Experiment 5: Invariant Quantities

Gravitational Potential – Hills

1. A marble rolls down 2 different hills. The hills are identical in surface and height, except one hill is straight the entire way, and the other is steep in the beginning and becomes gradually flatter at the end.

    a. Draw a sketch of the hills overlaid on each other.

    b. Predict how the *time* to reach the bottom of the hill will compare.

    c. Predict how the approximate *final speeds* at the bottom of the hill will compare.

    d. Design an experiment to explore the situation in #1. Describe your procedure including how you will make a quantitative measure of the final speed. Discuss the *average speed* of the two marbles.

    e. Perform this experiment and describe your results.

2. Now imagine a third hill shape, again the same height as the others but it is “S” shaped: fairly flat, then steep, then flat at the end, with gradual changes throughout.

    a. Sketch this hill, overlaid on the sketch in 1a, above.

    b. Predict how the time to reach the bottom of the hill will compare to both hills in #1.

    c. Predict how the speed at the bottom of the hill will compare to both hills in #1.

    d. Test this situation. What were your results?

The Simple Pendulum

There are four basic variables to the pendulum: period, mass, amplitude, and length.

- The *period* is the time it takes to complete one full swing forward and back.
- The *amplitude* is the angle from which the pendulum is released.
- The *length* is measured from the pivot to the center of gravity of the mass.

We're going to look at how the variables of mass, amplitude, and length affect the period.

1. Obtain the following materials: string, paper clip, 3 washers or nuts (heavy in comparison to the paper clip), stopwatch, meter stick

2. Design and perform experiments to investigate the 3 problems given below. For each experiment:

   a. state a hypothesis. (Think about the difference between "hypothesis" and "guess.")
   b. explain your procedure, clearly identifying constants, independent and dependant variables.
   c. produce a data table.
   d. state and explain your conclusion.

3. Before you start:

   a. How can you minimize the effect of stopwatch errors on the measured period?

   b. How can you make sure you are only changing one variable at a time? E.g., Question 1 asks you to find the effect of mass on the period; how do you prevent the variables of amplitude and length from confounding the effect of mass?

Problem 1*:* What is the effect of the mass of a pendulum on its period?

Problem 2: What is the effect of amplitude (or release angle) of a pendulum on its period? Note: Pendulums behave differently when the release angle becomes "large." Keep release angles below 20 degrees from the vertical. (Even a very slight swing of a few degrees is fine.)

Problem 3: What is the effect of length of a pendulum on its period? On this part, take at least 5 readings, over a wide range of lengths (e.g., 10cm to 80cm).

4. Graph the variable that most affected the period versus the period. Remember to put the I.V. on the horizontal axis and the D.V. on the vertical axis.

5. You will probably find this is not a linear relationship. Using the procedure from Lab 2, find what kind of relationship it is (you need not find the "k").

Experiment 5: Post Lab Exploration

1. You are sledding and have your choice of 2 different slopes, both covered by well-packed snow. They have an identical drop of 7 meters vertically. However, one slope is steeper than the other. You notice the sled doesn't even need a nudge to start coasting.

   a. What does the last sentence tell you about friction?

   b. How will the times compare for reaching the bottom of each slope?

   c. How will the speeds compare at the bottom of each slope?

   d. Where do you have the most potential energy?

   e. Where do you have the least potential energy?

   f. Where do you have the most kinetic energy? (Kinetic energy is the energy of motion.)

   g. Where do you have the least kinetic energy?

2. Pendulums were often used for clocks before the electronic age (a slowly falling weight was used to "power" the pendulum, i.e., counteract the small friction that would eventually bring it to a stop.) Why do you think the pendulum was chosen for precise clocks? How would you fine-tune the accuracy of such a clock?