Lab 8: Exploring Energy

Goals: Gain more experience seeing a data logger with a motion detector to measure motion; Gain more practice using LoggerPro software; Gain more experience with graphical representations of motion; Calculate kinetic energy, potential energy, and mechanical energy for a bouncing ball, a half-Atwood machine, and a vertical mass-spring system.

Equipment: Data collection will occur as a group using a motion detector, and then you will work at your own computer.

Groups & Lab Notebook: You should work at your own computer and complete the exercises on your own. Consultation with neighbors is allowed and encouraged though your individual learning is important. Update your Table of Contents. General Lab Notes guidelines apply.

Part 0: Data Collection

a) As a group, we will collect motion detector data for a bouncing ball, for a cart on a horizontal track attached via string over a pulley to a vertically falling mass (a "half-Atwood machine"), and for a vertical spring-mass system.
b) Take notes on procedures and record any data collected separately from the LoggerPro files.

Part 1: Bouncing Ball Energy Analysis

a) Copy the bouncing ball data file from the Handouts: Lab 8 folder to your Cubbie.
b) Using Data: New Calculated Column, calculate a column for kinetic energy as follows:
   - for Name: Kinetic Energy
   - for Short Name: K
   - for Units: J
   - for Expression (or Equation), type in the formula for kinetic energy as follows, using the numerical value for the ball mass that we measured, and finding "Velocity" under Variable(Columns)>. Type the formula using this form: 0.5*mass*"Velocity"^2 (note: you will enter in the measured value for the mass instead of typing in mass)
   - Click Done when done
   - If you have a data table displayed, this may be added automatically; otherwise you might need to Display the column on the table
c) Similarly, calculate a column for Gravitational Potential Energy, with Name: Gravitational Potential Energy, Short Name: U_G, Units: J. You should be able to figure out the expression to enter (note that you will need to type in 9.8 and not just g and that the height of the ball is given by "Position").
d) Now, calculate a column for Total Mechanical Energy, with Name: Total Mechanical Energy, Short Name: E_mech, Units: J. You should find your previous calculated columns for Kinetic Energy and Gravitational Potential Energy in the Variable(Columns)> drop down menu.
e) Make three separate graphs:
   - 1) Kinetic Energy vs. Time
   - 2) Gravitational Potential Energy vs. Time, and
   - 3) Total Mechanical Energy vs. Time.
   - Zoom your graphs horizontally to show 3 good bounces and vertically to fill the white space.
   - Each graph should have the same horizontal values.
   - Make sure these graphs show individual data points.
f) Make a 4th graph that shows each of Kinetic Energy, Gravitational Potential Energy, and Total Mechanical Energy (vs. Time) on the same graph. Zoom your graph horizontally as before (showing 3 good bounces), matching the horizontal values in the first 3 graphs.
g) Make a 5th graph, a version of the 4th graph that shows just one region of time while the ball is clearly in the air (and away from the bounce events).
h) Make a copy of this last graph in LoggerPro (use Copy and Paste), and modify the graph to produce a 6th graph that is a bar graph version of Graph 5 (you will find this option in the same place where you adjust your graph to show individual data points).
i) Discuss your graphs with an instructor.
j) Copy (and label as needed) each of the 6 graphs to your Word document for later printing and inclusion in your lab notebook. Make sure that graphs 1 – 4 are the same size for ease in direct comparison. Similarly, graphs 5 and 6 should also be the same size.
k) Save this file to your Cubbie with a useful name.

Part 2: Half-Atwood Machine Energy Analysis

a) Draw a sketch of the experimental set-up in your lab notes.
b) Copy the half-Atwood machine data file from the Handouts: Lab 8 folder to your Cubbie.
c) As you did before, create columns for kinetic energy, gravitational potential energy, and mechanical energy.
d) As you did before, make graphs showing Kinetic Energy vs. Time, Gravitational Potential Energy vs. Time, and Total Mechanical Energy vs. Time.
e) Consult with an instructor. It is very easy for you to have done your energy accounting incorrectly.
f) If needed after consultation with your instructors, adjust your energy formulas.
g) Produce 5 graphs:
  - 1) Kinetic Energy vs. Time
  - 2) Gravitational Potential Energy vs. Time
  - 3) Total Mechanical Energy vs. Time
  - 4) All three energies vs. Time on the same graph
  - 5) A bar graph version of the previous graph

h) Copy your 5 graphs, etc. Save file, etc.

Part 3: Half-Atwood Machine With Friction Energy Analysis

a) Draw a sketch of the experimental set-up in your lab notes.
b) Copy the half-Atwood machine with friction data file from the Handouts: Lab 8 folder to your Cubbie.
c) As you did before, create columns for kinetic energy, gravitational potential energy, and mechanical energy.
d) Make graphs showing Kinetic Energy vs. Time, Gravitational Potential Energy vs. Time, and Total Mechanical Energy vs. Time.
e) What do you notice about the Total Mechanical Energy vs. Time? What sense can you make of this?
f) Copy your 3 graphs, etc. Save file, etc.

Part 4: Vertical Spring-Mass Energy Analysis

a) Draw a sketch of the experimental set-up in your lab notes.
b) Copy the vertical spring-mass data file from the Handouts: Lab 8 folder to your Cubbie.
c) You will repeat the analysis exactly as you did for the bouncing ball, though for graphs 1 – 4, instead of 3 bounces, include 5 full oscillations, and for graphs 5, zoom in on just one oscillation (no need for a bar graph version).
d) What do you notice about Total Mechanical Energy, specifically contrasted with the case while the bouncing ball was in the air (away from any bounce events)? What can you conclude based on your analysis?
e) If we say that because of our observation of the repeated motion, the Total Mechanical Energy must be conserved, what sense can you make of your results?
f) Discuss with an instructor.
g) Copy your 6 graphs, etc. Save file, etc.

Extensions

- From the ball bouncing data, plot E_mech vs. bounce number. Does the ball lose the same amount of mechanical energy after each bounce? Does it lose the same fraction of mechanical energy after each bounce? Can you find an equation that models the mechanical energy loss?
- From the vertical spring-mass data and analysis, see if you can account for Spring Potential Energy by calculating it and adjusting your Total Mechanical Energy to include it. This is a challenging task including involving some research on material we have not yet covered.