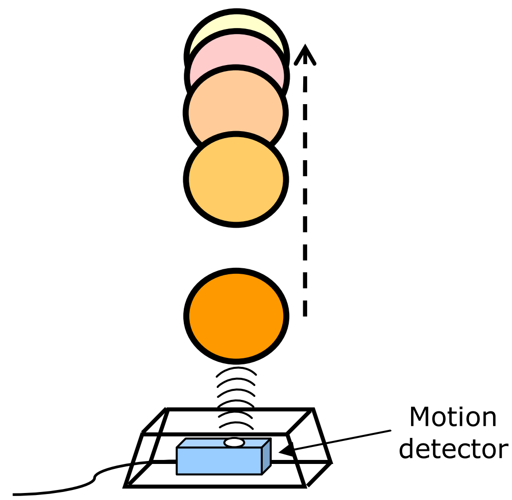
Experiment: Energy of a Tossed Ball

OBJECTIVES

1. Measure the change in the kinetic and potential energies as a ball moves in "free fall".
2. See how the total energy of the ball changes during free fall.

INTRODUCTION

When a juggler tosses a bean ball straight upward, the ball slows down until it reaches the top of its path and then speeds up on its way back down. In terms of energy, when the ball is released it has kinetic energy, *KE*. As it rises during its free-fall phase it slows down, loses kinetic energy, and gains gravitational potential energy, *PE*. As it starts down, still in free fall, the stored gravitational potential energy is converted back into kinetic energy as the object falls.



If there is no work done by frictional forces, the total mechanical energy will remain constant. In this experiment, you will observe whether or not this works out for the toss of a ball. In addition, you will study the energy transformations for the ball using a Motion Detector.

MATERIALS

- LabPro Interface
- Logger *Pro*
- Vernier Motion Detector
- basketball or other similar ball
- wire basket

PRELIMINARY QUESTIONS

Consider a ball tossed straight upward in free-fall motion, from just as the ball is released to just before it is caught. Assume that there is essentially no air resistance.

1. What form or forms of energy does the ball have while momentarily at rest at the top of the path?

2. What form or forms of energy does the ball have while in motion near the bottom of the path?

3. Sketch a graph of velocity *vs*. time for the ball.

4. Sketch a graph of kinetic energy *vs*. time for the ball.

5. Sketch a graph of potential energy *vs*. time for the ball.

6. If there are no frictional forces acting on the ball, how is the change in the ball's potential energy related to the change in kinetic energy?

PROCEDURE

1. Measure and record the mass of the ball you plan to use in this experiment.
2. Start LoggerPro software then open the experiment file, "16 Energy of a Tossed Ball".
3. Connect the Motion Detector to CH 2 of the LabPro Interface. Place the Motion Detector on the floor and protect it by placing a wire basket over it.
4. Practice the ball toss by holding the ball directly above and about 0.5 m from the Motion Detector. Toss the ball <u>straight</u> upward above the Motion Detector and let it fall back toward the Motion Detector. Catch the ball before it hits the sensor but stay out of the way of the motion detector signal, or your measurements will look screwy.
5. Begin data collection then toss the ball straight up after you hear the Motion Detector start to click (use two hands for stability). Be sure to pull your hands away from the ball after it starts moving so they are not picked up by the Motion Detector.
6. Verify that the distance *vs*. time graph corresponding to the free-fall motion is parabolic in shape, without spikes or flat regions. If the distance time graph look jagged or "spiky", try it again. If necessary, repeat the toss, until you get a good graph. When you have good data on the screen, proceed to the Analysis section.

DATA TABLE 1.

Mass of the ball	**(kg)**	

Position	**Time (s)**	**Height (m)**	**Velocity (m/s)**	**PE (J)**	**KE (J)**	**TE (J)**
After release						
Top of path						
Before catch						

ANALYSIS

1. Use the Examine tool in LoggerPro, perform the following:
   a. Identify the portion of each graph where the ball had just left your hands and was in free fall. Determine the height and velocity of the ball at this time. Enter your values in the data table.
   b. Identify the point on each graph where the ball was at the top of its path. Determine the time, height, and velocity of the ball at this point. Enter your values in the data table.
   c. Find a time where the ball was moving downward, but a short time before it was caught. Measure and record the height and velocity of the ball at that time.
   d. For each of the three points in the data table, calculate the Potential Energy (*PE*), Kinetic Energy (*KE*), and Total Energy (*TE*). *Use the position of the Motion Detector as the zero of your gravitational potential energy*.
2. How well does your data demonstrate conservation of energy? Explain.

3. Change the top graph's vertical axis label to display Kinetic Energy, *KE*.
4. Enter the mass of the ball in the parameter box *(lower right hand corner)*.
5. Inspect the kinetic energy *vs.* time graph for the tossed ball. Explain its shape.

6. Change the bottom graph's vertical axis to display Potential Energy, *PE*.
7. Inspect your potential energy *vs.* time graph for the free-fall flight of the ball. Explain its shape.

8. Cut-&-paste the two energy graphs into Word

Question: Compare your original energy graph predictions to the real data for the ball toss. How do they compare?

9. Use Logger *Pro* also calculate ball's Total Energy, i.e. the sum of *KE* and *PE*. Create a new graph to display Total Energy, *TE,* vs. time.
10. Cut-&-past the total energy graph into Word then print all 3 graphs on a single sheet of paper.

Final Questions:

1. Summarize what you can conclude from the graphs about the total energy of the ball as it traveled up then down in free fall.
   a. Does the total energy remain constant? Explain.

   b. Should the total energy remain constant? Why?

   c. If it does not, what sources of extra energy are there or where could the missing energy have gone? Explain.

2. Summarize how would your responses to the previous questions might change in this experiment if you used a very light ball, like a beach ball.
   a. Would the total energy remain constant? Explain.

   b. Should the total energy remain constant? Why?

   c. If it would not, what sources of extra energy are there or where could the missing energy have gone? Explain.

3. *If time permits*, repeat the original experiment using a light ball or balloon.

DATA TABLE 2. A LIGHT BALL

Mass of the ball	**(kg)**	

Position	**Time (s)**	**Height (m)**	**Velocity (m/s)**	**PE (J)**	**KE (J)**	**TE (J)**
After release						
Top of path						
Before catch						

4. How do the experimental results for the light ball compare to your predictions above?