Driver's Ed Project

Rule #1: All new drives must have at least 30 hours of driving in bad weather.

Intuitive explanation:

When you are driving on dry pavement in good weather you know how long it is going to take you to stop. You also can see if there is something in front of you. When you are driving in bad weather, rain or snow, it is a lot harder to know how long it is going to take you to stop and much harder for you to see what is in front of you.

Physics Explanation:

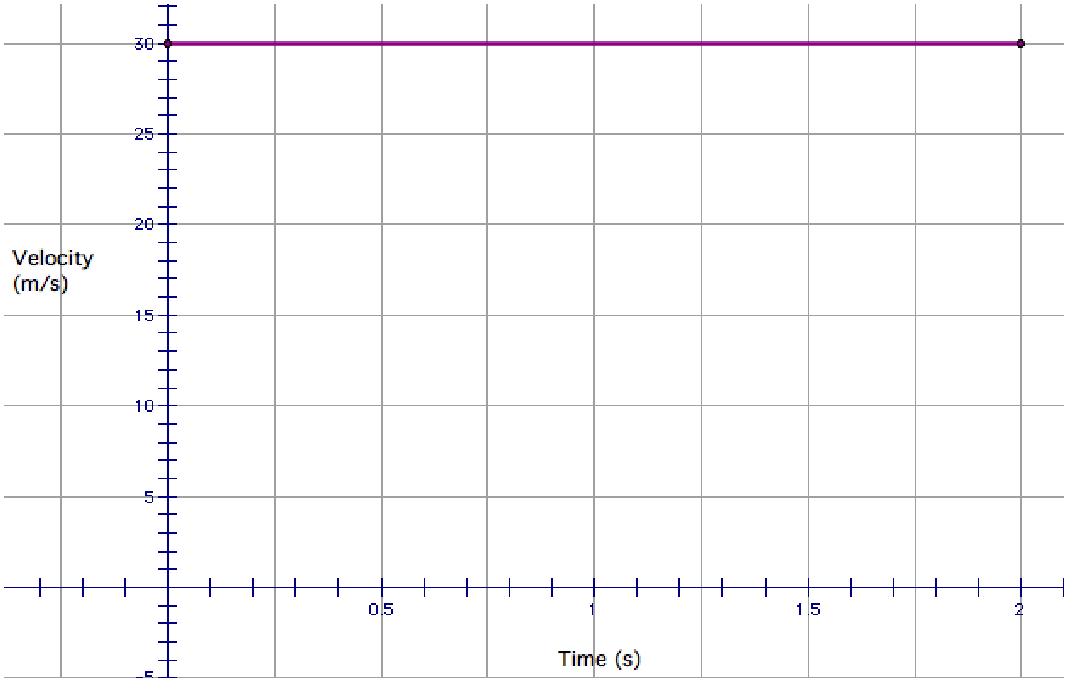
For the sake of argument I am only going to focus on bad weather being rain and snow. In these two scenarios the driver is going at a constant speed for 10 seconds and then needs to slam on the breaks. Based on the following information you may find yourself in one of three different positions.

The scenarios: You are driving on a road at a speed of 30 m/s. It is dry Even though you are look at the road it takes you two seconds to relive that there is someone in front of you at a red light. There is 100 meters between the two of you.
Its raining and your view of the road is blurred. Even though you are look at the road it takes you two seconds to relive that there is someone in front of you at a red light. There is 100 meters between the two of you.
Its snowing and your view of the road is blurred. Even though you are look at the road it takes you two seconds to relive that there is someone in front of you at a red light. There is 100 meters between the two of you.
I will be looking at the variations in the coefficient of friction with the difference in weather to see how it affects stopping time.

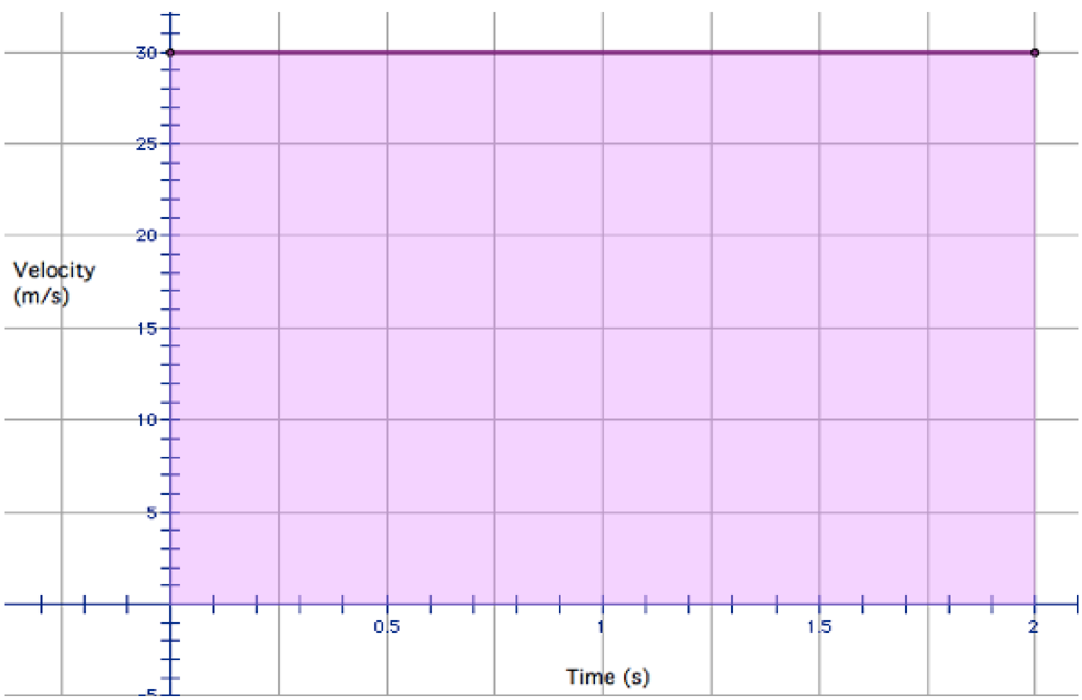
1.Example: car brakes on wet or icy surface vs. car brakes on dry surface
2. What affects the time?
3. How are is the car going to go in that time?

Background Information:

As we have talked about in class many times when a person is driving at a constant velocity the velocity vs time graph looks like this:

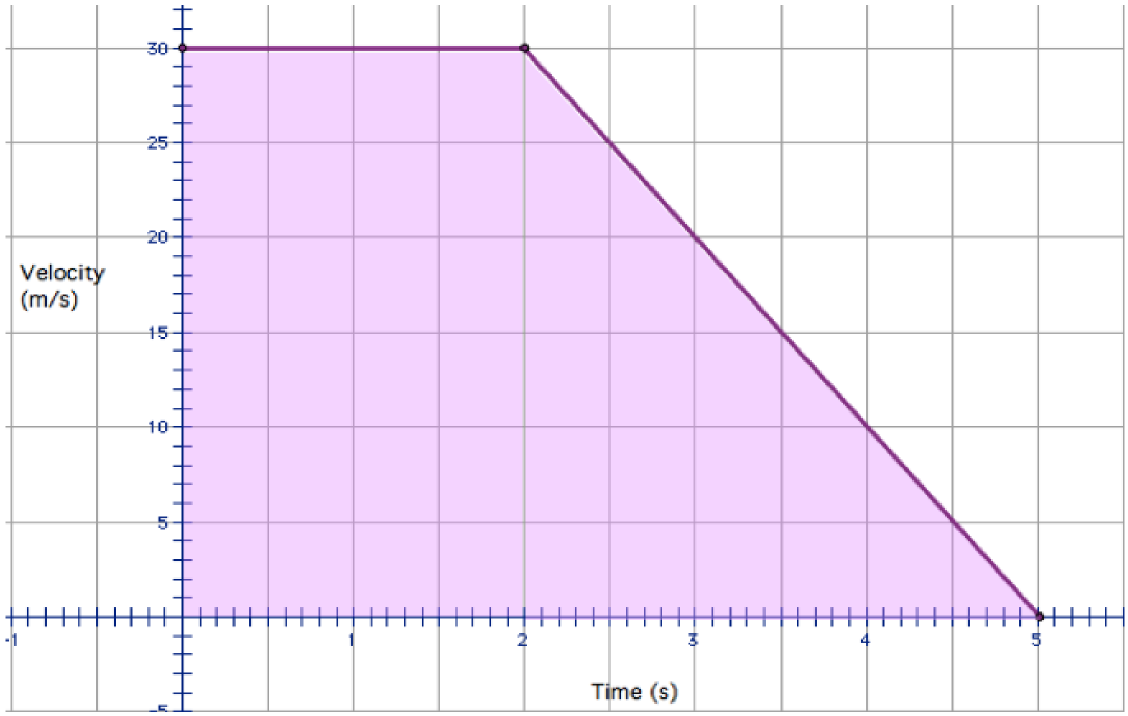


How if we wanted to find out how far that person want in two seconds we could find the area underneath this line, otherwise know as the displacement Δx:



The equation that represents this graph is $\Delta x = v * \Delta t$. Using the numbers that we can see on the graph we can tell that during those 2 seconds shown when the person is traveling 30 m/s they want 60 m.
Now that we know what it looks like for someone that is moving constantly we can use the same line of

reasoning to find a great of someone who is slowing down after constantly moving for two seconds:

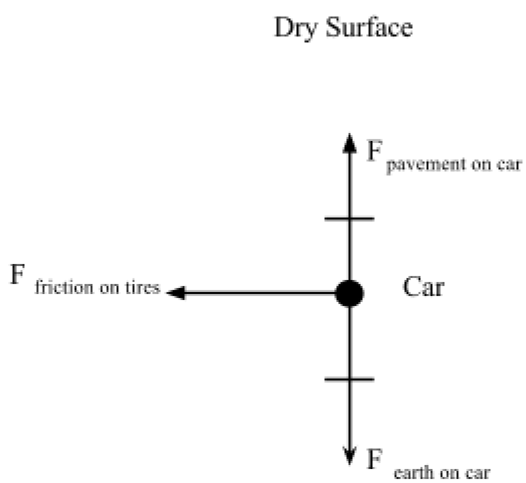


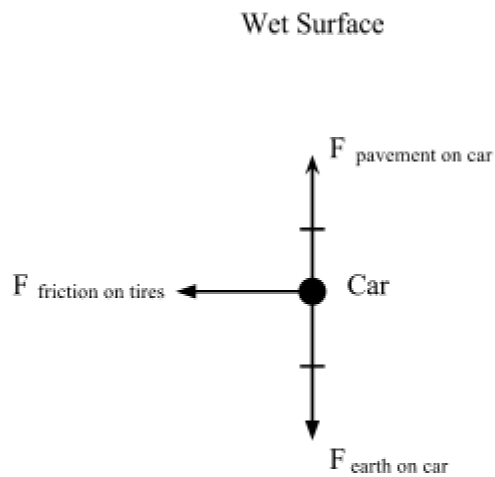
Even though right now we do not know how long it will take for the driving to stop. At this moment we are going to assume that it takes them 3 seconds after moving at a constant velocity for 2 seconds. Though this make look hard to find the displacement for it is not. We just have to break it into two spaces the first shape we already have answer for and the second we can find be using a displacement formula based on the area of a triangle: $\Delta x = \frac{1}{2} * \Delta v * \Delta t$

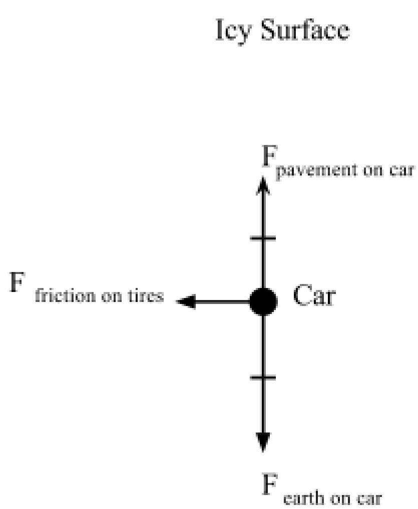
Again using the numbers that we can see on the graph we can get the a value of 120 m with the moving at a constant velocity for 2 seconds and just 60 meters to stop.

The Physics behind slowing down:

When you are trying to slow down on dry surface then the friction between your tires and the road are going to be opposing each other. This makes the force making you slow down unbalanced. However when the road is wet or covered in ice there is less of this opposing force making it take a longer time for you to slow down. This can be shown by force diagrams:







As you can see for each of these diagrams you can see that the vertical forces are balanced. This is because we know that the car is not floating above the ground or dropping through the pavement. F earth is also the gravitational force on the car. F earth or F gravity can be found by using the equation,
$F_g = g * m$

Because the vertical forces are balanced in each of these cases we know that F pavement on the car as to be equal to the F gravity.

Based on what we learned in class we know that the friction force on an object is determined by three things:
1. How the object is moving, if its sliding(kinetic) or rolling(static). If you are driving then the cars wheels are rolling on the road.
2. How much the friction is on the pavement is pushing you to move and what allows you to stop.
3. Then there are the types of surfaces involved.

A visual for this is the equation: $F_f = \mu * F_N$ In this equation you can see μ and that is the coefficient of friction and F_N is the upward force.

Here are is the math for theses scenarios:

Mass of the car: $1501.39078\ kg$ (with Goldie as the driver) however we are going to round that to $1501.4\ kg$

$F_g = 9.8 * m = 9.8 * 1501.4 = 14713.72N$

F_N will have to be the same for reason that have already been explained, so it is also $14713.72N$.

Based on the research that I did I now know the amount of the friction force for a car on the different surfaces would have the different friction coefficients of:
Dry surface: 0.90
Wet surface: 0.60
Icy surface: 0.10
(See reference)

So now that I have the I know the coefficients for all three surfaces I can find the friction force:

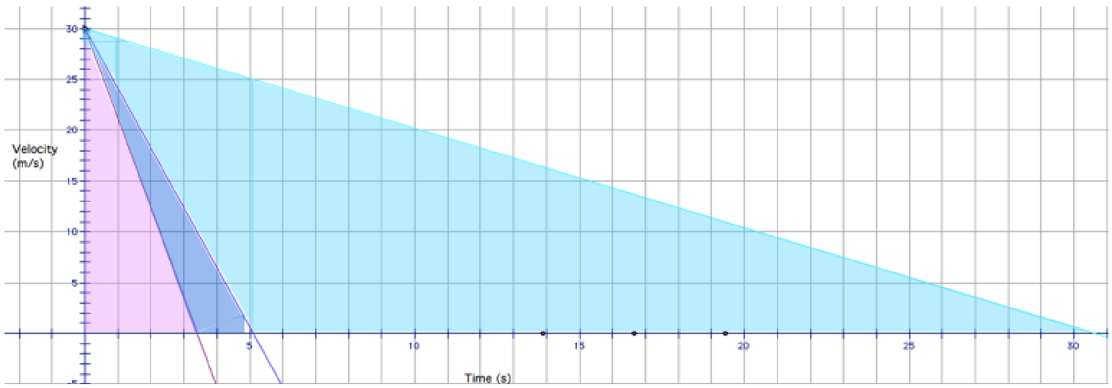
$F_f = 0.9 * F_N = 0.9 * 14713.72 = 13242.348N$ (Dry)
$F_f = 0.6 * F_N = 0.6 * 14713.72 = 8828.232N$ (Wet)
$F_f = 0.1 * F_N = 0.1 * 14713.72 = 1471.372N$ (Icy)

This lets you see the how different things can be by just changing one thing.

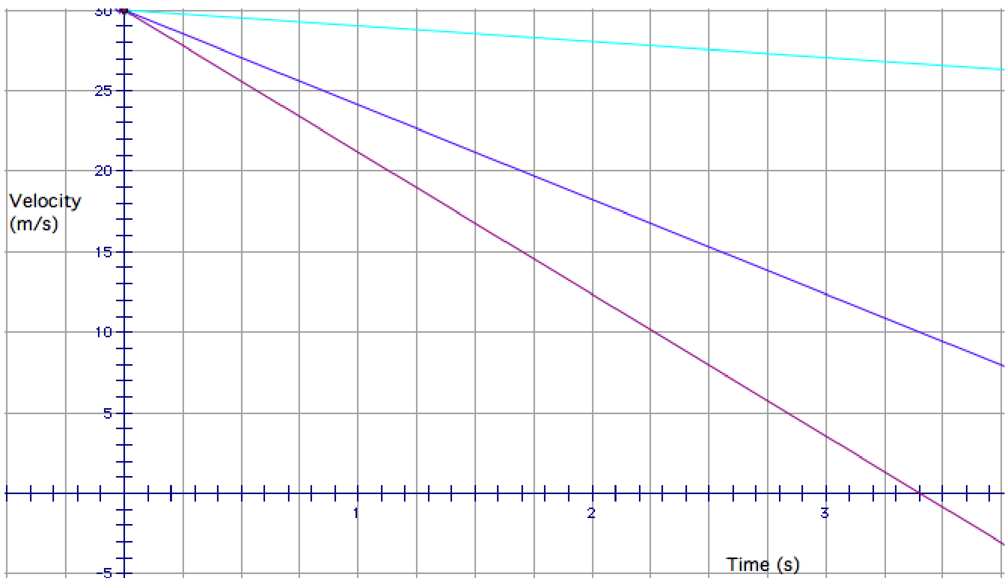
To find the negative acceleration, because we are slowing down its going to be negative, you need to find the acceleration of the car which can be found by dividing the ΣF ,which is the friction force that we just found, by the mass of the car: $a = \frac{\Sigma F}{m}$

$a = \frac{\Sigma F}{m} = \frac{13242.348N}{1501.4\ kg} = 8.82m/s/s$ (Dry)
$a = \frac{\Sigma F}{m} = \frac{8828.232N}{1501.4\ kg} = 5.88m/s/s$ (Wet)
$a = \frac{\Sigma F}{m} = \frac{1471.372N}{1501.4\ kg} = 0.98m/s/s$ (Icy)

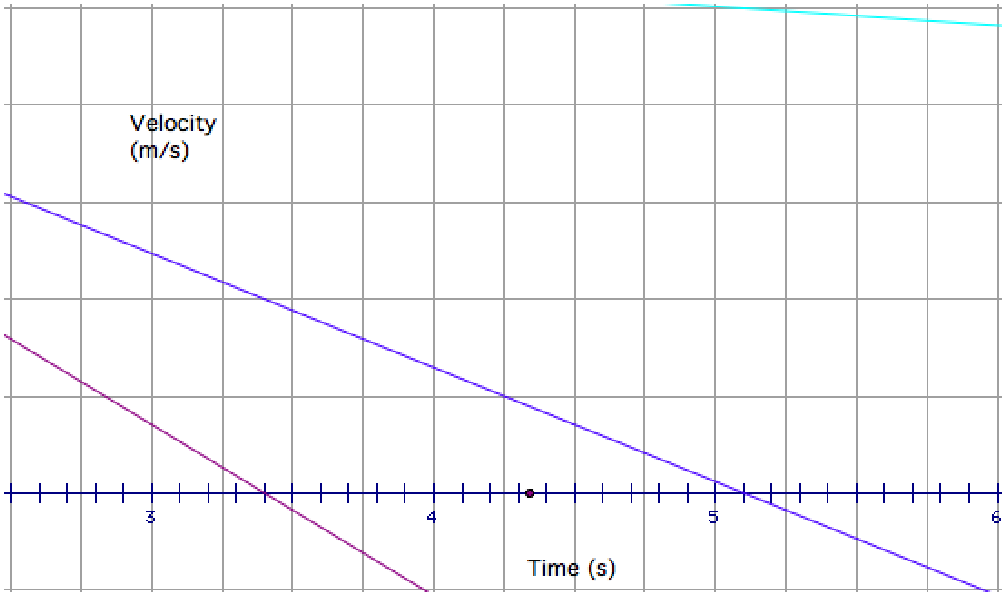
This would make the slope of the lines on the velocity vs. time graph -8.82m/s/s, -5.88m/s/s and -0.98m/s/s.



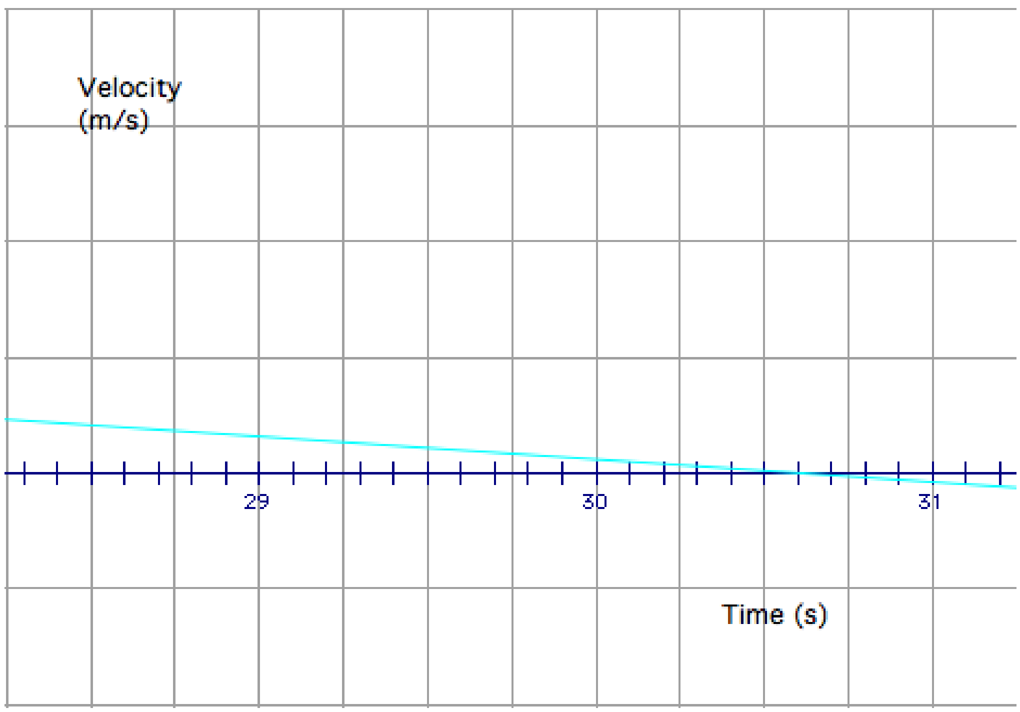
Even though at this point we could look at the graph and make a very close guess to how long it would take you(With gsp zoom).



On dry pavement it would take 3.4 seconds.



On wet pavement it would take 5.2 seconds.



On icy pavement it would take 30.5 seconds.

Now we can use this new equation to find out how far the car will move in each of these times: $x = \frac{1}{2}at^2 + v_0 t + x_0$. In this equation x is postions, a is acceleration, t is time, and v_o is your starting velocity. Because we have everything but the final x. If you look back through the past few pages you can see how we found each of the other given numbers. So now we can plug if for the three scenarios:

Dry:

$x = \frac{1}{2}at^2 + v_0 t + x_0$
$x = \frac{1}{2}(-8.82) * 3.4^2 + 30(3.4) + 0$
$x = (-4.41) * 3.4^2 + 30(3.4) + 0$
$x = (-4.41) * 11.56 + 30(3.4) + 0$
$x = (-50.9796) + 102 + 0$
$x = (-50.9796) + 102$
$x = 51.0204\ m$

Wet:
$x = \frac{1}{2}at^2 + v_0 t + x_0$
$x = \frac{1}{2}(-5.88) * 5.2^2 + 30(5.2) + 0$
$x = (-2.94) * 5.2^2 + 30(5.2) + 0$
$x = (-2.94) * 27.04 + 30(5.2) + 0$
$x = (-79.4976) + 156 + 0$
$x = (-79.4976) + 156$
$x = 76.5024\ m$

Icy:
$x = \frac{1}{2}at^2 + v_0 t + x_0$
$x = \frac{1}{2}(-0.98) * 30.5^2 + 30(30.5) + 0$
$x = (-0.49) * 30.5^2 + 30(30.5) + 0$
$x = (-0.49) * 930.25 + 30(30.5) + 0$
$x = (-455.8225) + 915 + 0$
$x = (-455.8225) + 915$
$x = 459.1775\ m$

Why students need 30 hours of driving in bad weather:

Now going back to the original problem, You are driving on a road at a speed of 30 m/s. Even though you are look at the road it takes you two seconds to relive that there is someone in front of you at a red light. There is 100 meters between the two of you. Now that we have found the time that it takes for you to slow down and how far you will go in that time we can determine that on both dry and wet weather you would be able to stop with leftover space. However when it comes to an icy surface you would not be able to stop in time.

With this evidence we can see that there is plenty of reason for a new driver to have at least 30 hours of experience in bad weather. An experienced driver would find a way to move around the other car depending on the kind of road they are on, however a new driving would not know how to do this and most likely crash. With this new law it will insure the safety of new teen drivers and whoever is in the car in front of them.