy transformations within your system. The pies should be accurately divided and labeled with the energy storage mechanisms involved.

A. A pendulum is held up to your nose. When it is released, it swings away from your nose and then returns. Ignore air resistance. System:	
B. You press your palms together and then rub your palms up and down against each other. Include yourself in the system. System:	
C. A wind-up Volkswagen toy car has been wound up and set on a tabletop. As the spring unwinds, it speeds up. When it is fully unwound, it slows to a stop. System:	

D. A spring jumper is compressed on a table top. It pops up into the air and then returns to the ground. Ignore air re System:	

2. A ball is dropped from a certain height and it bounces several times as shown in the picture. Your system is ball + earth. There is no air resistance.
   a) Do a pie chart for each position of the ball shown.
   b) Why does the ball not bounce as high each time? Where did the energy "go"?