

ENERGY OF A TOSSED BALL

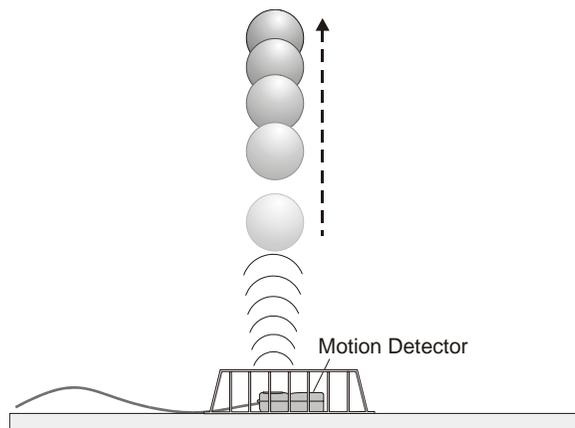
LAB MECH 15. CALC (Version 1)

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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 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.

PURPOSE

The purpose of this experiment is to measure the kinetic and potential energies of a ball moving vertically undergoing free-fall due to gravity and to study changes in these energies and the total energy during the free-fall.

MATERIALS

LabPro or CBL 2 interface
TI Graphing Calculator
DataMate program
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 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 its 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 Vernier Motion Detector to the DIG/SONIC 1 port of the LabPro or the DIG/SONIC port of the CBL 2 interface. Use the black link cable to connect the interface to the TI Graphing Calculator. Firmly press in the cable ends.
3. Place the Motion Detector on the floor and protect it by placing a wire basket over it.
4. Turn on the calculator and start the DATAMATE program. Press **CLEAR** to reset the program.
5. In this step, you will toss the ball straight upward above the Motion Detector and let it fall back toward the Motion Detector. This step may require some practice. Hold the ball directly above and about 0.5 m from the Motion Detector. 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. Select **START** to begin data collection. You will notice a clicking sound from the Motion Detector. Wait one second, then toss the ball straight upward. Be sure to move your hands out of the way after you release it. A toss of 0.5 to 1.0 m above the Motion Detector works well. You will get best results if you catch and hold the ball when it is about 0.5 m above the Motion Detector.
6. After data collection is complete press **ENTER** to view the distance graph.
7. Examine the distance *vs.* time graph. Repeat Step 5 if your distance *vs.* time graph does not show a region of smoothly changing distance. Check with your instructor if you are not sure whether you need to repeat the data collection. To repeat data collection, press **ENTER** to return to the **SELECT GRAPH** menu; select **MAIN SCREEN** and then **START** to repeat data collection.

DATA TABLE

Mass of the ball	(kg)
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Position	Time (s)	Height (m)	Velocity (m/s)	PE (J)	KE (J)	TE (J)
After release						
Between release and top						
Top of path						
Between top and catch						
Before catch						

ANALYSIS

- To analyze only the free-fall portion of the data you must discard all other data:
 - Press **ENTER** to return to the GRAPH menu.
 - It is easiest to select the proper region using the velocity graph. Use the **▲** and **▼** cursor keys to select VELOCITY.
 - Select SELECT REGION.
 - Using the cursor keys move the flashing cursor to the beginning of the straight-line, negative-slope region. This portion corresponds to free fall.
 - Press **ENTER** to select the left (lower) bound.
 - Use the cursor keys **◀** and **▶** to move the flashing cursor to the end of the straight-line section, corresponding to free fall.
 - Press **ENTER** to select the right (upper) bound.
 - Press **ENTER** again to see your selected data.
- To explore the energy of the ball (kinetic and potential) at various moments during the motion, you can trace across the graph using the cursor keys and read positions and velocities at certain times. Record the following times and velocities in your Data Table: Trace to the moment just after the ball was released into free fall, then when the ball was at the top of the path (where velocity was about zero), and then just before the free-fall motion ended. Choose two more points approximately halfway in time between the three recorded so far. You should now have five times and velocities.
- Now read the position of the ball at the same five times. Press **ENTER** and choose DISTANCE to see the distance graph. Trace across the graph to the same five times you used in the previous step and record the corresponding distances in the Data Table.
- For each of the five 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.

5. How well does this table you have just completed show conservation of energy? Explain.

EXTENSIONS

1. What would change in this experiment if you used a very light ball, like a beach ball?
2. What would happen to your experimental results if you entered the wrong mass for the ball in this experiment?
3. Try 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.