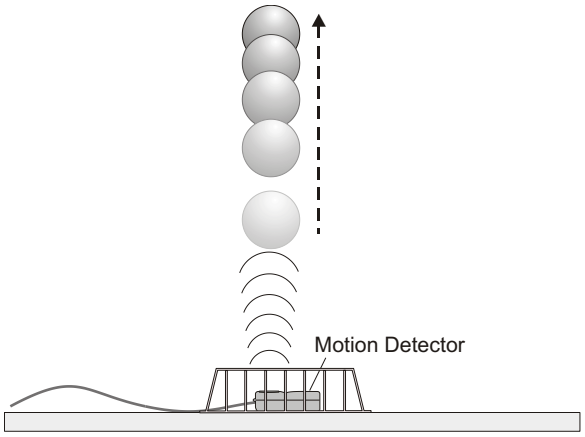
Physics I – Lab #6

Part I – Energy in a Tossed Ball

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 energy will remain constant. In this experiment, we will see if this works out for the toss of a ball.



OBJECTIVES

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

PRELIMINARY QUESTIONS

For each question, consider the free-fall portion of the motion of a ball tossed straight upward, starting just as the ball is released to just before it is caught. Assume that there is very little 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.

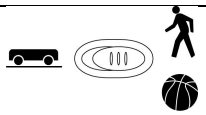
5. Sketch a graph of potential energy *vs*. time for the ball.

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. Connect the Motion Detector to the DIG/SONIC 1 channel of the interface. If the Motion Detector has a switch, set it to Normal. Place the Motion Detector on the floor.



3. Open the file "16 Energy of a Tossed Ball" from the *Physics with Vernier* folder.

4. Hold the ball directly above and about 1.0 m from the Motion Detector. In this step, you will toss the ball straight upward above the Motion Detector and let it fall back toward the Motion Detector. Have your partner click Collect to begin data collection. Toss the ball straight up after you hear the Motion Detector begin to click. Use two hands. Be sure to pull your hands away from the ball after it starts moving so they are not picked up by the Motion Detector. Throw the ball so it reaches maximum height of about 1.5 m above the Motion Detector. Verify that the position *vs*. time graph corresponding to the free-fall motion is parabolic in shape, without spikes or flat regions, before you continue. This step will require some practice and, likely, multiple trials. **Repeat the toss until you get a good graph – one free of spikes or flat regions**. When you have good data on the screen, proceed to the Analysis section.

DATA TABLE

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. Click on the Examine button, , and move the mouse across the position or velocity graphs of the motion of the ball to answer these questions.
   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 your 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 your 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 your 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 this part of the experiment show conservation of energy? Explain.

3. Calculate the ball's kinetic and potential energy.
   a. Logger *Pro* can graph the ball's kinetic energy according to $KE = \frac{1}{2} mv^2$ if you supply the ball's mass. To do this, adjust the mass parameter.
   b. Logger *Pro* can also calculate the ball's potential energy according to $PE = mgh$. Here m is the mass of the ball, g the free-fall acceleration, and h is the vertical height of the ball measured from the position of the Motion Detector. The same mass parameter will be used to finde PE.
   c. Go to the next page in Logger Pro by clicking on the Next Page button, .

4. Inspect your kinetic energy *vs.* time graph for the toss of the ball. Explain its shape.

5. Inspect your potential energy *vs.* time graph for the free-fall flight of the ball. Explain its shape.

6. Print the two graphs.

7. Compare your energy graphs predictions (from the Preliminary Questions) to the real data for the ball toss.

8. Logger *Pro* also calculates Total Energy, the sum of *KE* and *PE*, for plotting. Print that graph out, as well.

9. What do you conclude from this graph about the total energy of the ball as it moved up and down in free fall? Does the total energy remain constant? Should the total energy remain constant? Why? If it does not, what sources of extra energy are there or where could the missing energy have gone?

Part II – Energy of a Bouncing Ball

Conduct a similar experiment using a bouncing ball. You should mount the Motion Detector high and pointed downward so it can follow the ball through several bounces. ***Think carefully about the modifications you will need to make to the way energies are calculated by Logger Pro*** (you will need to make a ***small*** change to one of the equations for energy calculations by going into Data -> Column Options).

Conduct at least two trials – one with simply dropping the ball and the other with giving the ball some initial push towards the ground. Print out graphs for each of your trials.

Make sure to sketch your experimental setup (with annotations of height/distance) and record the relevant data in your lab notebook.

ANALYSIS

1. Use Logger Pro to determine the KE, PE, and total energy after each bounce. Record these values in your lab notebook and annotate the graphs you printed out.

2. Determine the energy lost to non-conservative forces (e.g friction, air resistance) for the bouncing ball for each bounce. Does it appear that more energy is lost during the bounce (i.e. when it hits the floor) or during the subsequent flights through the air? What does this tell you about *where* energy is lost?

3. Is the same amount of energy lost every time or is more lost in early/late bounces?

4. Is there a difference between the fractional energy loss (i.e. change in energy / total energy) for the simply dropped ball vs. the ball that is thrown down?

5. Where does the energy go? What experiment could you devise to measure this energy loss directly?

Try a similar experiment with a different type of ball. Is the energy loss more with the different balls? Less? Is there a correlation between the energy loss and the “bounciness" of the ball?