Energy and Work - MBL

In this experiment you will use a cart, a track, and an ultrasonic motion sensor to investigate the friction between the cart and the track. You will do this from an energy perspective.

PROCEDURE

Part I – On the level (the track should be horizontal, in other words).

1. Initially, the track should be level. Check this by setting the cart on the track. If it rolls one way or the other, level the track using the adjustable feet on the track supports.

2. You may find it useful to set a zero point for position. Position the cart at a convenient zero point. Then, from the Experiment menu, select Zero, and choose “Zero Distance”. The motion sensor will click as it reads the cart’s position. Make sure the cart is stationary, and nothing is between the cart and the motion sensor, when the zeroing is going on.

3. Give the cart a push along the track, collecting data as you do so. You should see two graphs, one of the cart’s velocity as a function of time and another with the cart’s velocity as a function of position.

4. Let’s plot the cart’s kinetic energy instead of the cart’s velocity. To do this you will need to get the software to calculate the kinetic energy for you. To do this, go to the Data menu and select “New Column”, and then “Formula”. Enter the name of the new column, an abbreviated version of the name, the units, and then select the Definition tab. Set up an appropriate equation. Hint: you should use “Velocity” from the Variable pull-down menu.

5. When you successfully set up a column with the kinetic energy, you should then display it on the graphs instead of the Velocity. By clicking on the y-axis of each graph, where it says Velocity, you can access a list of the columns you can plot on the y-axis. Un-check the Velocity and check the Kinetic Energy instead. Do this for both of the graphs.

6. What you should observe is that the cart’s kinetic energy decreases because of the work done by friction. Following the procedure outlined above, set up a new column that represents the energy lost to friction (another way to say this is that it is the energy transformed to thermal energy).

Question 1: We expect only one of the kinetic energy graphs (K vs. time, or K vs. position) to be linear. Which one should be linear? Do you observe it to be approximately linear?

7. Plot the energy lost to friction on the graphs that show the kinetic energy. With the aid of the graphs, and possibly with the aid of other columns you may want to set up, determine the effective coefficient of kinetic friction associated with the cart moving on the track.

Question 2: What did you determine the effective coefficient of friction to be? In your lab book, describe clearly how you determined it.

Part II – On an incline.

1. Now incline the track and take data showing the cart’s kinetic energy and the energy lost to friction.

Question 3: Do you need to modify your equations giving kinetic energy and energy lost to friction because the track is now on an incline? If so, describe what needs to be modified.

2. Now we also need to account for the fact that the cart’s gravitational potential energy is changing. Set up a new data column to show the cart’s gravitational potential energy. Hint – you may want to make use of the fact that the cart’s height relative to the origin is given by $h = X\sin(\theta)$, where X is the position measured by the motion sensor, and θ is the angle at which the track is inclined. It is easiest to just put a number in for the value of $\sin(\theta)$, rather than using the sine function built into the software. (Note: the equation for h may need a minus sign, depending on what direction the motion sensor is taking to be positive.)

3. Set up another new column to show the cart’s total mechanical energy (the sum of the gravitational potential energy and the kinetic energy), and plot this on the graphs.

4. Once again, with the aid of the graphs, and possibly with the aid of other columns you may want to set up, determine the effective coefficient of kinetic friction associated with the cart moving on the track.

Question 4: What do you get for the effective coefficient of kinetic friction now? Once again, describe clearly in your lab book how you obtained the value.

Question 5: How do your two values of the effective coefficient of kinetic friction compare? Comment on any discrepancies you observe.

Question 6: If you have time, set up the track so it is horizontal again and see if you can figure out whether the effective coefficient of friction depends on the cart’s speed.