# Pre-Lab Information

Purpose Experimentally observe how an object’s position and velocity change while it is moving with a constant acceleration.

Time Approximately 50 minutes

Question How does an object’s position and velocity change as the object accelerates?

Hypothesis If the angle of the track increases, then the acceleration of the cart increases, because a greater track angle increases the cart’s velocity.

Variables *Independent Variable:* angle of the track

*Dependent Variable:* acceleration of the cart

*Constant*: mass

**Summary** You will set up a dynamics track and allow a cart to move down the inclined track. A sensor will be used to measure the time and corresponding displacement of the cart. Complete three trials using different track angles to compare results, and then calculate the average velocity of the cart for each of the three track angles. Construct position vs. time and velocity vs. time graphs, and determine the acceleration of the cart from the graph of velocity vs. time.

# Safety

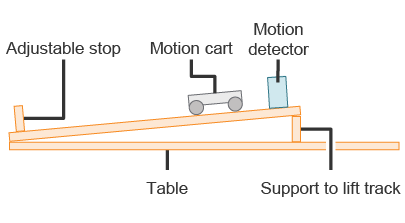
* Always wear safety goggles when performing an experiment, especially with objects in motion.
* Make sure you understand the proper use and assembly of the cart, track, and sensors.
* Use caution when assembling and adjusting the dynamics track. Dynamics tracks may have sharp edges or other parts that may pinch hands or fingers.
* Behavior in the lab needs to be purposeful.
* Report all accidents–no matter how big or small–to your teacher.

# Lab Procedure

1. **Gather materials.**

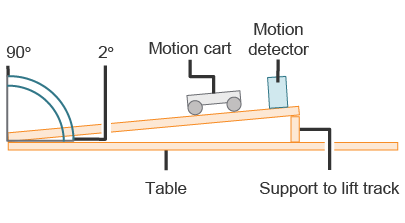
|  |  |
| --- | --- |
| * 1 dynamics track (1.2 m) * 1 low-friction dynamics cart (500 g mass) * 1 sonic motion sensor | * 1 LabQuest© data collector with USB cord * Logger Pro© software * Horizontal extension clamp or books * Protractor |

1. **Use this diagram as a guide to set up your track.**



* 1. Assemble the dynamics track on a level table with one end elevated. Use a support stand with a horizontal extension clamp to place the elevated end of the track on, or just place books under the elevated end of the track.
  2. Set up the track with a bumper restraint or adjustable stop so the cart cannot roll off the track. Assign a person to catch the cart just before it hits the adjustable stop during each trial.
  3. Set the motion sensor at the top end of the track, pointing down the track.

1. **Elevate one end of the track so the angle between the track and the table is 2°.**



* 1. The 0° or 180° angle of the protractor must be at the level of the table top.See the diagram above, which shows where to place the protractor to get that angle. The 90° angle of the protractor must be perpendicular to the table and directly over the end of the track.
  2. The gap between the track and the table should be at the 2° angle line as read on the protractor.

1. **Position the cart approximately 1 meter from the adjustable stop and run the trial.**
   1. You may want to mark the position to ensure that you start the cart consistently from the same place each time. Assign a person to hold the cart in place and release it for each trial.
   2. Trigger the start of the Logger Pro© software as you release the cart. This will record displacement, time, and velocity data.
   3. Once the trial is done, record the displacement and velocity data in Table A.
2. **Perform more trial runs at different track angles.**
   1. Elevate the track to perform two more runs to collect data: one at a 5° angle and one at a 10° angle. Use your protractor to confirm that the angle of the track is correct before each run.
   2. Record the data for each run in Table A.
3. **Calculate average velocities for each run.**
   1. Calculate the average velocity of the cart for each angle of the track. Remember the formula for average velocity, which is the total displacement (Δ*x*) over the total elapsed time (Δ*t*):

*vavg* = Δ*x*/Δ*t*

Record your answers in Table B.

* 1. Compare the average velocities with the interval velocities recorded in your table. You may see that maximum velocities are different from the average velocity. Include your observations in your lab report as part of your analysis.

1. **Graph your results to examine position over time.**
   1. Construct a position vs. time graph using the displacement and elapsed time data for the 2° track angle. Elapsed time should be on the *x*-axis, and displacement on the *y*-axis.
   2. Draw a single line of best fit through the data points.
   3. Plot the displacement and elapsed time data for the 5° track angle and the 10° track angle on the same graph. You may need to adjust the scale of the *y*-axis to accommodate the greater displacements from the 10° track angle.
   4. Draw a line of best fit through each set of data points.
   5. Title the graph and label the axes with units.
   6. Compare each line in terms of its slope. The slope of each line represents the velocity of the cart at the different track angles. Below your graph, write down your interpretations of the graph.
2. **Graph your results to determine acceleration.**
   1. Construct a velocity vs. time graph using the velocity and elapsed time data for the 2° track angle. Elapsed time should be on the *x*-axis, and velocity on the *y*-axis.
   2. Draw a single line of best fit through the data points.
   3. Plot the velocity and elapsed time data for the 5° track angle and the 10° track angle on the same graph. You may need to adjust the scale of the *y*-axis to accommodate the higher velocities from the 10° track angle.
   4. Draw a line of best fit through each set of data points.
   5. Title the graph and label the axes with units.
   6. Compare each line in terms of its slope. The slope of each line represents the acceleration of the cart at the different track angles. Below your graph, write down your interpretation of the graph.
   7. Use the graph to determine the acceleration of the cart for each of the three track angles. Be sure to calculate the slope of the line of best fit. Record your answers in Table C.
3. **Clean up the lab.**
   1. Put away the track, motion cart, and other equipment in locations specified by your teacher.

# Data

Record your data either in your lab notebook or in the tables below.

**Table A**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Angle of Track** | **2°** | | **5°** | | **10°** | |
| **Elapsed Time**  ***t***  **(s)** | **Displacement**  **Δ*x***  **(m)** | **Velocity**  ***v*= Δ*x*/*t***  **(m/s)** | **Displacement**  **Δ*x***  **(m)** | **Velocity**  ***v*= Δ*x*/*t***  **(m/s)** | **Displacement**  **Δ*x***  **(m)** | **Velocity**  ***v*= Δ*x*/*t***  **(m/s)** |
| 0.1 |  |  |  |  |  |  |
| 0.2 |  |  |  |  |  |  |
| 0.3 |  |  |  |  |  |  |
| 0.4 |  |  |  |  |  |  |
| 0.5 |  |  |  |  |  |  |
| 0.6 |  |  |  |  |  |  |
| 0.7 |  |  |  |  |  |  |
| 0.8 |  |  |  |  |  |  |
| 0.9 |  |  |  |  |  |  |
| 1.0 |  |  |  |  |  |  |
| 1.1 |  |  |  |  |  |  |
| 1.2 |  |  |  |  |  |  |
| 1.3 |  |  |  |  |  |  |
| 1.4 |  |  |  |  |  |  |
| 1.5 |  |  |  |  |  |  |
| 1.6 |  |  |  |  |  |  |
| 1.7 |  |  |  |  |  |  |
| 1.8 |  |  |  |  |  |  |
| 1.9 |  |  |  |  |  |  |
| 2.0 |  |  |  |  |  |  |

**Table B**

|  |  |
| --- | --- |
| **Angle of Track** | **Average Velocity (m/s)** |
| 2° |  |
| 5° |  |
| 10° |  |

**Table C**

|  |  |
| --- | --- |
| **Angle of Track** | **Acceleration (m/s2)** |
| 2° |  |
| 5° |  |
| 10° |  |