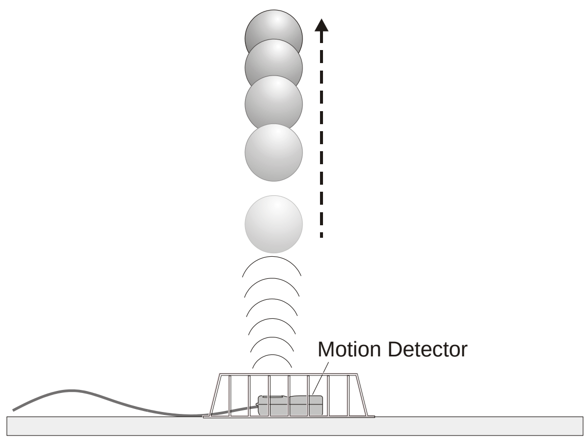
Mechanical Energy Conservation

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.



In this experiment, we will study these energy changes using a Motion Detector.

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.

MATERIALS

computer
Vernier computer interface
Logger *Pro*
Vernier Motion Detector
volleyball, basketball, or other similar, fairly heavy ball
wire basket

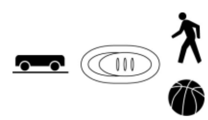
PRELIMINARY QUESTIONS

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 momentarilly 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 and protect it by placing a wire basket over it.



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 may require some practice. If necessary, repeat the toss, until you get a good graph. When you have three good data runs, record each run and then analyze these three runs and compare results. Confirm with your TA that you have good data on the screen for each run and then proceed to the Analysis section.

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 $KE = ½\ mv^2$ 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 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. Record the two energy graphs by printing or sketching.

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

8. Logger *Pro* will also calculate Total Energy, the sum of *KE* and *PE*, for plotting. Record the graph by printing or sketching.

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?

10. What would change in this experiment if you used a very light ball, like a beach ball?

11. What would happen to your experimental results if you entered the wrong mass for the ball in this experiment?

DATA TABLE

RECORD FOR EACH OF YOUR THREE TRIALS

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						