NRG lab

Purpose: To investigate the relationship between the kinetic energy and the gravitational potential energy of a bouncing ball.

Set-up:
For this lab you will need to set up a motion sensor and Airlink and have it linked to the Capstone software. Change the sign for the motion sensor by going to "*Data Summary*" and clicking on the icon to the right of "*Motion Sensor*" and click the box for "*Change Sign*" then "*OK*". Click on "*Data Summary*" again to exit this window. Set the sampling rate to 100 Hz. Set up a *Position vs Time* graph and a *Velocity vs Time* graph on Capstone; think about what information you need from these graphs to calculate an object's gravitational potential energy **and** kinetic energy. You will also need to obtain a book (or any medium sized object that you can drop on the floor) and a large bouncy ball.

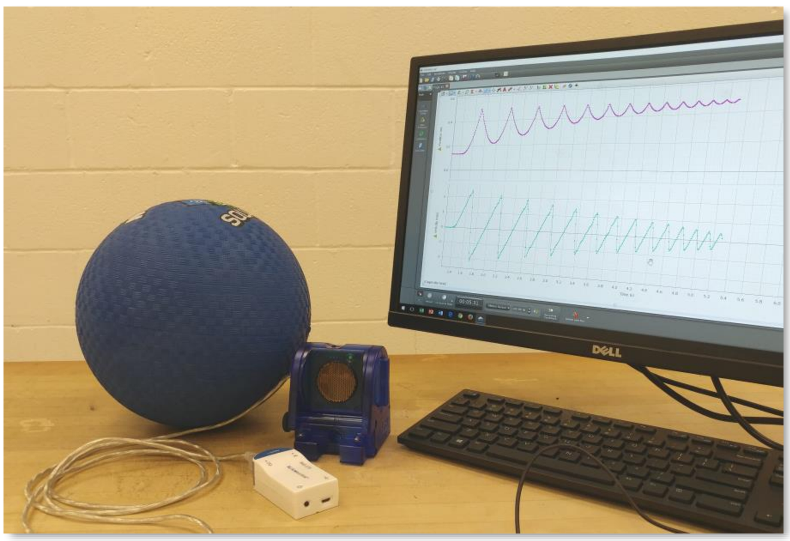

Fig. 1 - Setup to Investigate Potential and Kinetic Energy

Activity 1: Calculating the Potential Energy, Kinetic Energy, and Total Energy

Obtain a book (or a similar object) from your bag. Have one group member hold the motion sensor in the air (about chest high) so that it is aimed at the floor. Have another group member hold the book about 15 cm below the sensor. Your third group member should start and stop the data collection. The objective is to drop the book so that it falls directly underneath the motion sensor and obtain a *Position vs Time* graph and a *Velocity vs Time* graph as the book drops to the floor. Start the "*Record*" button while the book is being held stationary under the sensor and then let the book drop. Do a couple of test trials to improve your technique; also try the different beam settings on the motion sensor (cart or person) and determine which gives the best result.

Once you are confident with your technique, record a run as the book drops to the floor. Make sure you get a clean run that should look like the graphs in Figure 1.

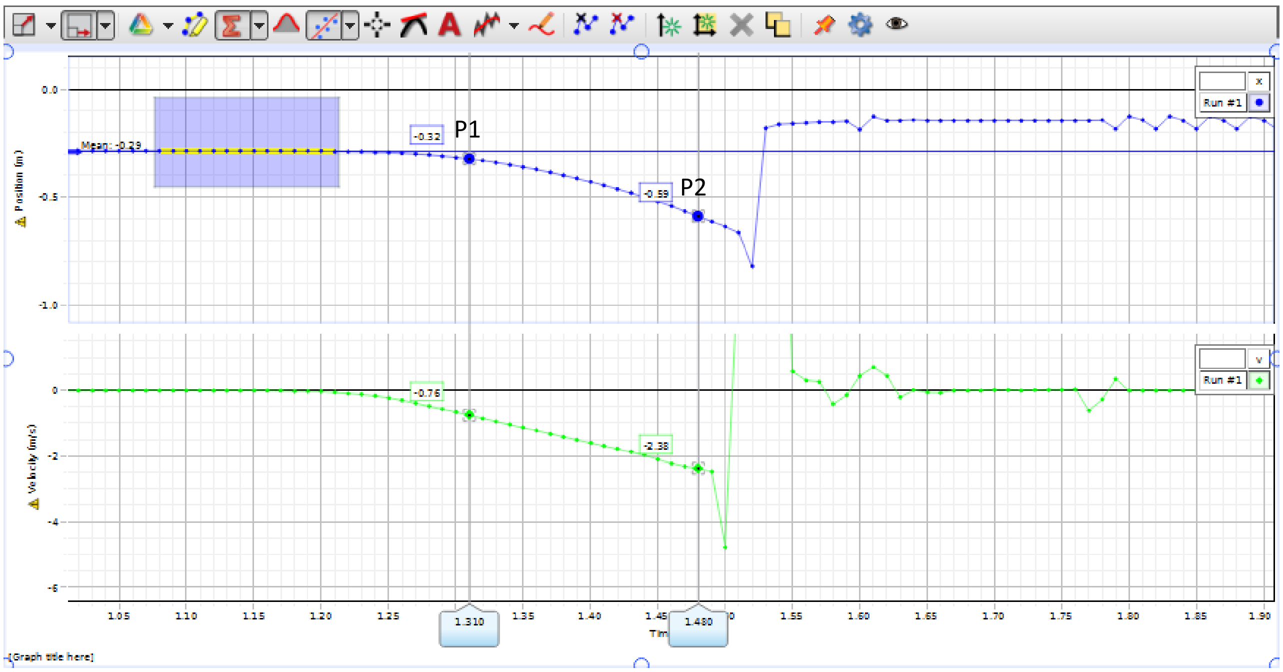

Fig. 1 - *Position vs Time* and *Velocity vs Time* graphs for a falling book

Discussion/Questions:

1. Identify regions in your resulting plots and describe the position and velocity of the book at each of the regions that you identified.
2. Identify the region where the ball is being held stationary. Use the highlighting tool and the statistics tool to determine the initial position of the ball. Record this value.
3. Using the multicoordinate tool , identify a point (P1) where the book has started dropping. Using the same process, identify a point (P2) before the book hits the floor. Record the position and velocity for each of these 2 points.
4. On the *Position vs Time* graph, use the tool to identify the lowest position recorded for the book (just use the 'clean part' of the plot) before it crashed to the floor. This point will be used as the reference position for zero potential energy. Using this position as the reference, what is the height of the book before it was dropped? at P1? at P2?
5. Calculate the potential energy of the book at when it was at P1 and when it was at P2. Similarly, calculate the kinetic energy of the book at each of those positions. Show all the calculations in your report.
6. Calculate the total energy of the book for each of the two positions P1 and P2. Show your calculations and results. Compare the two values of total energy obtained. Does your result conform with expected theoretical results?
7. Calculate the total energy of the book before it dropped. How does it compare to the results on (6) above?
8. Printout your Capstone graphs showing the points P1 and P2 and mark the regions that you identified in (1) above. Write the names of the members of the group on the printout.
9. Discuss your results with the staff and have them check off on your work before proceeding to Activity 2.

Activity 2: Calculating the Total Energy of a Bouncy Ball

Hold the motion detector in the air (about knee high) and drop the bouncy ball underneath the sensor and record the motion of the ball just like you did in Activity 1. Your goal is to obtain the best graph(s) possible for the entire motion of the ball from the time it drops until it comes to rest, or at least 4 complete bounces. Make sure you understand the resulting graphs – look at the graphs and identify the point when the ball touches the floor and the point where the ball is at its highest point during the bounce.

Discussion/Questions:

10. Identify the point in the *Position vs. Time* graph where the ball hits the floor. Use this point as the reference for zero potential energy. Using this point as the reference, how do you calculate the height of the ball at any given point on the flight of the ball? What is the maximum height reached by the ball in each of the first 3 consecutive bounces?

On your clean run, use the multi-coordinate tool  to mark five points during the first bounce. Those points could be: one third of the way to the top of the bounce; two thirds of the way to the top of the bounce; at the top of the bounce; one third of the way back down; and two thirds of the way back down.

For each of these five points, get the pertinent data that you need and determine the kinetic energy and gravitational potential energy at each point during the bounce. Use the reference point for zero potential energy identified in question (10) above in your calculations. Record the data and energy values in a clearly labeled and easy to understand data table using Excel.

Repeat the process and obtain and record data as discussed above for a total of three (3) consecutive bounces.

Print out a copy of the graph with the points used in the calculations marked. Print a copy of the completed data table. Write the names of the group members on the printouts.

Discussion/Questions:

11. Describe what happens to the potential energy and kinetic energy of the ball as it goes through one bounce.
12. What happens to the total energy of the ball as it goes through one bounce? Describe what your data table shows. Pick two points during one bounce and show the calculation of the total energy at each point to support your answer. It is not enough to simply provide a table or list some numbers!
13. What happens to the total energy of the ball from one bounce to the next? Describe the results based on your data table. Why do you think this happens? Pick a point from one bounce and pick another point from the next consecutive bounce and show the calculation of the total energy of the ball for each of these 2 points to support your answer. It is not enough to simply provide a table or list some numbers!