

## No Free Lunch

### Pre-Lab Assignment -20pts

Read the entire lab & Complete Pre-Lab in your lab composition notebook.

The first page is for Teacher Sign-offs that occur at various points in the lab:

Use the following format/example for the Teacher Signature Sign-off page.

You'll need to read the lab and create a table similar to the example below based on the # of sign-off points for the lab.

### Teacher Signature Sheet for ...No Free Lunch

Question Number	Section	Teacher signature
-----	Pre-lab	
3	Procedure	

*(this is only a partial table...you must READ through the lab and determine all the sign-offs)*

The second page begins the Pre-lab:

The pre-lab should follow the steps below:

Be sure to "label" each Heading of the pre-lab

Title of lab and unit (Conservation of Energy)

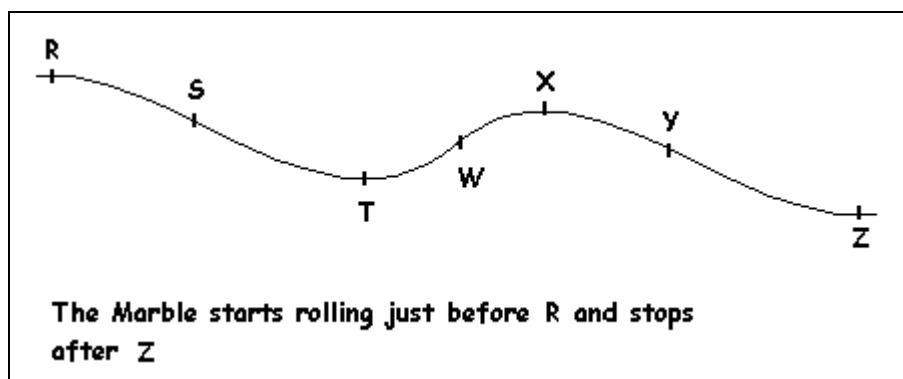
- **Definitions:** "Define" the following terms: energy, potential energy, kinetic energy, law of conservation of energy
- **Write** the equations for potential energy and kinetic energy
- **Read** through entire the lab and list the "key points" (as you determine)
- **Purpose:** In a sentence, write the purpose of the lab.
- **Procedure:** In a numbered list write what you will be doing.
- **Diagram:** Sketch and label the set-up of the investigation.
- **Preliminary Questions:** Write and answer all preliminary questions.
- **Copy** all data tables into your lab notebook.
- **Print** out lab
- Have your teacher initial your pre-lab before you begin the lab.

# No Free Lunch

## Introduction:

Throughout history people have searched for a free energy source. The perpetual motion machine has been invented countless times and touted over and over by many an inventor as such an energy generator. The idea of the perpetual motion machine is that you can put in a finite amount of energy and the machine will generate an infinite amount of energy in return. Unfortunately, there is a law of physics, man did not write it, that *states energy cannot be created nor destroyed, it can only change forms*. This means if you “generate” energy you are actually converting one form of energy into another. The U.S. Office of Patents has seen numerous applications for perpetual motion machines, each that claims more energy out than in is put in to the machine. These patent requests can be quickly denied due to the fact that it violates the law of conservation of energy. Some examples of energy changing forms are: you flip the light switch on in your room; the light bulbs convert electrical energy into light and heat energy. Energy stored in Lake Alatoona, a reservoir, is converted into kinetic, mechanical, and electrical energy as it passes through the turbines in the dam holding the water. The moral of this story is that there is no such thing as a free lunch with energy, you must have energy to “generate” energy. You will be investigating energy through the use of a roller coaster:

**Preliminary Questions:** Answer on your individual paper. Note you may choose “it stays the same” for any of these questions; the wording is not meant to exclude that possibility. **You will need to copy the diagram of the coaster track in your lab notebook.**



1. At which point on the roller coaster will the ball have the greatest **speed**? (If friction is negligible)
2. At which point on the roller coaster will the ball have the most **total energy**? (If friction is negligible)
3. At which point on the roller coaster will the ball have the most **kinetic energy**? (If friction is negligible)
4. At which point on the roller coaster will the ball have the most **potential energy**? (If friction is negligible)

**Available Materials** (Get only the materials you need as you read through the procedure):

1 physics stand  
1 roller coaster

1 CPO Timer II  
▶ 2 photogates

1 steel marble – step #6  
1 half-meterstick

## Procedure:

1. Attach the roller coaster to the fifth hole from the bottom of the Physics Stand.
2. Measure the height (from the table) of the roller coaster track at each position. **Record this in Data Table #2.**
3. **Have your teacher approve your data before continuing.**

In order to determine the speed at each point on the roller coaster you will need to use the photogates to measure the time it takes for the marble to pass each point. **Since you have two photogates you can determine the times for two points at a time.**

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4. Setting-up and using the photogates:  
(for a description w/ diagrams refer to the CPO Investigations Book, p. 2-3)
  - a. Be sure the photogate is flush up against the bottom of the roller coaster.
  - b. The timer should be in the **interval mode**.
  - c. The timer will start when the marble first blocks the light beam of the photogate and will stop timing when the light beam is no longer blocked. The resulting time is how long it took the marble to pass that point on the roller coaster. This will allow you to calculate an “instantaneous” speed.
  - d. When the “A” light is lit the timer displays the time for the marble to pass through photogate “A”. When the “B” light is lit the timer displays the time for the marble to pass through photogate “B”.
  - e. Test the photogates with your finger to be sure it works.
5. You may now ask for your marble. Measure the mass (kg) and the diameter (m) of your marble.  
**Record these values in Data Table #2.**
6. Do a few test rolls of your marble to be sure it rolls all the way to the end without falling off.
7. Measure and **record the time** for the marble to pass each position on the roller coaster. Perform three trials for each position and record each time. **Record your trials in Data Table #1.**
8. Be careful not to change anything about the roller coaster until you have the data for all seven points on the roller coaster.
9. Calculate your average times in Data Table #1 then transfer those average times to Data Table #2.
10. **Have your teacher approve your data before beginning the analysis.**

**Analysis: K-U-E-S are to be done individually as indicated.**

The following applies to #1, 7, & 9: (a) For groups of three: Each group member should show K-U-E-S for at least two different speeds and **one member** needs to do the last. (b) For groups of four: Each group member should show K-U-E-S for at least two different speeds. There will be a duplicate set of K-U-E-S.

1. Calculate the speed of the marble at each position. **Record these values in Data Table #2.**
2. **Have your teacher approve one member’s K-U-E-S**
3. Construct a graph with Graphical Analysis that will show both height and speed on the vertical axis and position on the horizontal axis. **Save your graph as “roller”.**
4. Using your graph, describe the relationship between the marble’s speed and the height of the roller coaster.
5. **Have your teacher approve your graph before continuing.** *Print the graph*

Potential energy is stored energy. In this activity the stored energy is due to the marble’s position relative to the table. This energy is equal to the energy required to lift it to its height. That energy is the weight of the marble multiplied by the height.

6. Calculate the weight of the marble (**K-U-E-S**)
7. Calculate the potential energy of the marble at each position. **Record these values in Data Table #2.**
8. **Have your teacher approve one member’s K-U-E-S**

Kinetic energy is the energy due to motion. In order to determine the kinetic energy you need the mass of the marble and the speed of the marble. The equation for kinetic energy is:

$$KE = \frac{1}{2} mv^2$$

9. Calculate the kinetic energy of the marble at each position. **Record these values in Data Table #2.**
10. **Have your teacher approve one member’s K-U-E-S**

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11. Construct a graph on Graphical Analysis that will show kinetic energy and potential energy on the vertical axis and position on the horizontal axis. **Save your graph as “coaster” in your class period folder.**
  12. Using your graph, describe the relationship between the marble’s kinetic energy and potential energy as it rolls along the roller coaster.
  13. **Have your teacher approve your graph before continuing.** *Print the graph*
  14. Determine the total energy of the marble at each point on the roller coaster. Explain how you determined the total energy. Explain why that is the correct method.
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### **Individual Report (25 pts) to be done on your own time!**

#### Cover Sheet

Title, name, group, group members, date, class period

#### Conclusion

Now that you have completed the lab procedure,

- **Restate** purpose of lab
- **Re-answer** all **four** of the preliminary questions. Then explain why you were right or how you changed your thinking if you were wrong. Must include data from lab for support.
- Based on the **results & graphs** of this investigation, describe the **relationship** between:
  1. speed of the marble & the height
  2. marble’s kinetic & potential energy as it rolls along the roller coaster
- **Identify** possible sources of error or factors influencing the lab, including equipment and student technique.
- **Describe, using proof of lab data & observations, whether or not the law of conservation of energy was supported in the lab. Use data to defend your answer.**

### **Group Participation & Report (15 pts)**

#### Cover Sheet

Title, group, group members, date, class period

#### Group Participation & Graphs

- **Both graphs (in order)**
- **Group participation (ability to work as a group member Including working & staying on task in group, using lab time wisely, keeping work station clean & proper use & care of equipment**

#### Lab Notebook Scoring (60 pts)

pre-lab – 20pts  
data approval #3 – 2 pts  
data approval #10– 10 pts  
K-U-E-S approval #2 – 5 pts  
A#5 approval – 4 pts  
K-U-E-S approval #8 – 5 pts  
K-U-E-S approval #10 – 6 pts  
A#12 approval – 4 pts  
A#14 approval – 4 pts

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Copy these data tables in your lab notebook

### Data Table #1

Coaster Location	Time thru photogate (s)			Average Time (s)
	Trial			
	1	2	3	
R				
S				
T				
W				
X				
Y				
Z				

### Data Table #2

	Position (cm)	Height above table (m)	Marble diameter (m)	Avg. Time (s)	Speed (m/s)	Kinetic energy ( )	Potential Energy ( )	Total Energy ( )
R	2.50							
S	25							
T	42.5							
W	62.5							
X	84							
Y	110							
Z	123							

Marble Mass (kg)	
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