Downhill Race

Overview: The force that is acting on an object is equal to its mass times the amount of acceleration acting on it at any given time. Now the thing to be careful of when trying to calculate this is that this force that is being used to calculate this is the net force. Remember from earlier lessons that net force is all of the forces being added together (in the same axis). When you add up the net force of you standing still, you would take the force of gravity (-490 N) and the normal force (490 N). Add them together and the net force is 0 N. If a = F/m, then a = 0 N/50 kg, and the acceleration = 0 m/s^2. So remember that F=ma works, but only when the F is actually F_{NET}.

What to Learn: You may notice that when things move they rarely move at the same speed all the time. Especially when you drive, you can see right away that your speed is constantly changing. When your speed changes, you are accelerating. You can be either speeding up or slowing down. The type of acceleration we deal with, especially in introductory physics, is uniform acceleration, which means that it is accelerating at a constant rate.

Materials

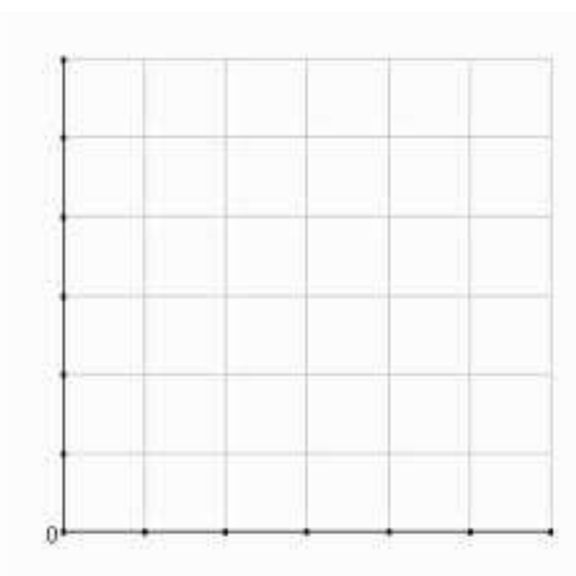
- sloping surface(such as a driveway, a board propped on one end as a ramp, or a table propped on one end)
- toy car or ball (to roll)
- stopwatch
- pen
- tape
- block or textbook

Lab Time

1. Raise the wooden ramp up, but not very tall, about 1-2 inches is fine.
2. Place the toy car at the top of the ramp and make a mark with a piece of tape (It doesn't matter if you place the mark at the front or back of the car, just be consistent. If you place the mark at the back, take the mark at the back at each set time interval)
3. Release the car and start the stopwatch. At the 1 second mark, note the location of the car and place a piece of tape or make a mark somehow.
4. Repeat this for 2 more trials to get a total of 3 trials at 1 second.
5. Continue this for up to time intervals up to 6 seconds

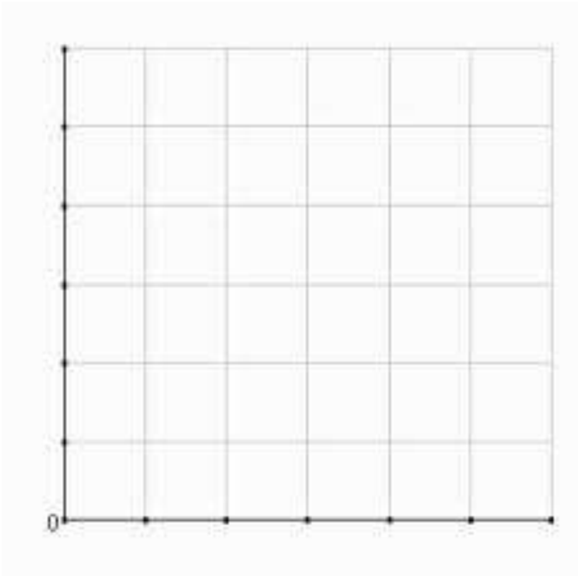
Downhill Races Data Table

Trial #	Trial 1 Distance	Trial 2 Distance	Trial 3 Distance	Average



Graph the results below with time on the x-axis and distance in the y-axis using the grid here.

Now graph the results with the distance on the y-axis and time on the x-axis, but square the time and take half of it.



Reading

What I'm hoping you will see here is that the car accelerates from zero to a certain velocity but then stays at that velocity as it continues down the driveway. In other words, it reaches its terminal velocity. If you timed and marked the distances, you should see that the car goes the same distance each second if it is indeed staying at a constant velocity. If the object you are using to roll down the slant continues to accelerate down the entire ramp, see if you can find something that has more friction to it (a toy car that doesn't roll quite to easily, for example).

Ok, so what's going on? F=ma right? Acceleration can't happen without force. What two forces are affecting the car? (Imagine the "Jeopardy" theme song here). If you said gravity and friction, give yourself a handshake. When the car is going at a constant velocity, is it accelerating? Nope, acceleration is a change in speed or direction.

"But you just said two forces are affecting my little car and that force causes acceleration and yet my car is not accelerating. Why not?"

Well, there's one little thing I haven't mentioned yet, which is why we did this experiment. In this case, the force of gravity pulling on the car and the force of friction pushing on the car are equal (remember, that's terminal velocity right?). So the net force on the car is zero. The pulling force is equal to the pushing force so there is zero force on the car. Force is measured in Newtons (name sounds familiar right?) so imagine that there are 3 Newtons of force pulling on the car due to gravity and 3 Newtons of force pushing on the car due to friction. 3 – 3 = 0. Zero force equals zero acceleration because you need force to have acceleration. By the way, 1 Newton is about the same amount of force that it takes to lift a full glass of milk.

Exercises Answer the questions below:

1. You should notice a difference between these graphs and the ones from the driveway races. What is it? (Hint: look to second half of the graph.)

2. The first graph doesn't continue to curve, but straightens out. What does this mean about the velocity?

3. in the second graph, the slope flattens out completely, what does this mean about the acceleration?

4. If the acceleration is zero, what does that mean about the net force?

5. What are the forces acting on the toy car as it is going down the ramp?

6. Name 3 other examples

Answers to Exercises: Downhill Races

1. You should notice a difference between these graphs and the ones from the driveway races. What is it? (Hint: look to second half of the graph. The graph stopped curving!)
2. The first graph doesn't continue to curve, but straightens out. What does this mean about the velocity? (It was a constant velocity after about 3 seconds.)
3. In the second graph, the slope flattens out completely, what does this mean about the acceleration? (The acceleration stopped.)
4. If the acceleration is zero, what does that mean about the net force? (The net force must be zero.)
5. What are the forces acting on the toy car as it is going down the ramp? (gravity and friction)
6. Name 3 other examples of an object that has reached a terminal velocity. (skydiver, racecar driver, bullet fired from a gun)