# Pre-lab Information

**Purpose** Exploremotion by determining the speed and acceleration of an objectusing a laboratory procedure.

Time Approximately 45 minutes

Question How can motion be described?

Hypothesis If the starting height of a sloped racetrack is increased, then the speed at which a toy car travels along the track will increase because the toy car will have a greater acceleration.

Variables *Independent variable:* The height of the starting point

*Dependent variable:* The speed of the toy car

Summary Construct a sloped racetrack and mark four reference points along the track. Then, measure the time that it takes for the car to travel past the reference points, and calculate the car’s speed. Alter the track by raising the starting position while keeping the overall length the same, and then repeat the procedure. Graph the results from the two tracks to compare the speed and acceleration of each set of conditions.

# Safety

* Always wear safety goggles when performing an experiment, especially with objects in motion.
* Use caution when constructing the track. Longer racetracks may yield better results, but they may be more difficult to build, maintain, and protect.
* Make sure that the track is clear and that group members with timers are ready before releasing the cars.
* Behavior in the lab needs to be purposeful. Remember that this is a serious experiment, even if you get to use toy cars in the process.
* Report all accidents—no matter how big or small—to your teacher.

# Lab Procedure

1. **Gather Materials**

|  |  |  |
| --- | --- | --- |
| * Multiple sections of plastic rain gutter, with connectors, if needed * One toy racecar appropriate for the size of the track | * Four stopwatches * A meter stick or metric measuring tape * Masking tape | * Books, blocks, or other material to raise and support the racetrack * A marker, pen, or pencil |

1. **Build the Racetrack**
   1. Assemble multiple segments of the racetrack (the rain gutter) to a length appropriate for the space you are working in. Longer tracks and gentler grades may make it easier to measure time, but may be more difficult to build. Do your best to minimize bends or curves in the track, as well as changes in slope. Ask your teacher for guidance as needed. In Table A record the length, in centimeters, of your track.
   2. Calculate a starting height for your track that is 10% of the track’s length. You will increase this to 15% in the next set of trials. These heights allow for reasonable timing of your car. Cars that go fast may be fun, but timing them accurately may be difficult. Perform a trial run at both heights to ensure that your setup is reasonable. In Table A record the heights, in centimeters, of both the lower track and the higher track.
   3. Divide the length of your racetrack (from Table A) by 4 to calculate the distance of each of the four quarters of your racetrack. These four distances will become your checkpoints for the lab. Use the meter stick or measuring tape to mark off these checkpoints with masking tape or marker and label them with the appropriate distance in centimeters. Record these distances in Table A.
   4. Convert the length of the racetrack, the checkpoint distances, and the lower and higher heights of the racetrack from centimeters to meters. Record your answers in Table A. Then record the appropriate racetrack heights and checkpoint distances, in meters, in the left column of Tables B and D.



1. **Measure the Speed of the Toy Car on the Lower Track**
   1. Position one person with a stopwatch at each of the four checkpoints along the racetrack.
   2. Position the car at the top of the ramp so that it begins its motion from rest.
   3. When the person holding the car says, “Go,” the car is released down the track and the stopwatches are started.
   4. As the car passes a checkpoint, the person at that location stops the stopwatch and notes its time. At the end of each run, record all four times, in seconds, in Table B.
   5. Repeat steps 3a–d twice more for this height. Then calculate the average time and record your answer in Table B.
   6. In Table C, calculate the elapsed time for each quarter of the track. Elapsed time equals Time (Final) – Time (Initial). Time (Initial) is the time at which the car starts that quarter of the track (which is zero for the first quarter of the track, and equal to the end time of the previous quarter for the other three). Time (Final) is equal to the average time for each quarter checkpoint from Table B.
   7. Calculate the speed of the car at each checkpoint by dividing the distance between each checkpoint, in meters, (which is the same for each quarter; see Table A) by the elapsed time calculated in step 3f. Record your answers in Table C.
2. **Increase the Height of the Racetrack**
   1. Raise the starting point of the racetrack to the height calculated in Table A, and record this height in Table D. Remember to provide support under your track to keep it as straight as possible.
3. **Measure the Speed of the Toy Car on the Higher Track**
   1. Position one person with a stopwatch at each of the four checkpoints along the racetrack.
   2. Position the car at the top of the ramp so that it begins its motion from rest.
   3. When the person holding the car says, “Go,” the car is released down the track, and the stopwatches are started.
   4. As the car passes a checkpoint, the person at that location stops the stopwatch and notes its time. At the end of each run, record all four times in seconds in Table D.
   5. Repeat steps 5a–d twice more for this height. Then calculate the average time and record your answer in Table D.
   6. In Table E, calculate the elapsed time for each quarter of the track. Elapsed time equals Time (Final) – Time (Initial). Time (Initial) is the time at which the car starts that quarter of the track (which is zero for the first quarter of the track, and equal to the end time of the previous quarter for the other three). Time (Final) is equal to the average time for each quarter checkpoint from Table D.
   7. Calculate the speed of the car at each checkpoint by dividing the distance between each checkpoint, in meters, (which is the same for each quarter; see Table A) by the elapsed time calculated in step 5f. Record your answers in Table E.
4. **Construct Graphs**
   1. Follow these directions to construct graphs of your data. Sketch your graphs in Section 2 of your Lab Report Guide.
   2. Construct a graph to show distance traveled as a function of time for each racetrack. First, plot the distance traveled versus the average time for the lower track. Then, plot the distance traveled versus the average time for the higher track on the same graph.
      * + 1. Label this as Figure A and provide it with an appropriate title.
          2. Visually assess the slope of each line on the graph to estimate under which set of conditions the car had greater speed.
   3. Construct a graph to show speed as a function of time for each racetrack. First, plot the average speed versus the elapsed time for the lower track. Then, plot the average speed versus the elapsed time for the higher track on the same graph.
      * + 1. Label this as Figure B and provide it with an appropriate title.
          2. Visually assess the slope of each line to estimate under which set of conditions the car experiences the greater acceleration.
5. **Disassemble the Racetrack According to Your Teacher’s Directions, and Return Materials to Their Designated Areas**

# Data

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

**Table A: Measurements of the Racetrack**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Units** | **Length of**  **Racetrack**  **(D)** | **Length of Quarters**  **for Checkpoints**  **(D/4)** | **Height of Lower Racetrack**  **(10% of D)** | **Height of Higher Racetrack**  **(15% of D)** |
| cm |  |  |  |  |
| m |  |  |  |  |

**Table B: Time Recorded at Checkpoints for Lower Racetrack**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Height at Start \_\_\_\_ m** | **Time of**  **Trial #1**  **(s)** | **Time of**  **Trial #2**  **(s)** | **Time of**  **Trial #3**  **(s)** | **Average**  **Time**  **(s)** |
| **¼ Checkpoint**  **\_\_\_\_ m** |  |  |  |  |
| **½ Checkpoint**  **\_\_\_\_ m** |  |  |  |  |
| **¾ Checkpoint**  **\_\_\_\_ m** |  |  |  |  |
| **Finish Line**  **\_\_\_\_ m** |  |  |  |  |

**Table C: Average Speeds for Lower Racetrack**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Time (Initial)**  **(s)** | **Time (Final)**  **(s)** | **Elapsed Time**  **(s)** | **Average Speed (m/s)** |
| **1st ¼ of the Track** |  |  |  |  |
| **2nd ¼ of the Track** |  |  |  |  |
| **3rd ¼ of the Track** |  |  |  |  |
| **Final ¼ of the Track** |  |  |  |  |

**Table D: Time Recorded at Checkpoints for Higher Racetrack**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Height at Start \_\_\_\_ m** | **Time of**  **Trial #1**  **(s)** | **Time of**  **Trial #2**  **(s)** | **Time of**  **Trial #3**  **(s)** | **Average**  **Time**  **(s)** |
| **¼ Checkpoint**  **\_\_\_\_ m** |  |  |  |  |
| **½ Checkpoint**  **\_\_\_\_ m** |  |  |  |  |
| **¾ Checkpoint**  **\_\_\_\_ m** |  |  |  |  |
| **Finish Line**  **\_\_\_\_ m** |  |  |  |  |

**Table E: Average Speeds for Higher Racetrack**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Time (Initial)**  **(s)** | **Time (Final)**  **(s)** | **Elapsed Time**  **(s)** | **Average Speed**  **(m/s)** |
| **1st ¼ of the Track** |  |  |  |  |
| **2nd ¼ of the Track** |  |  |  |  |
| **3rd ¼ of the Track** |  |  |  |  |
| **Final ¼ of the Track** |  |  |  |  |