Name _____ Date _____

A3 Energy Transformations

How is motion on a rollercoaster related to energy?

Materials:

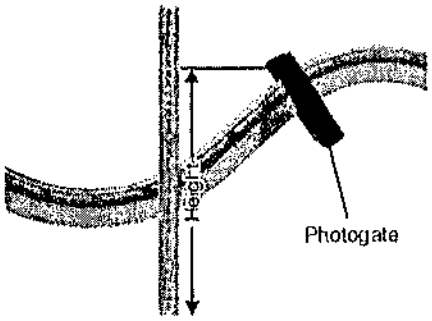
- ✔ Physics stand
- ✔ Rollercoaster with a steel marble
- ✔ CPO Timer and photogate
- ✔ Metric ruler or meterstick
- ✔ Calculator

Have you ever ridden a rollercoaster at an amusement park? If so, you may have noticed that the ride starts with being pulled up a large hill by a motor-driven chain, which requires **energy**. Once you reach the top of that hill, the cart slows down, then plummets over the other side of the hill at a fast speed. Interestingly, it continues throughout the ride, traveling over other hills, without the need for the motor-driven chain! How is this possible?

As the cart is being pulled up the hill, energy is being stored in the form of potential energy. **Potential energy** is energy that is stored in the form of position in a system. When the cart goes down the hill, the potential energy is converted into **kinetic energy**, the energy of motion. As the cart travels on the rollercoaster track, it trades potential and kinetic energy back and forth. This conversion of energy from one form to another is explained by the **law of conservation of energy**, which states that energy can be converted from one form to another but not created or lost. In this investigation, you will explore the transformation of energy from potential to kinetic using the marble and Rollercoaster track.

❶ Conducting the experiment

The marble and rollercoaster track are a **system**. In science, a system is defined as a group of variables that are related to each other in some way. You will investigate potential and kinetic energy in this system. To measure the kinetic energy, you will use the photogate to find the speed of the marble. To measure the potential energy, you need to measure the height. The light beam passes through the center of the marble, so you should measure the height from the table to the center of the hole for the light beam.



For the positions close to the start, you will have to measure from the base of the stand. Add the height of the base to the height you measure to get the total height.

1. Place the photogate at 12 different places along the rollercoaster. Use the ruler on the rollercoaster track to identify each position of the photogate. Measure the speed and height of the marble at each place.

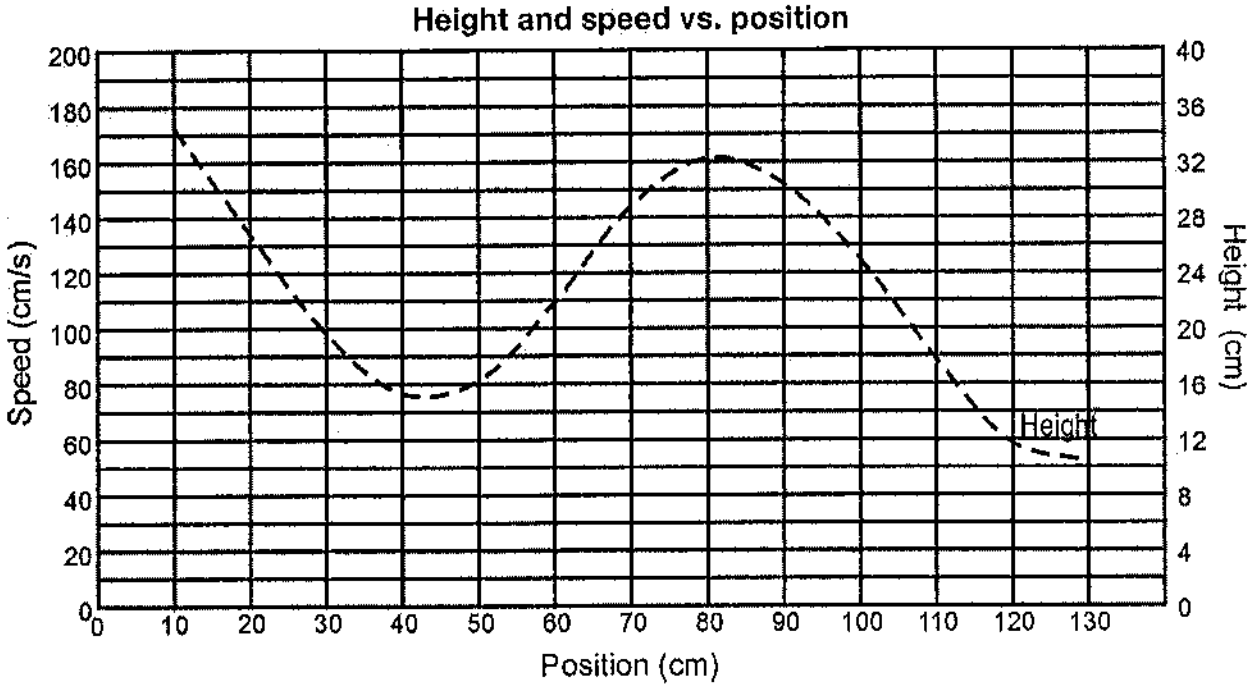
2. Write your data in Table 1 below.

Table 1: Speed, height, and position

Position (cm)	Height (cm)	Distance traveled by marble through A (cm)	Time from photogate A (s)	Speed of marble (cm/s)
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		
		1.90		

❷ Creating a model of your data

Use your measurements to make a graph of your data. The graph provided on the next page already shows the height of the rollercoaster plotted against the position along the track. Using the data from Table 1, plot the speed vs. position on the same graph.



❸ Arguing from evidence

According to the law of conservation, energy can be transformed from one form into another, but the total energy remains the same. Answer the questions below to develop a model for how energy is transformed in the rollercoaster system.

a. What forms of energy are present in the rollercoaster experiment?

b. Based on your work and observations in this investigation, define kinetic energy and potential energy in your own words. Which form of energy is directly related to speed? Which form of energy is directly related to height?

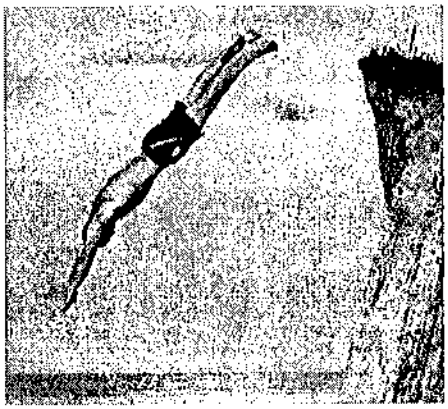
✓ **c.** Use your graph as evidence to describe the flow of energy between potential and kinetic along the rollercoaster. Your answer should indicate where the potential energy is greatest and least and where the kinetic energy is greatest and least.

✓ **d.** Earlier in the investigation, you learned about the law of conservation of energy. How does the graph you made illustrate the law of conservation of energy?

4 Conducting the experiment

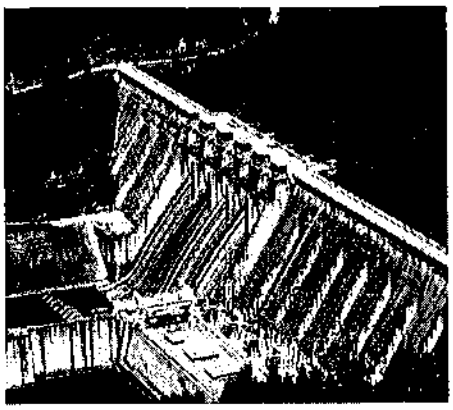
For each scene, specify whether kinetic energy is being changed to potential energy, or potential is being converted to kinetic. Explain your answers.

a.



b.

c.



Roller Coaster Challenges 2016

Constructing Roller Coasters

A quick review before we begin building our roller coasters.

1. How can you give your marble more PE?

2. What force will slow down your marble as rolls along the track?

3. Why should you NOT have any part of your track higher than where the marble begins to roll?

Materials Needed:

Foam pipe insulation tubes, glass marbles, plastic cups, masking tape

Safety & Success Rules:

1. Keep track of your marble. These are 'hide and seek' marbles.
2. Do not climb on tables. They are not for sitting or standing upon.
3. You may use your table, stools, 2 Physics Stands, your roll of tape, your tubes, your marble, and your red cup. Anything else, check with me first.
4. You will be safer and more successful as a group if you work together, listen to one another's ideas, & learn from your mistakes along the way.
5. Once you have constructed your track, you may not touch the track while the marble is in motion. The track needs to be free-standing. Your track does not work unless I see it work.

Challenge 1:

Your initial task today is as follows: Your group will be given one marble, one piece of track, one roll of masking tape, one physics stand, and one cup. Construct a coaster so that the marble rolls down a hill, up another hill, then down another hill. Then the marble needs to land in the red cup and STAY. You may go on when Mr. Beier sees your project be successful.

Challenge 2:

Construct a track with TWO hills so that the marble rolls up and down both hills and comes out the other end. It must land in the other cup and STAY.

When you succeed, have Mr. Beier observe your success before you go on.

Challenge 3:

On this one, you may choose to use 2 pieces of track. You need 3 hills, land in the cup and stay.

Challenge 4:

Two hills and one loop. They can be in any order. Then the marble needs to land in the cup and stay.

Challenge 5:

One hill and two loops (in any order), then land in the cup and stay.

Challenge 6:

Two tracks, two hills, two loops, (in any order), then land in a cup and stay.

Challenge 7:

Two tracks, one hill on each track, jump 25 cm between the tracks and land in a cup and stay.

Challenge 8:

Two tracks, two hills, one loop, (in any order), 25 cm jump between the tracks, land in the cup and stay.

Challenge 9:

THREE tracks, 25 cm jump between each track, one loop on each track, land in a cup and stay.

BONUS TRACKS

Challenge 10:

Three tracks, a hill on each track, a 30cm jump between each track. Land in the cup and stay.

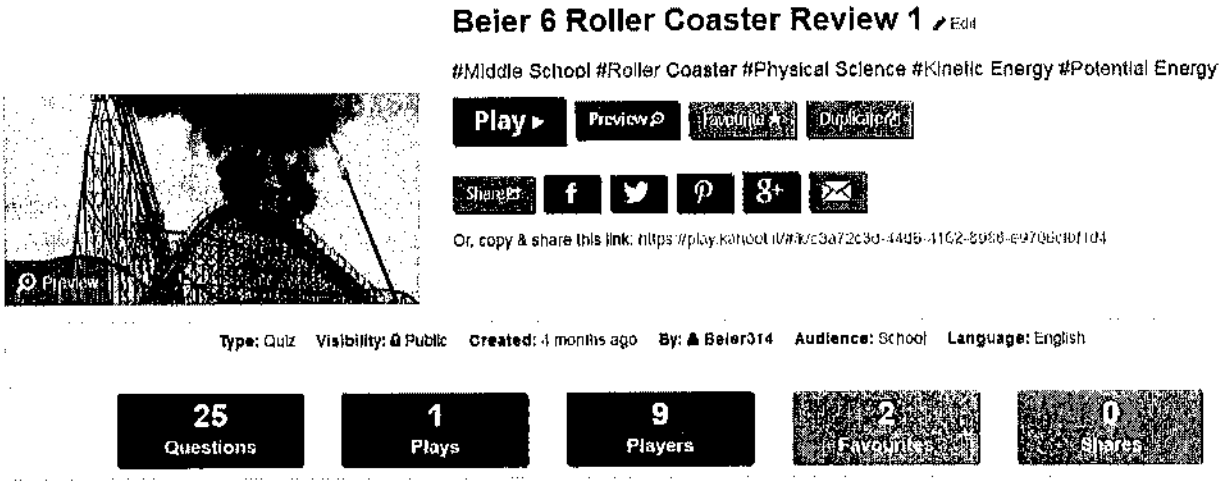
Challenge 11:

Three tracks, two hills, one loop, a 30cm jump between each track. Land in the cup and stay.

Challenge 12:

Three tracks, a loop on each track, a 30cm jump between each track. Land in the cup and stay.

Here are the links to my two Roller Coaster Kahoot reviews. PLAY! You just might learn something that comes in handy! ☺ db



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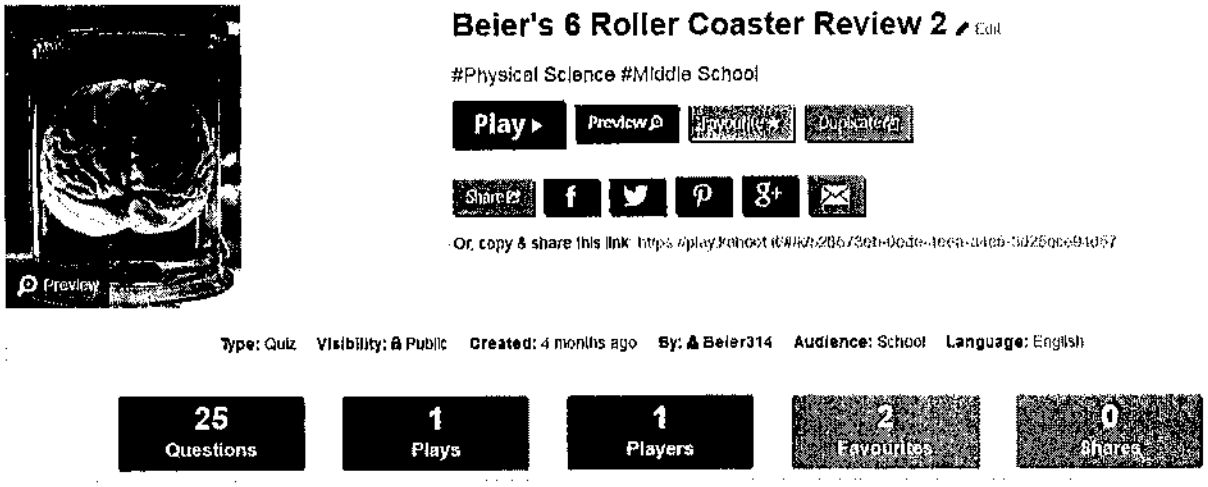

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Roller Coaster Physics Review

Energy and the Conservation of Energy

Without energy, nothing could ever change. Pure energy itself cannot be smelled, tasted, touched, seen, or heard. However, energy does appear in many forms, such as motion and heat. Energy can travel in different ways, such as in light and sound waves and in electricity. The workings of the entire universe (including all of our technology) depend on energy flowing and changing back and forth from one form to another.

What is energy?

A definition of energy

***Energy* is a quantity that measures the ability to change. Anything with energy can change itself or cause change in other objects or systems. Energy can cause changes in temperature, speed, position, momentum, pressure, or other physical variables.** Energy can also cause change in materials, such as burning wood changing into ashes and smoke.

Energy measures the ability to change in a physical system.

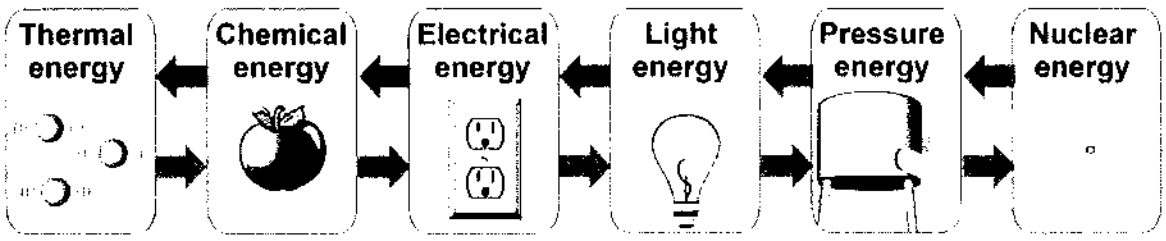
Examples

- A gust of wind has energy because it can move objects in its path.
- A piece of wood in a fireplace has energy because it can produce heat and light.
- You have energy because you can change the motion of your body.
- Batteries have energy; they can be used in a radio to make sound.
- Gasoline has energy; it can be burned in an engine to move a car.
- A ball at the top of a hill has energy because it can roll down the hill and move objects in its path.

The law of conservation of energy

Kinds of energy

Energy appears in many forms, such as heat, motion, height, pressure, electricity, and chemical bonds between atoms.



Energy transfomations

Systems change as energy flows from one part of the system to another. Parts of the system may speed up, slow down, get warmer or colder, or change in other measurable ways. **Each change transfers energy or *transforms* energy from one form to another. Friction transforms energy of motion to energy of heat. A bow and arrow transform energy in a stretched bow into energy of motion of an arrow.**

Law of conservation of energy

Energy can never be created or destroyed, just converted from one form into another. The idea that energy converts from one form into another without a change in the total amount is called the **law of conservation of energy**. The law of conservation of energy is one of the most important laws in physics. It applies to all forms of energy.

Energy can never be created or destroyed, just converted from one form into another.

Energy has to come from somewhere

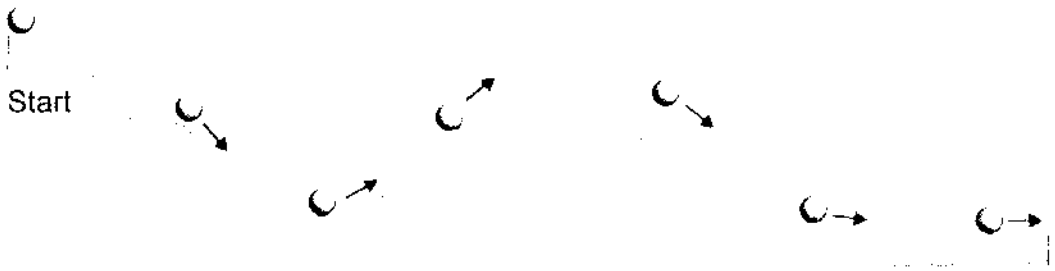
The law of conservation of energy tells us energy cannot be created from nothing. **If energy increases somewhere, it must *decrease* somewhere else.** The key to understanding how systems change is to trace the flow of energy. Once we know how energy flows and transforms, we have a good understanding of how a system works.

When we use energy to drive a car, that energy comes from chemical energy stored in gasoline. As we use the energy, the amount left in the form of gasoline decreases.

Following an energy transformation

An experiment in energy

We performed an experiment in class that followed a rolling marble up and down a hilly track. The marble starts slow then speeds up as it rolls down the first hill. The marble slows down almost to a stop as it rolls up and over the second hill. The marble speeds up again as it rolls down the second hill. How do we explain the changes in the speed of the marble? The easiest way is to think about energy.



Potential energy

The marble and the track are a system. This system has two major kinds of energy called *potential energy* and *kinetic energy*. **Potential energy** is energy due to *position*. When you lift the marble off the ground it gets potential energy because of its height. **The higher you lift it, the more potential energy it has.**

Kinetic energy

Kinetic energy is energy of motion. The faster the marble moves, the more kinetic energy it has. The marble has zero kinetic energy at the start because it is not moving. **The marble has the most kinetic energy when its speed is greatest.**

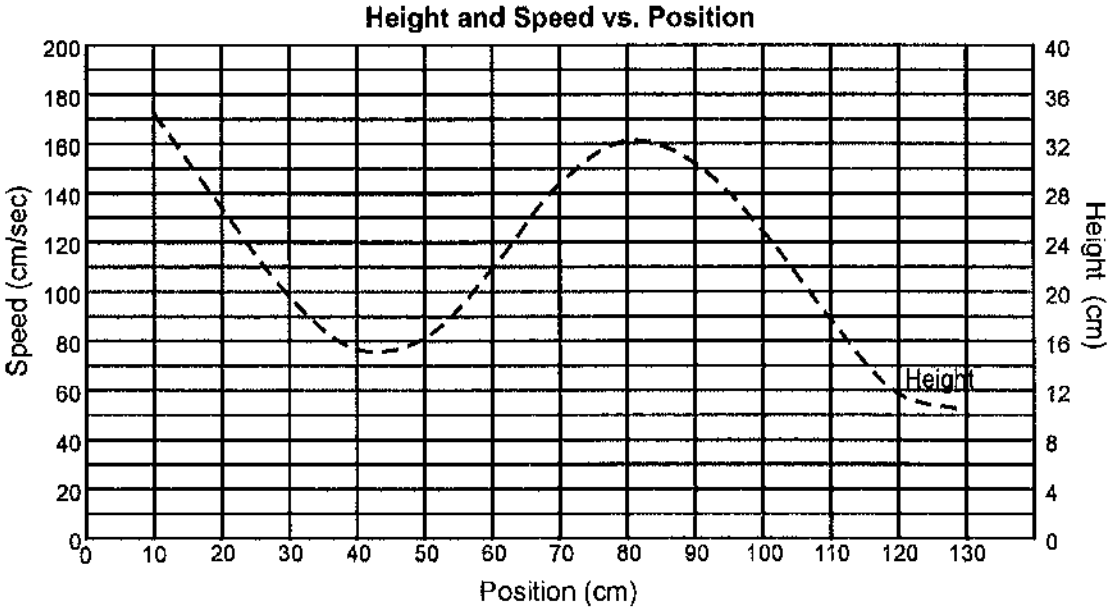
Using the law of conservation of energy

Assume the system starts with the marble at the top of the first hill. ***Conservation of energy says the total energy stays the same as the marble moves up and down.*** As the marble moves down, it loses potential energy. Where does the energy go? It changes into kinetic energy which is why the marble speeds up. To get up the hill the marble needs potential energy. It can only get it by reducing its kinetic energy. That is why the marble slows down as it goes up. Its kinetic energy is being changed into potential energy. The potential energy changes back into kinetic energy again as the marble rolls down the last hill.

A closer look at Roller Coasters and energy transformation

More about Energy Transformation

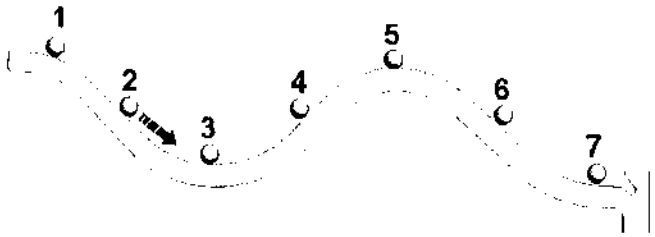
When the marble is at its highest point, it has the most potential energy. We created a graph of the height of the coaster track, with the speed of the marble superimposed on it.



This graph of the Height and Speed vs Position is an elegant graph – and one that exhibits a special mathematical relationship. The Height represents Potential Energy and the Speed represents Kinetic Energy. **AND these two lines on the graph represent a special reciprocal relationship – when the potential energy is highest, the kinetic energy is lowest, and visa versa.**

As for TOTAL ENERGY, anywhere along the track (potential energy plus kinetic energy) will be the same. There is a small amount of energy that is converted to HEAT energy as the marble rolls down the track. This is caused by rolling friction as the marble rolls along the track.

An important science concept here is the speed of the marble as it rolls down the coaster track.



The steel marble is moving fastest at the place numbered '7' on the track above for a several important reasons. **First**, it is the lowest point on the track, so all of the potential energy has been transformed into kinetic energy. **Second**, the slope of the track from point 5 to point 7 is steeper than it is from point 1 to point 3. **And last**, the marble is already moving at point 5 when it starts to roll down that hill, as opposed to it starting from a stop at point 1 as it starts down the first hill.

You might also notice that points 2, 4, and 6 are parallel to one another. The speed of the marble at these points is nearly identical. This is a direct relationship with the potential energy at these points on the track.

Now for a question that was asked earlier in the week.

Where will a light plastic marble be moving the fastest on this track?

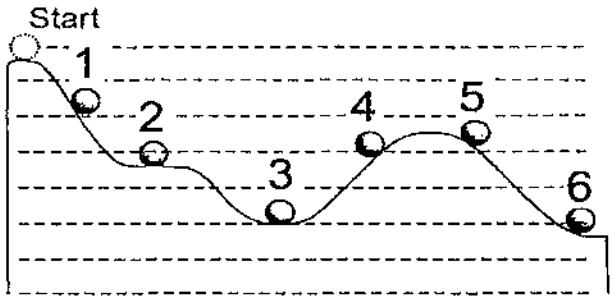
The light plastic is MOVING FASTEST AT POINT 7, since gravity acts the same on both marbles.

AND, how will the speed of the steel marble compare with the hollow plastic marble compare at points 1 – 7 along the track? They will be nearly identical! Why? Gravity is acting on them in the same manner.

Gravity and the Roller Coaster

When you toss a ball straight up into the air, it will slowly decrease in speed, come to a stop, and then increase in speed as it comes back down to your hand. **If you measure the speed of the ball going up at any point with the speed of the ball passing that same point going down, the speed will be the same. Why? Because gravity is acting on the ball the same way whether it is going up or going down.**

Looking at the roller coaster below, where will the marble be rolling the fastest?



It is fastest at point 6, slightly faster than point 3 because 6 is slightly lower on the track than 3. The lower you are on the track, the faster the marble will be rolling. The higher on the track, the slower the marble will be rolling.

"Using" and "conserving" energy in the everyday sense

"Conserving" energy

Almost everyone has heard that is good to "conserve energy" and not waste it. This is good advice because energy from gasoline or electricity costs money and uses resources. But what does it mean to "use energy" in the everyday sense? If energy can never be created or destroyed, how can it be "used up"? Why do smart people worry about "running out" of energy?

"Using" energy

When you "use" energy by turning on a light, you are really converting energy from one form (electricity) to other forms (light and heat). What gets "used up" is the amount of energy *in the form of electricity*. Electricity is a valuable form of energy because it is easy to move over long distances (through wires). In the "physics" sense, the energy is not "used up" but converted into other forms. The total amount of energy stays constant.

Power plants

Electric power plants don't *make* electrical energy. Energy cannot be created. What power plants do is convert other forms of energy (chemical, solar, nuclear) into electrical energy. When someone asks you to turn out the lights to conserve energy, they are asking you to use less electrical energy. If people used less electrical energy, power plants would burn less oil, gas, or other fuels in "producing" the electrical energy they sell.

"Running out" of energy

Many people are concerned about "running out" of energy. What they worry about is running out of certain *forms* of energy that are easy to use, such as oil and gas. At the beginning of the industrial age, the planet Earth had a certain amount of oil and gas. It took millions of years to accumulate and once it is used up, there will be no more.

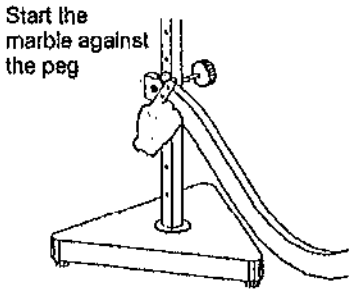
When you use gas in a car, the chemical energy in the gasoline mostly becomes heat energy. It is impractical to put the energy back into the form of gasoline, so we say the energy has been "used up" even though the energy itself is still there, only in a different form. Other forms of energy, such as flowing water, wind, and solar energy are not as limited. Many scientists hope our society will make a transition to these forms of energy over the next 100 years.

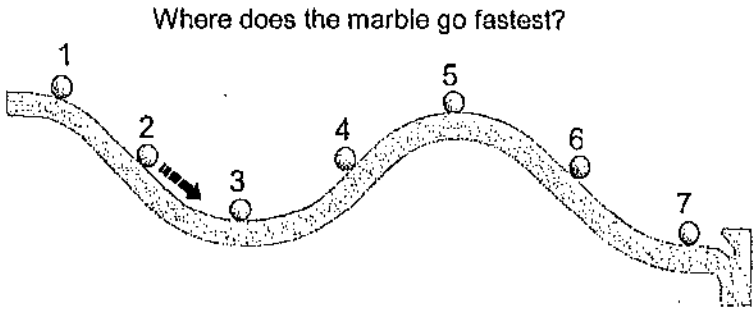
Roller Coaster Physics

1. Define potential energy and tell me two specific different examples of potential energy. (NOT roller coasters)

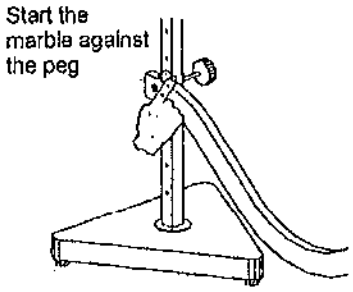
2. Define kinetic energy and tell me two specific different examples of kinetic energy. (NOT roller coasters)

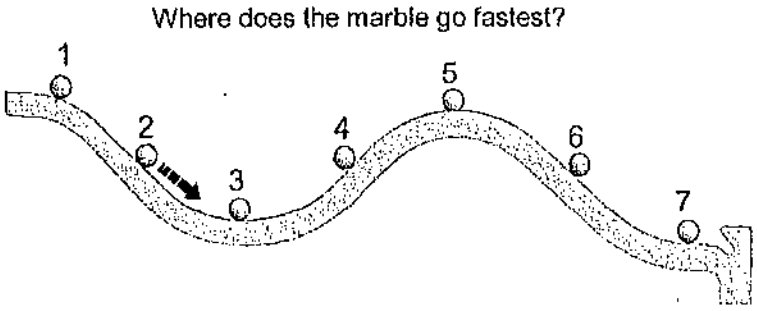
3. Imagine you have the CPO Roller Coaster below and placed a steel marble at the very beginning. Oh, yeah. You DID this. Write the numbers in order to tell the speed of the steel marble as it goes down the track. Write the numbers from FASTEST TO SLOWEST point.





4. Explain your reasoning as to why you chose the place on this coaster that was the fastest.



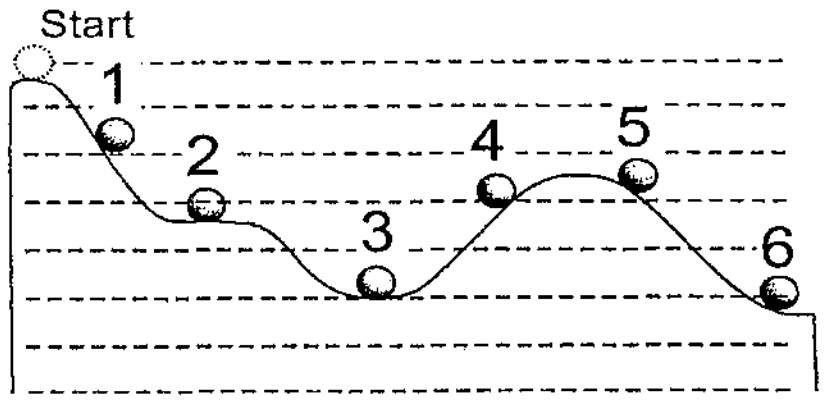


5. If you used a hollow plastic marble instead of a solid steel marble on the coaster above, would that change where the marble would be moving the fastest? Explain.

6. Write down a mathematical term to describe the relationship between potential and kinetic energy.

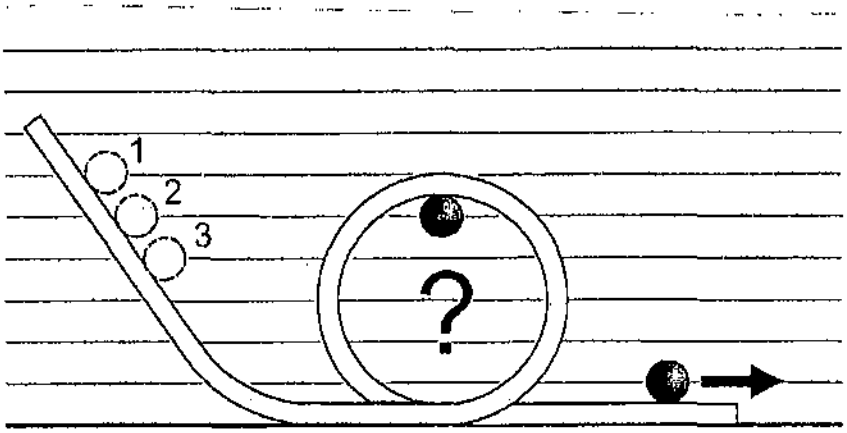
7. Why is it a poor choice to have a hill along your roller coaster track that is higher than the starting point of your track?

8. Where on the coaster track below is the marble moving the SLOWEST? Explain your reasoning. Use the terms Potential Energy (PE) and Kinetic Energy (KE) in your answer.



9. On the graph above list the numbers in order to represent the speed of the marble from FASTEST TO SLOWEST.

10. Explain the motion of the marble on the track below if it is released at potion 1, 2, and 3 on the graph of the roller coaster below. Be sure to explain your reasoning in each case (1, 2, and 3).



Name: _____ Class: _____ Date: _____ ID: A

Roller Coaster Physics

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. As an object is raised to a higher position, the object is most likely to experience an increase in its:
a. kinetic energy.
b. potential energy.
c. heat energy.
d. light energy.

The diagram below represents a cart rolling from left to right along a frictionless surface.

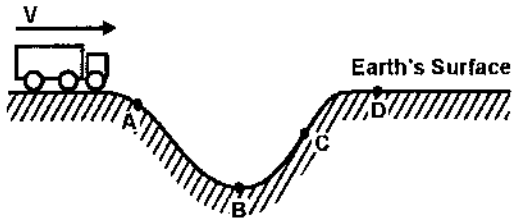


Figure 6-1A

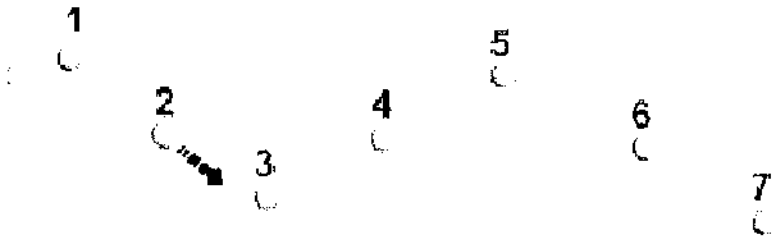
____ 2. At which point in the diagram shown in Figure 6-1A does the cart have the most amount of kinetic energy?
a. A
b. B
c. C
d. All the points have the same amount of kinetic energy.

____ 3. At which point in the diagram shown in Figure 6-1A does the cart have the most amount of potential energy?
a. A
b. B
c. C
d. All the points have the same amount of potential energy.

____ 4. Which of the following stores energy?
a. A battery
b. Food
c. A stretched rubber band
d. All of the above

____ 5. If you go twice as fast, your kinetic energy becomes:
a. 2 times smaller.
b. 4 times smaller.
c. 2 times larger.
d. 4 times larger.

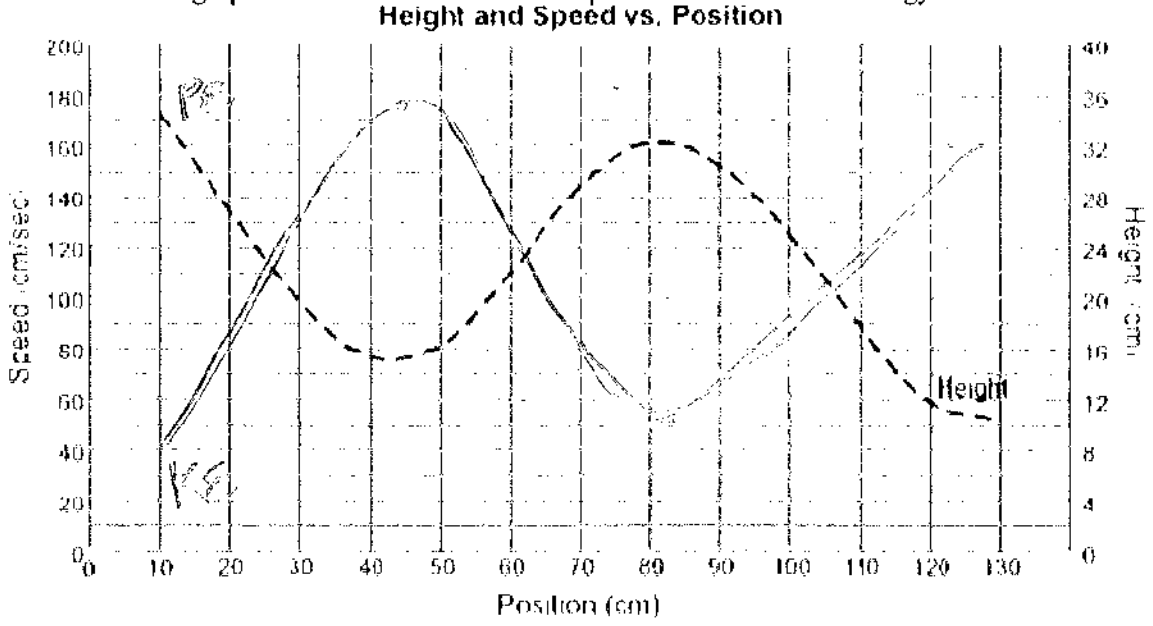
____ 6. Compare the speed of the marble at point #7 as the heavy steel marble and the light plastic marble roll down the Roller Coaster track.



a. The heavy marble will be faster at #7 because it has more mass.
b. The light plastic marble will be faster at #7 because it is less affected by gravity.
c. The speed of the two marbles will be virtually the same at point #7.
d. The heavy marble will be faster at #7 because gravity pulls it down more.

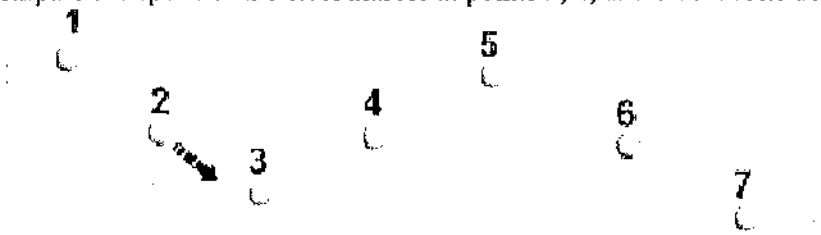
____ 7. Potential energy on our roller coaster systems is energy due to the:
a. motion of an object.
b. height of an object.
c. temperature of an object.
d. speed of an object.

____ 8. What does this graph from our Roller Coaster Experiment tell us about energy?



a. Total energy in a system stays the same.
b. The height of the Roller Coaster creates more potential energy
c. The speed of the marble is represented by the graph of potential energy
d. Potential energy and kinetic energy are never equal

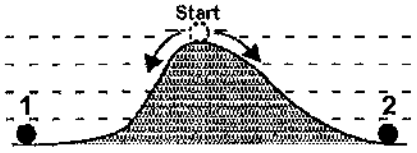
____ 9. Compare the speed of the steel marble at points 2, 4, and 6 as it rolls down the track.



a. It will be fastest at point 6 because it is rolling down the steepest hill.
b. The speed will be virtually the same at all 3 of these points on the track.
c. It will be fastest at 6, a little slower at 2, and a little slower at 4.
d. The speed of the marble will be fastest at 2 and 6 because it is rolling uphill on 4

____ 10. What happens to the potential energy of a marble on a hill if you move the marble twice as high on the hill?
a. It increases by 4 times
b. It increases by 2 times
c. It decreases by 4 times
d. It decreases by 2 times.

____ 11. Ball #1 is rolled down the steeper side of a hill while ball #2 rolls down the opposite side which is less steep. Both balls roll out onto a flat surface at the same level. Assuming there is no friction, how do the speeds of the balls compare when they reach the flat surface?

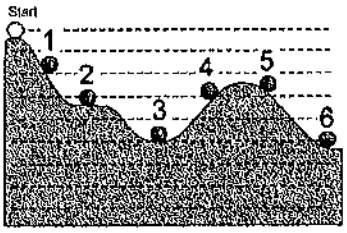


a. Ball #1 has the greater speed.
b. Ball #2 has the greater speed.
c. The speed will be the same for both balls.
d. Not enough information is given.

____ 12. As an object is raised to a higher position, which type of energy increases?
a. kinetic energy.
b. potential energy.
c. height energy.
d. light energy.

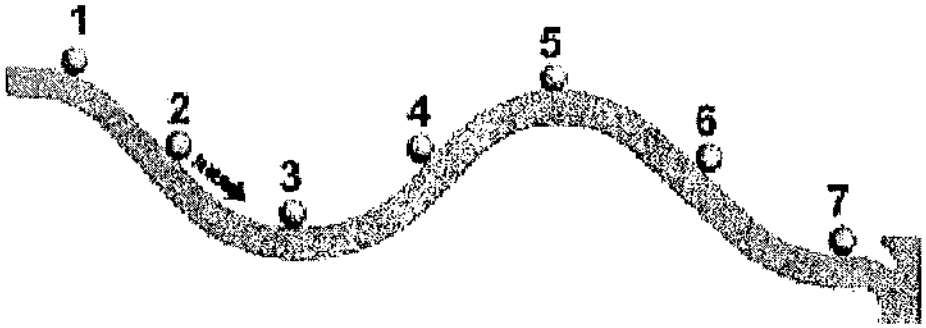
____ 13. When energy in a system is transformed, what happens to the total amount of energy in the system?
a. It increases.
b. It decreases.
c. It stays the same.
d. It goes to zero.

____ 14. A marble rolls along the track below with no friction. The sequence of positions on the track listed in order from the **lowest** kinetic energy to the **highest** kinetic energy is:



a. 1, 5, 4, 3, 6, 2
b. 1, 2, 3, 4, 5, 6
c. 1, 5, 4, 2, 3, 6
d. 6, 3, 5, 4, 2, 1

____ 15. On this Roller Coaster track, where would the heavy steel marble and the light plastic marble be moving the fastest?

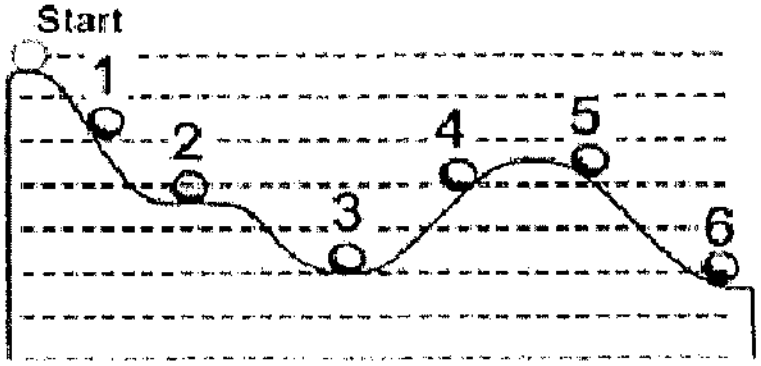


a. The plastic marble would be fastest at #3, the steel marble fastest at #7
b. They would both be fastest at point #7.
c. They would both be fastest at point #3
d. The plastic marble would be fastest at #2, the steel marble fastest at #3

____ 16. When a ball is thrown into the air, the potential energy gained must come from its kinetic energy. As the ball gains potential energy, its speed will:
a. increase.
b. decrease.
c. remain the same.
d. Not enough information is given.

____ 17. One way a person can create energy would be to
a. rub your hands together, creating heat energy
b. raise a ball higher in the air, creating more potential energy
c. turn on a light switch, creating light energy
d. energy cannot be created

____ 18. List the speed of the marble down the track at points 1 thru 6, from fastest to slowest.



a. 6, 3, 2, 5, 4, 1
b. 1, 5, 4, 2, 3, 6
c. 6, 3, 2, 4, 5, 1
d. 6, 5, 3, 4, 2, 1

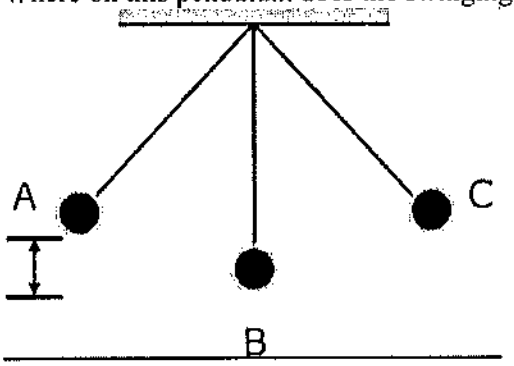
____ 19. Energy can never be created or destroyed
a. until all of the energy is gone
b. but sometimes energy does disappear
c. but it can be converted from one form to another
d. until you turn out the lights

____ 20. Which of the following phrases is the best synonym for Potential Energy?
a. Energy of Motion
b. Energy due to Gravity
c. Mechanical Energy
d. Stored Energy

____ 21. Imagine that you toss a ball up into the air. As the ball is rising, which of these statements is true?
a. Potential Energy is decreasing. Kinetic Energy is increasing.
b. Potential Energy is increasing. Kinetic Energy is decreasing.
c. Potential Energy does not change since gravity does not change.
d. There is no Potential Energy in the ball in this example.

____ 22. What force causes the Potential Energy to change to Kinetic Energy on our marble track?
a. Magic
b. Jedi Force
c. Gravity
d. Friction

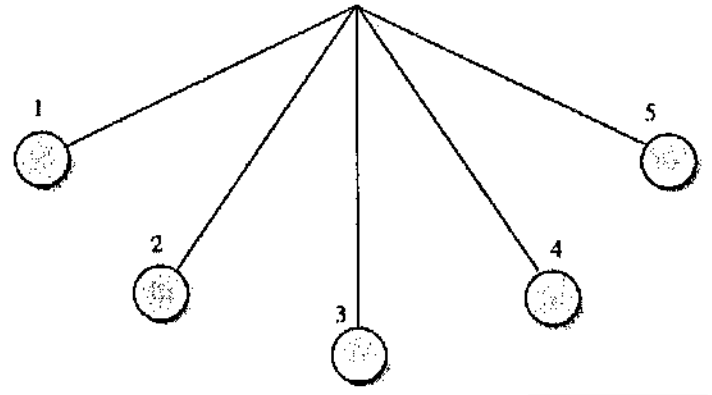
____ 23. Where on this pendulum does the swinging ball have the most Kinetic Energy?



a. Point A
b. Point B
c. Point C
d. There is not enough information to know

____ 24. To increase the Potential Energy of a marble on a roller coaster track you could
a. use a heavier marble
b. use a lighter marble
c. start the marble higher on the track
d. use a red marble

____ 25. Compare the speed of the ball at Point 2 and Point 4 as it swings on this pendulum from left to right.



a. It is faster at Point 2 than at Point 4 because it is going down
b. It is faster at Point 4 than at Point 2 because it is going up
c. It is the same speed at both Point 2 and Point 4
d. It depends on how heavy the ball is

Roller Coaster Physics
Answer Section

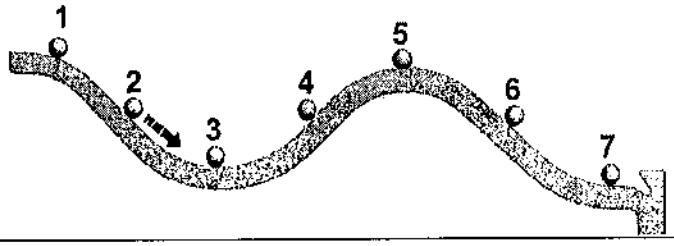
MULTIPLE CHOICE

1. ANS: B PTS: 1 DIF: intermediate REF: section 6.1
2. ANS: B PTS: 1 DIF: intermediate REF: section 6.1
3. ANS: A PTS: 1 DIF: intermediate REF: section 6.1
4. ANS: D PTS: 1 DIF: basic REF: section 7.1
5. ANS: C PTS: 1 DIF: basic REF: section 7.1
6. ANS: C PTS: 1
7. ANS: B PTS: 1 DIF: basic REF: section 7.1
8. ANS: A PTS: 1
9. ANS: B PTS: 1
10. ANS: B PTS: 1 DIF: intermediate REF: section 7.1
11. ANS: C
    Conversion from potential energy to kinetic energy is independent of the path. Both balls will have the same kinetic energy and same speed at the bottom since they both "fall" the same vertical distance.

    PTS: 1 DIF: advanced REF: section 7.1 | section 7.2
12. ANS: B PTS: 1 DIF: intermediate REF: section 7.3
13. ANS: C PTS: 1 DIF: intermediate REF: section 7.2
14. ANS: C PTS: 1 DIF: advanced REF: section 7.3
15. ANS: B PTS: 1
16. ANS: B PTS: 1 DIF: advanced REF: section 7.3
17. ANS: D PTS: 1
18. ANS: C PTS: 1
19. ANS: C PTS: 1
20. ANS: D PTS: 1
21. ANS: B PTS: 1
22. ANS: C PTS: 1
23. ANS: B PTS: 1
24. ANS: C PTS: 1
25. ANS: C PTS: 1

1. Roller Coaster Hypothesis

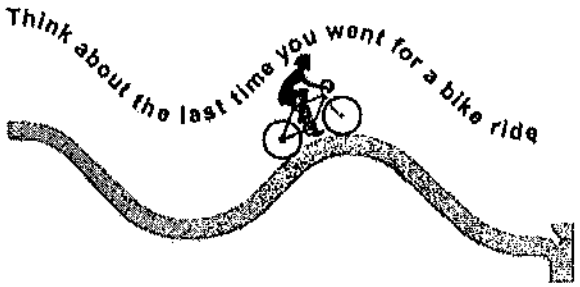
a. Think about the seven places in the diagram. If a marble is released from the top of the roller coaster and rolls down the track, where do you think the marble is moving the fastest? Choose one of the seven places and write down why you think that will be the fastest place.



b. Now that we have discussed this as a class, you may choose to revise your prediction, if you wish, or leave it the same. Respond on the lines below with your new prediction, AND your reason why you now believe this to be true.

c. Imagine that you release a light hollow plastic marble from the top of the hill instead of the heavy steel marble. Now, at which of the seven points do you think the marble is moving the fastest? Commit to a number, 1 thru 7, and explain your reasoning.

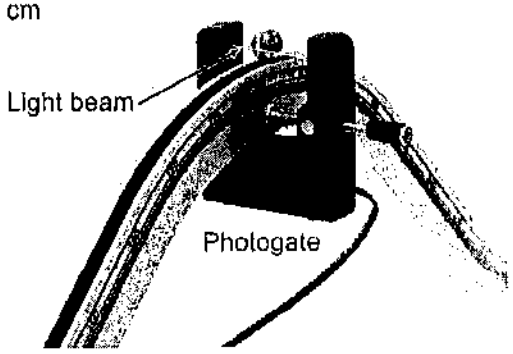
Energy Transformations on a Roller – Part 2



3. Testing your idea

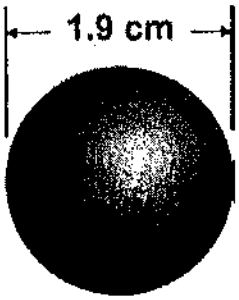
1. Set the timer in interval mode and plug a photogate into input "A."

$$\text{Speed} = \frac{\text{diameter (1.9 cm)}}{\text{time through photogate}}$$



2. Measure the time it takes the marble to roll through the photogate at each of the seven places. Be sure the photogate is pushed up against the bottom of the track.
3. The speed of the marble is its diameter divided by the time it takes to pass through the photogate. Find the speed of the marble at each position by dividing the diameter of the marble **(1.9 cm)** by the time through photogate A.

Remember: Speed is distance divided by time. The distance is the diameter of the marble, so the distance will always be 1.9cm.



The seven spots on the track where you will place the photogates are as follows.

Position 1: **4 cm**
Position 2: **27 cm**
Position 3: **43 cm**
Position 4: **62 cm**
Position 5: **84 cm**
Position 6: **108 cm**
Position 7: **127 cm**

Table 1: Speed of the Marble

Position	Distance (cm)	Time A (s)	Speed (cm/s)
1	1.9		
2	1.9		
3	1.9		
4	1.9		
5	1.9		
6	1.9		
7	1.9		

4. Stop and think

a. Which position was fastest?_____

b. Propose an explanation for why that place was fastest.

c. The marble has more **potential energy** (PE) at the top of the roller coaster than at the bottom. What happens to this energy?

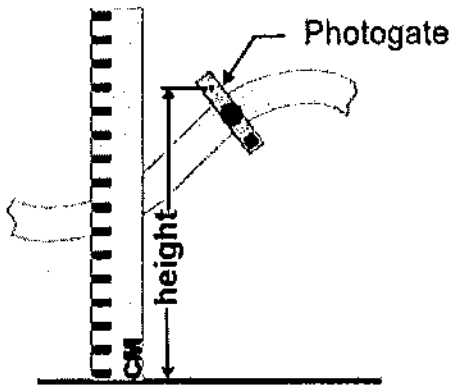
d. It takes energy to increase the marble's speed. Where does this energy come from?

Energy Conservation: Energy is NEVER lost, only converted

When the marble speeds up, it is gaining kinetic energy from falling down a hill. The kinetic energy is converted from the potential energy the marble had at the top of the hill. As the marble rolls the track along it trades potential and kinetic energy back and forth.

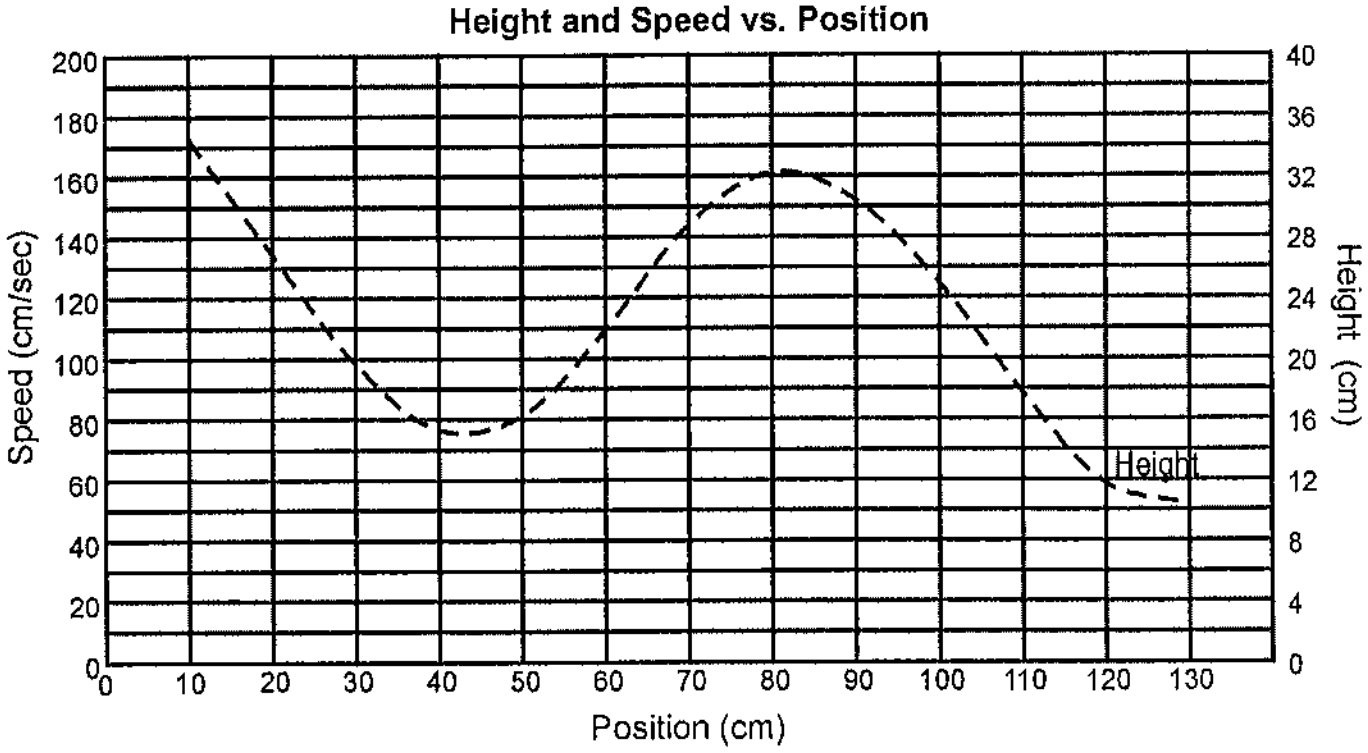
To measure the kinetic energy, we use the photogate to find the speed of the marble. To get the potential energy, we need to measure the height of the track where the marble is rolling. The light beam passes through the center of the marble, so you would measure the height from the table to the center of the hole for the light beam.

Lucky for you, we have already measured the height of the ramp and graphed it on the following page. The graph of the potential energy is simply the picture of the track.



5. Energy and change

1. On the graph below we see the drawing of Position vs. Height of the roller coaster. You are to now take the data you collected and put in the points of the Speed of the marble vs. Position. You have seven positions along the track where you can place a point. After you have those seven spots on the graph, connect them in the same manner that the other shows. It should be a somewhat curved line.



a. What does the graph tell you about the relationship between speed and height?

b. Explain the graph in terms of potential energy, kinetic energy, and total energy.

c. Where is the speed of the marble the greatest?

d. Describe the flow of energy between potential and kinetic energy along the roller coaster. Your answer should indicate where the potential energy is greatest and least along the track.