Group Members: Cameron K, Sara N, Tyler C and Jalen S

Driver's Ed Project

Quick Facts About Driving:

In the year of 2011, more than 3,000 people were killed in crashes involving a distracted driver. An additional, 300,000+ people were injured in vehicle crashes involving a distracted driver, compared to 400,000+ injured in 2010. According to Distraction.Gov, about 18% of injury crashes in 2010 were reported as a distraction affected crash.

Important Facts About The Vehicle In This Scenario:

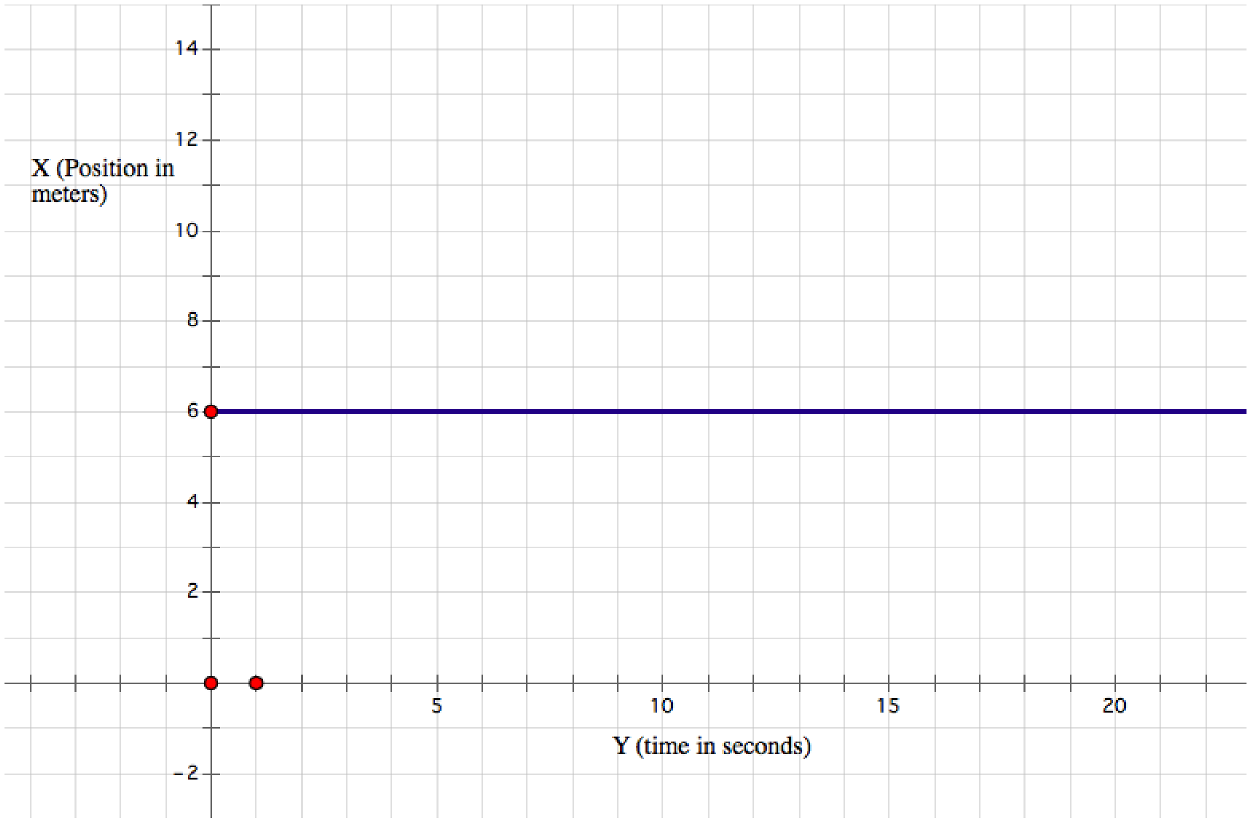
The average midsize sedan with a driver weighs in at about 1600 kg. In this scenario we are assuming that the speed limit is 30 miles per hour, loosely converted it gives us 15 meters per second.

Rule #1: Stop at Red Lights

What is a red light?

Traffic lights manage the flow of traffic at intersections. They are designed to make getting across the intersection is efficient and safe. They do this by signaling what the appropriate action is to the driver with three different color lights. The red light (almost always at the top of the traffic light) means that all drivers facing the traffic light should stop.

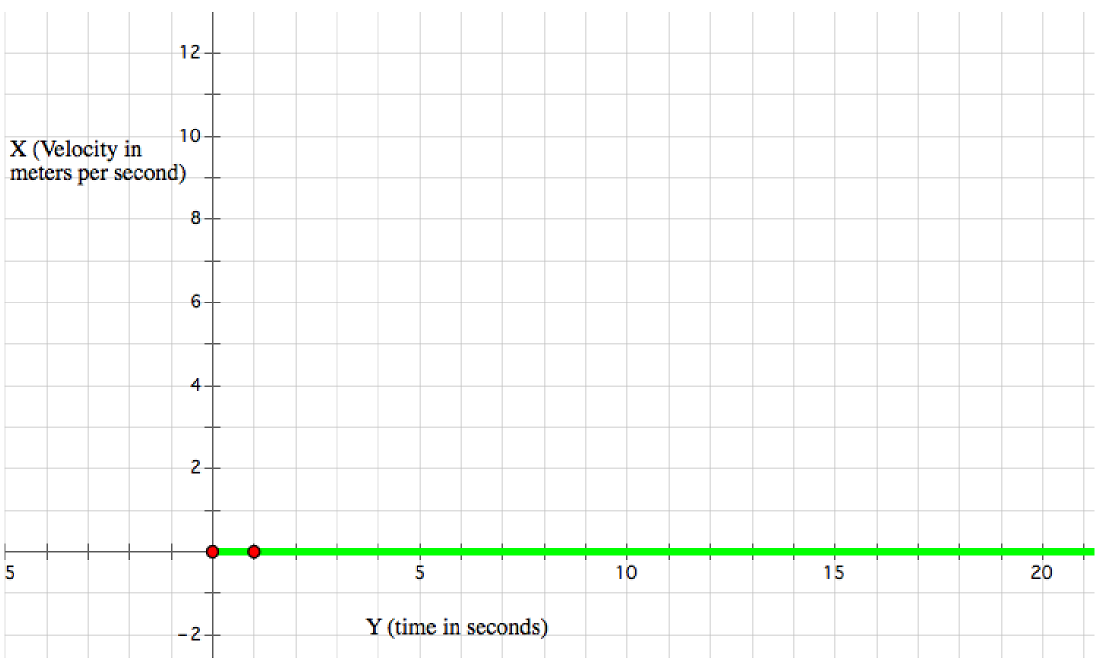
This means, on a position vs. time graph, their movement would look like this.



Note that the line being at a positive integer does not mean the unit is moving. It indicates that as the time goes on, the position stays the same distance away from the point of origin.

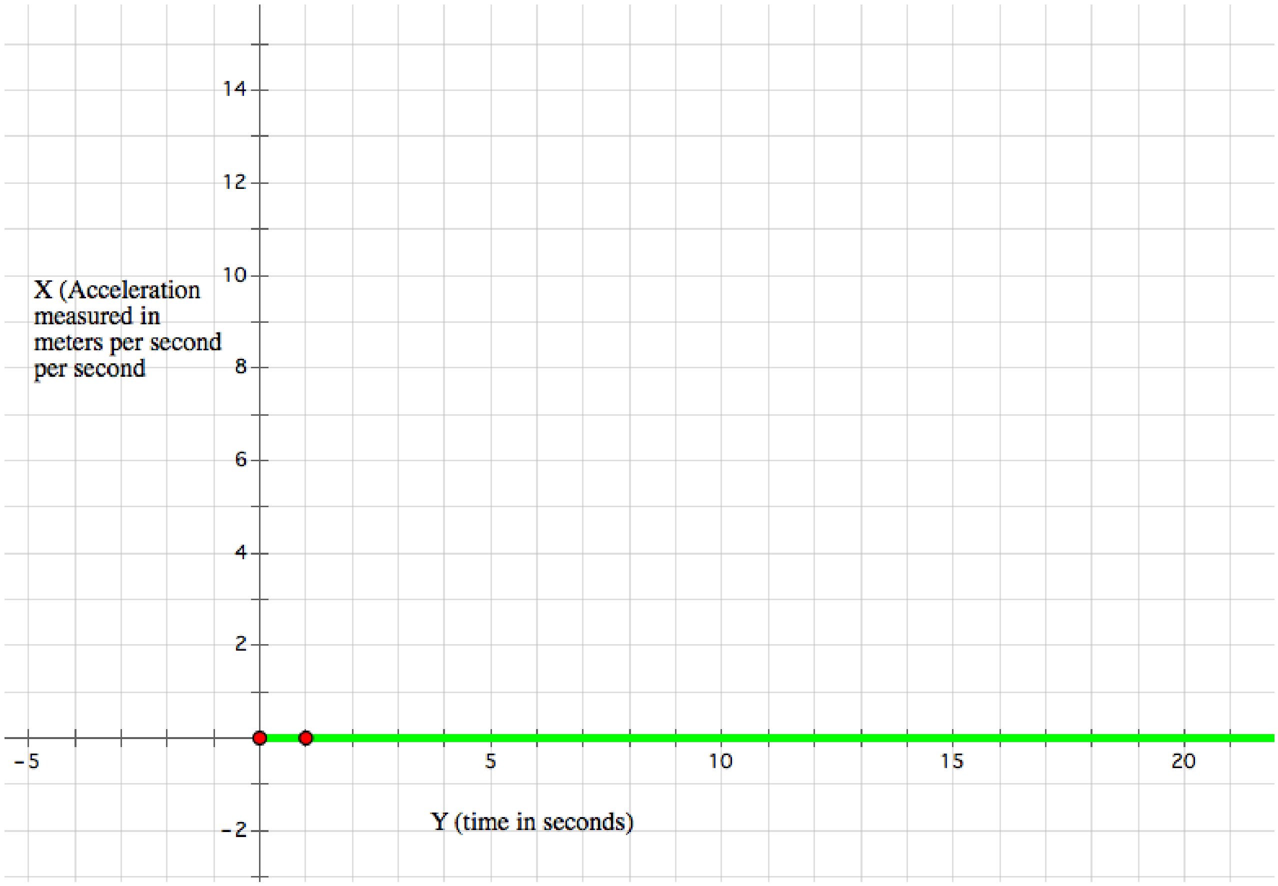
On a velocity vs time graph, it would look like this.

(Velocity vs. Time graph here)



The line is at 0 on the y axis because there is no change position over the time that the vehicle goes through at the red light.

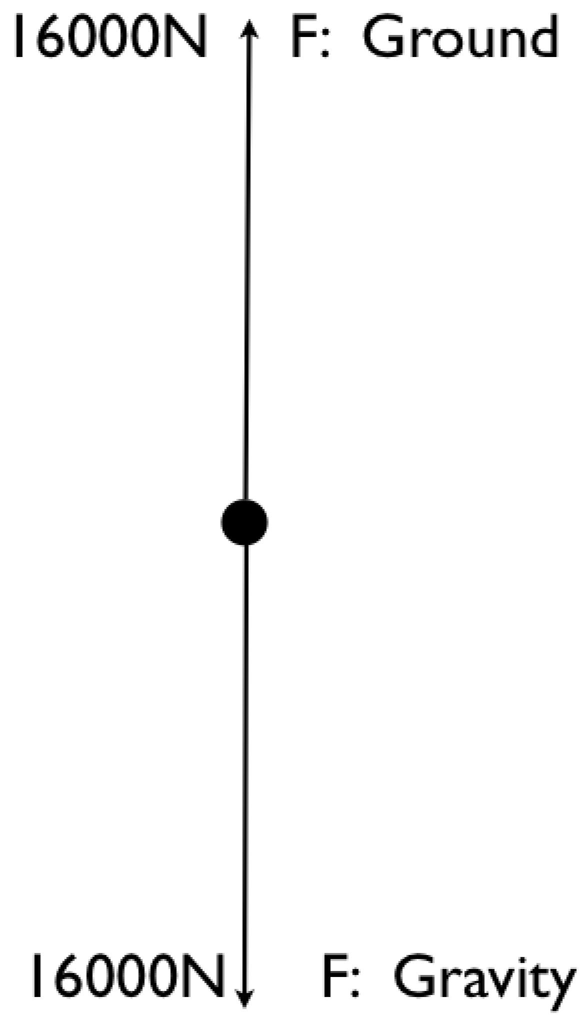
On an acceleration vs time graph it would look like this.



There is no change in velocity, so the line is flat.

This is what a free body diagram, would look like in this situation.

The object has a constant velocity of zero. The only forces acting on the object are the downward pull of gravity and the upward push of the ground on the wheels



Important things to know about you and your vehicle.
So say you see a traffic light turn red somewhere up the street. Having read the manual, you know this means you have to stop. But, you aren't anywhere near the traffic light. So the first question that pops into your head is “How much distance do I need in order to stop my car?” You don’t want to stop too soon or you might clog up traffic, but if you stop too late then you will end up in the middle of the intersection. There are two ways you can solve this. The first way is to do this is make a wild guess and hit the breaks. This would work through trial and error, but you need to stop now and it’s too risky. The other way to do this is to calculate it using your knowledge of physics.
To figure this out, the first thing we need to do is determine out the vehicle's acceleration after the break is applied.

The easiest way to do this is to use this equation:
$a = \frac{\Sigma F}{m}$

ΣF represents the sum of forces
m represents the mass of the object
a represents the acceleration
What this equation means in english terms is that the acceleration of an object is equal to the sum of the forces divided by the mass.

We know that m is equal to the mass of the object (or 1600kg). This is the only variable we know as of now. But that doesn't mean we are helpless. We know that once the car starts to brake, the only force applying to it will be the force of the breaks moving against the car's motion. We can solve for the force of the breaks. For this we will use the equation:

$\Sigma F = \mu mg$

In this equation

ΣF still represents the sum or forces and m still represents mass

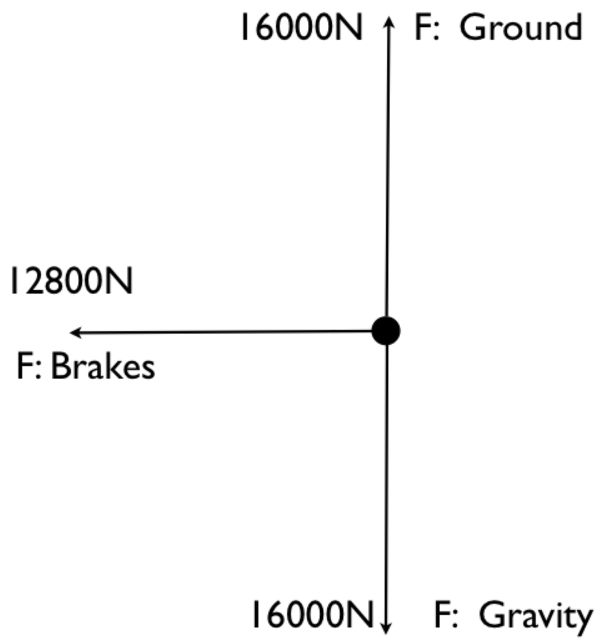
The two new variables we have to deal with are μ which represents the coefficient of friction. The coefficient of friction for rubber tires on asphalt is 0.8. g represents the coefficient of earth's gravity. The coefficient of earth's gravity is about 10.

So now that we know all of the variables, we can plug them into the equation.

$\Sigma F = (0.8)(1600)(10)$

$\Sigma F = -12800N$

The force is negative because it is working against the motion of the car. On a free body diagram, it would look like this.



$a = \frac{-12800}{1600}$

and we get $a = \frac{-12800}{1600}$ and we get $a = -8m/s/s$.

Now we know how quickly the car will slow down. So the next step is to calculate how much time it will take it to slow down from $15m/s/s$ to $0m/s/s$. To do that, we can use this equation: $v_f = at + v_0$

v_f is the final velocity, in this case 0m/s

v_0 is the initial velocity, or 15m/s

Now that we know both the sum of forces and the mass of the vehicle, we can plug in and solve for acceleration.

$\Sigma F = (0.8)(1600)(10)$

now we just multiply everything out

$\Sigma F = 12800N$

The next step is to plug this number back into the acceleration equation

$a = \frac{-12800}{1600}$ and we get $a = -8m/s/s$ This means that the car is slowing down by meters per second for each second.

Now that we know the acceleration we can solve for how long it takes the car to reach a velocity of zero meters per second. To do this, we will use this equation

Now that we have the acceleration, and we know the initial velocity. we can solve for how long it takes the car to stop.

This is the equation for velocity $v_f = at + v_0$. v_f represents the final velocity t represents time a is equal to the acceleration of the vehicle and v_0 is the initial velocity.

First let's list everything we know

We know the initial velocity is 15m/s.

We know the acceleration is -8m/s/s

We know that we are solving for t when the car is not moving. So we know that the final velocity must be 0m/s

Because we know all of the variables accept *t* we can solve for *t*

Now we plug all of this into the equation and solve for *t*

$v_f = at + v_0$

$0 = \left(\frac{-8m}{1s^2}\right)\left(\frac{ts}{1}\right) + \frac{15m}{1s}$

Since we are multiplying two fractions, we can cancel out the unit *s* (seconds)

$0 = \left(\frac{-8m}{1s}\right)\left(\frac{t}{1}\right) + \frac{15m}{1s}$

Now we multiply

$0 = \ -8m/s/s * t + 15m/s$

Now we move -15 to the other side of the equation

$-15m/s = \ -8m/s/s * t$

The last step is to divide both sides by $-8m/s$

$\frac{-15m/s = -8m/s * t}{-8m/s}$

And now we have time.

$t = 1.875s$

This means it takes your car 1.875 seconds to come to a complete stop.

The last thing we will solve for is how far it will take the vehicle to stop. To do this we use the equation

$x_f = 1/2at^2 + v_0 t + x_0$

To recap what we know

a represents the acceleration, which is equal to -8

t represents time, we know this is equal to 1.875s, and will be rounded to 1.9s

v_0 represents velocity, which represents the initial velocity which is equal to 15 m/s/s

x_0 represents initial position which is equal to 0

We are solving for x_f which represents final positon

So the first thing we do is plug in all of the variables

$x_f = 1/2(\frac{-8m}{s^2})(\frac{1.875s}{1})^2 + (\frac{15m}{1s})_0(\frac{19s}{1}) + x_0$

The first thing we do is square the time

$x_f = 1/2(\frac{-8m}{s^2})(\frac{3.6s^2}{1}) + (\frac{15m}{1s})(\frac{1.9s}{1})$

Now we can cancel out some of the units so that we are only using meters

$x_f = 1/2(\frac{-8m}{1})(\frac{3.6}{1}) + (\frac{15m}{1})(\frac{1.9}{1})$

Now we multiply everything

$x_f = -14.4m + 28.5$

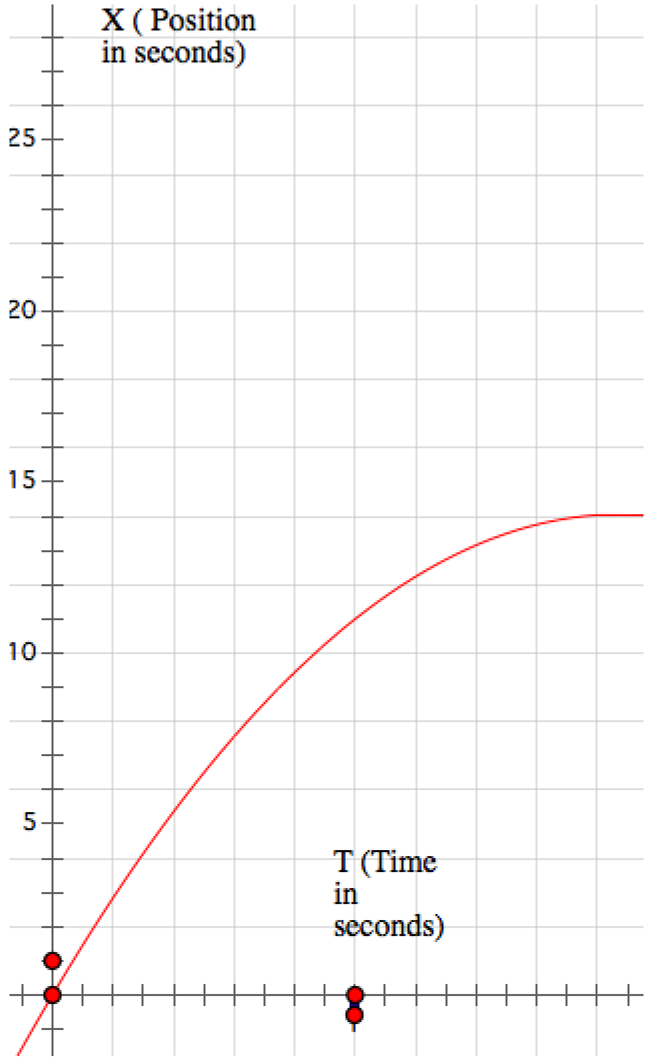
The last step is to add everything

$x_f = 14.1$

So we know it will take the car 14.1 meters to stop.

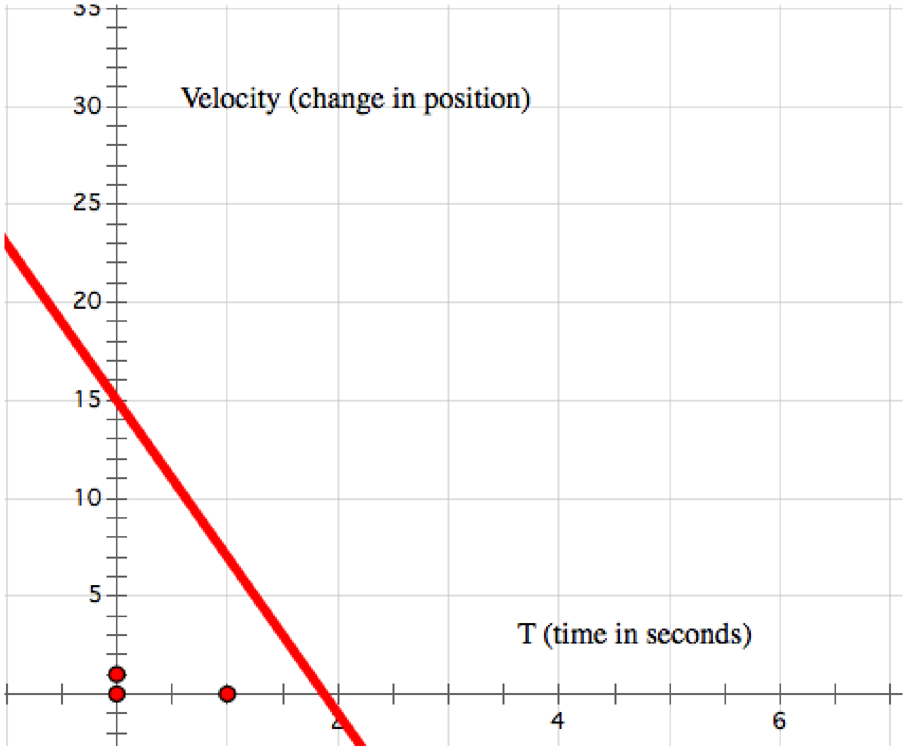
Position vs Time

To put this in context, on a position vs time graph the vehicles motion would look like this.



This is a position vs time graph. It shows how many meters away from the starting position the vehicle is at any given time. As you can see, with each second, the vehicle travels a smaller and smaller distance.

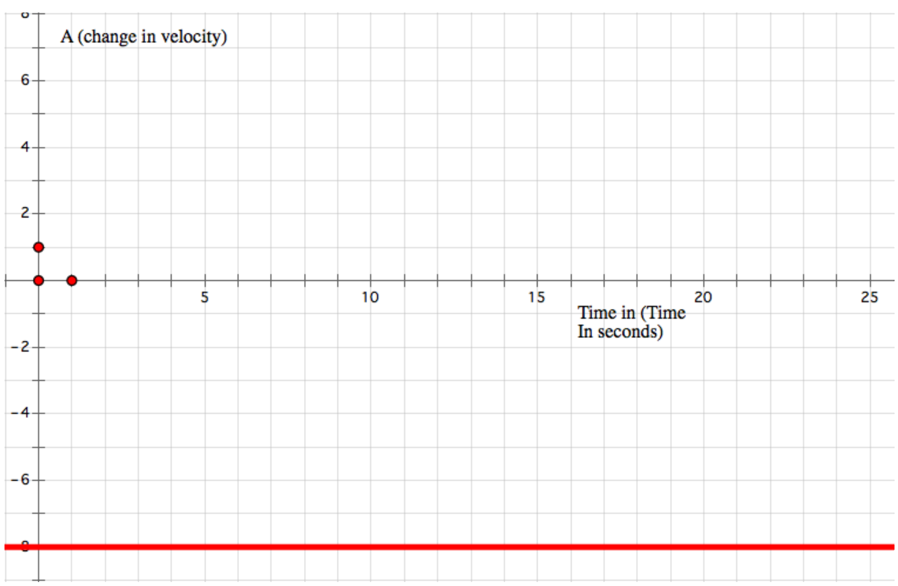
Velocity vs Time graph:
On a velocity vs time graph, the vehicles motion would look like this.



The velocity is constantly decreasing by 8 meters per second. Remember, velocity is a measure of change in position over time. So as the change decreases, so does the velocity.

Acceleration vs Time graph:

On an acceleration vs time graph, the objects motion would look like this.



Acceleration is the measure of the change in velocity over the change in time. Since the change in velocity is constantly -8m/s/s the line is flat.

Later in the year you are driving home from work in the snow. You try to stop at a red light, and you do it your usual distance away from the traffic light. But you somehow end up in the middle of an intersection. You wonder what happened. What happened on here is that the coefficient of friction is significantly lower on wet or icy roads. This means that the force your brakes apply to your vehicle are much lower than they would be otherwise.
In heavy weather conditions like snow/rain, the roads can be icy. The coefficient of friction for rubber on icy roads is $.15$.

$\Sigma F = (0.15)(1600)(10)$
ΣF =-2400N

Now find the acceleration

$a = \frac{-2400N}{1600}$ =-1.5m/s/s

The velocity is negative because the force of friction is acting against the motion of the vehicle.

Now that we have the acceleration, and we know the initial velocity. we can solve for how long it takes the car to stop.

Equation for final velocity: $v_f = a_t + v_0$

v_f = final velocity
a = acceleration
t = time
v_0 = initial velocity 15m/s
acceleration = -1.5m/s/s

Final velocity would be 0 because we will be stopped at the red light.

We are now solving for t or time.

$0 = \frac{-1.5m}{1s^2}\frac{ts}{1} + \frac{15m}{1s}$
$0 = \frac{-1.5m}{1s}\frac{t}{1} + \frac{15m}{1s}$
$0 =- 1.5m/s * t + 15m/s$

$-15m/s = -1.5m/s * t$
$\frac{-15m/s}{-1.5m/s} = t$
$10 = t$

This means that it will take you 10 seconds to make a complete stop on an icy road.

This is a lot more time to stop than on a regular rode, therefore you have to be more aware and have no distractions.

Now that we have acceleration and time....
We can plug all of our information into this equation
$x = \frac{1}{2}at^2 + v_0t + x_0$

We know:
Acceleration= -1.5m/s/s
Time=10s
Final Velocity= 0m/s
Initial velocity=15m
Initial position=0m

$x = \frac{1}{2} - \frac{1.5m}{s^2}(\frac{10s}{1})^2 + \frac{15m}{1s}(\frac{10s}{1}) + 0$
$x = \frac{1}{2} - 1.5m * 100 + 150m$
$x = \frac{1}{2} - 150m + 150m$
$x = -75m + 150m$
$x = 75m$

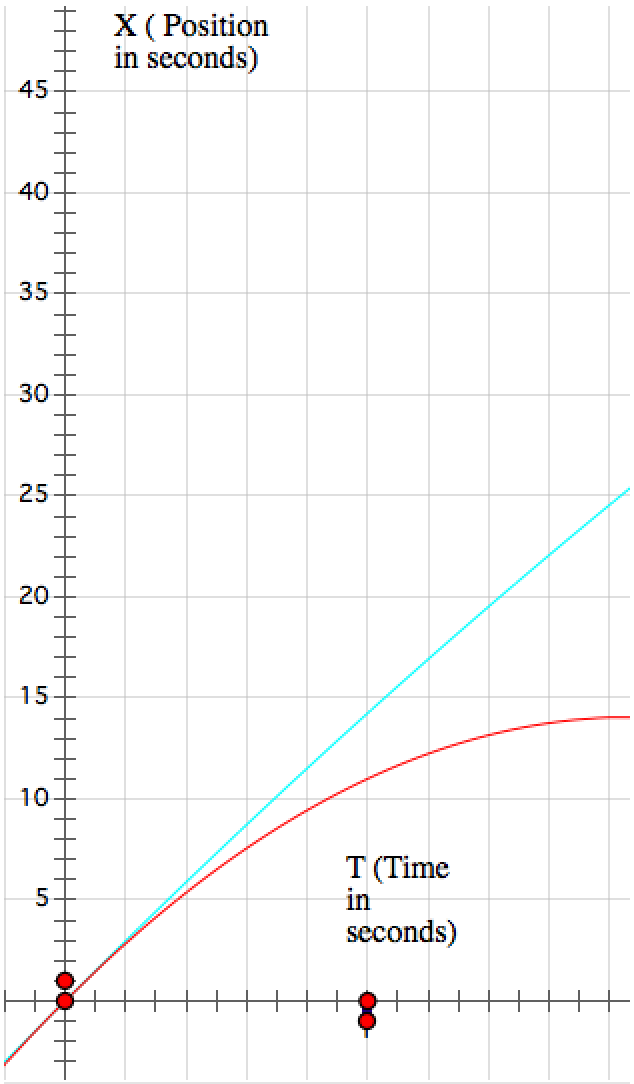
On icy roads, it takes 75 meters to stop.

So when your car is coming to a stop in usually looks like this.

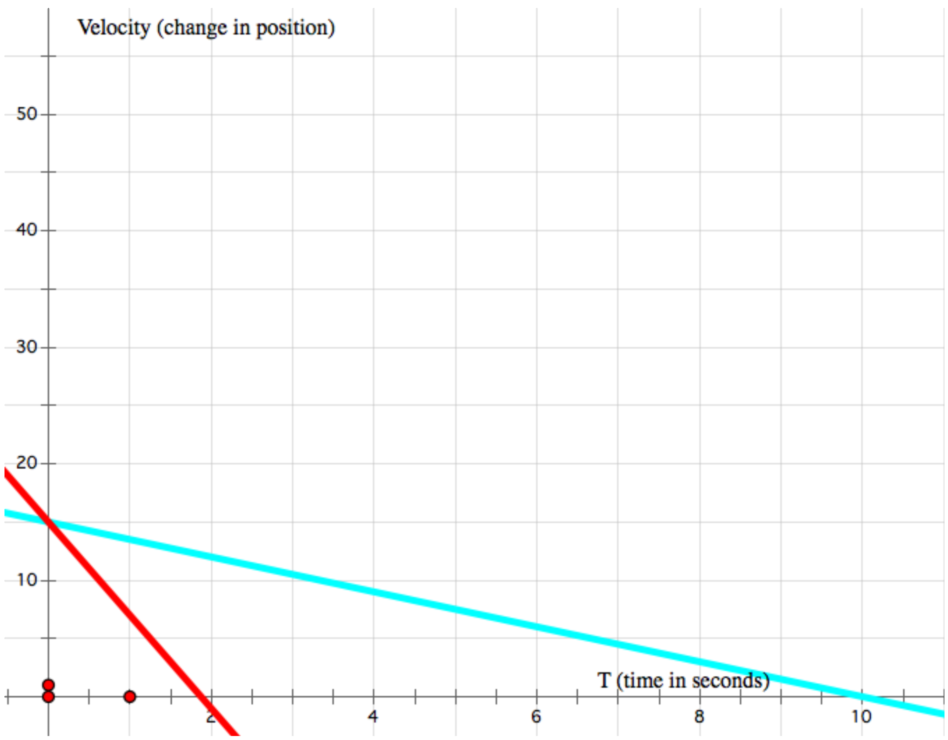
(Graphs)

Here is a visual representation of what it looks like to stop on an icy road vs a dry road

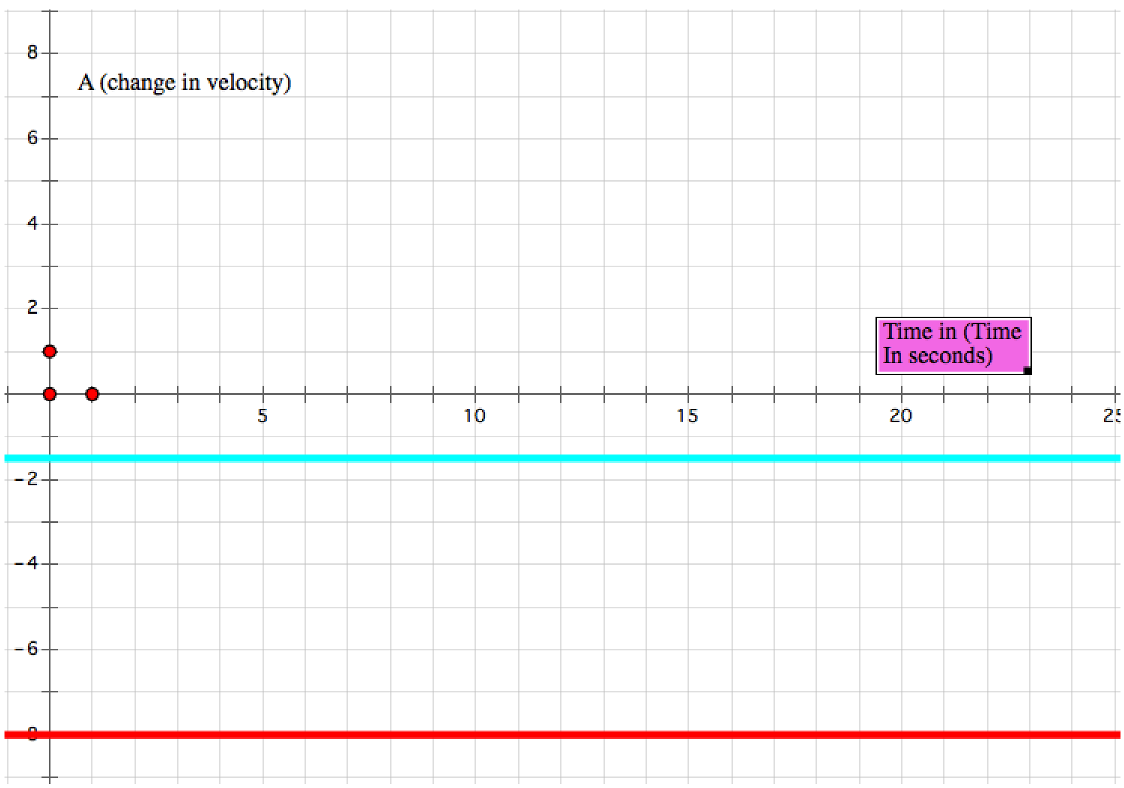
Position vs. time:



Velocity vs. Time:



Acceleration vs. Time

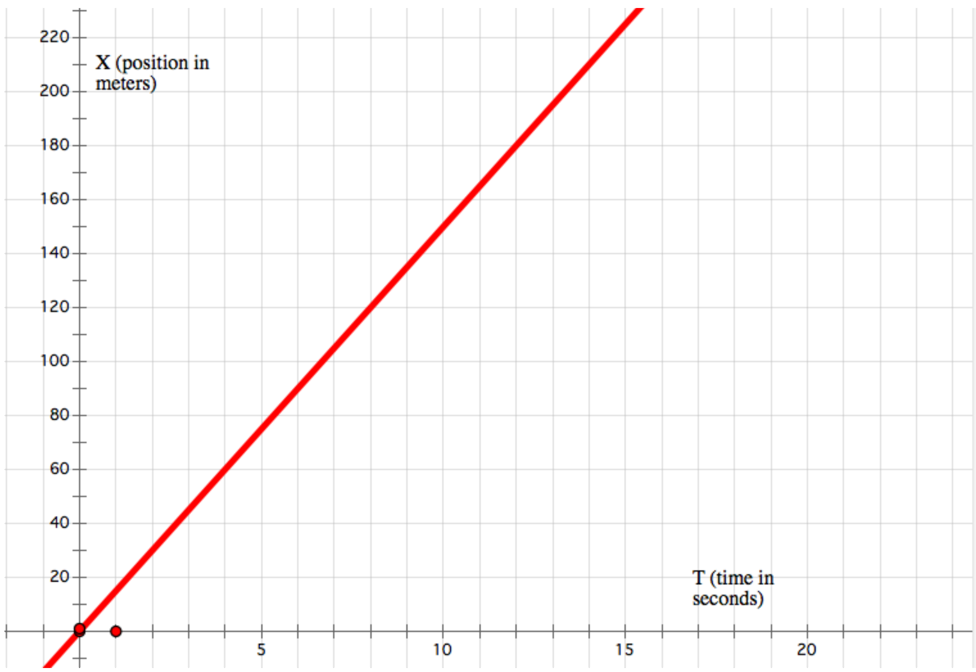

A (change in velocity)
Time in (Time In seconds)
8
6
4
2
-2
-4
-6
-8
5
10
15
20
25

Scenario #2: Don't text and drive

Why it's important: When you text, you are only focusing on texting, and reading what the other person is saying on the phone. If you're distracted from driving, you could hit another car, run a light/stop sign, or even hit a pedestrian who is crossing the street.

On a Position vs. Time Graph, the movement would also look like the graph that was in the previous scenario because when a person is driving and not focusing on anything, they are only focusing on that one thing which is the phone. This means that as they are traveling, they are traveling at a constant speed. They aren't stopping nor are they accelerating. They will always stay constant. This is how the Position vs. Time graph would look like.

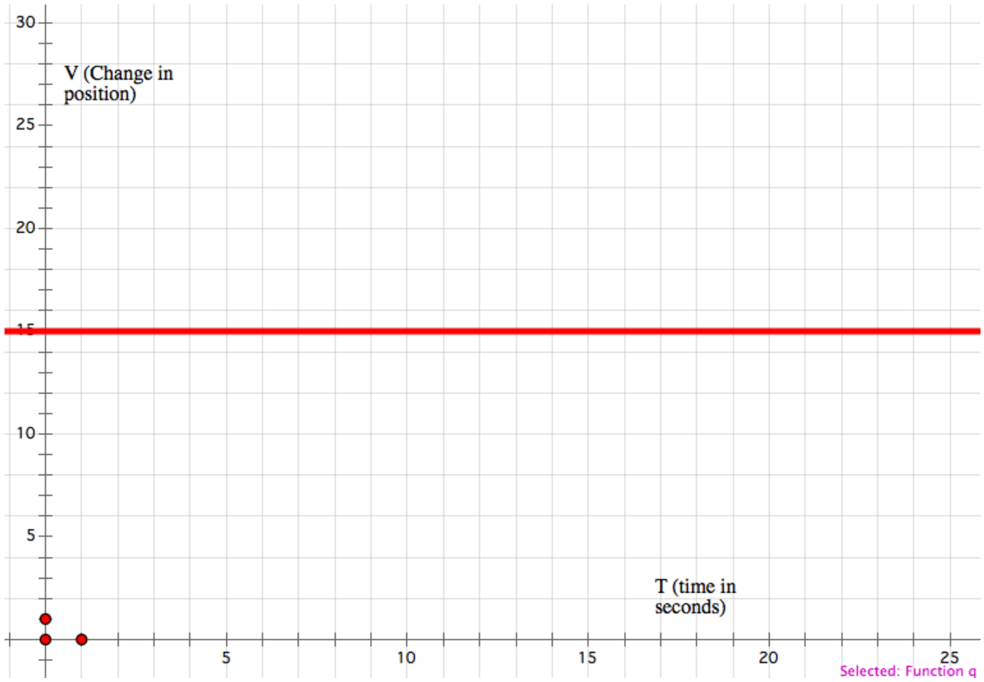
Position vs. Time Graph



This motion map indicates that as time goes on the object gets further and further away from the point of origin. The change is consistently 15 meters for every one second

On a Velocity vs time graph, it would look like this.

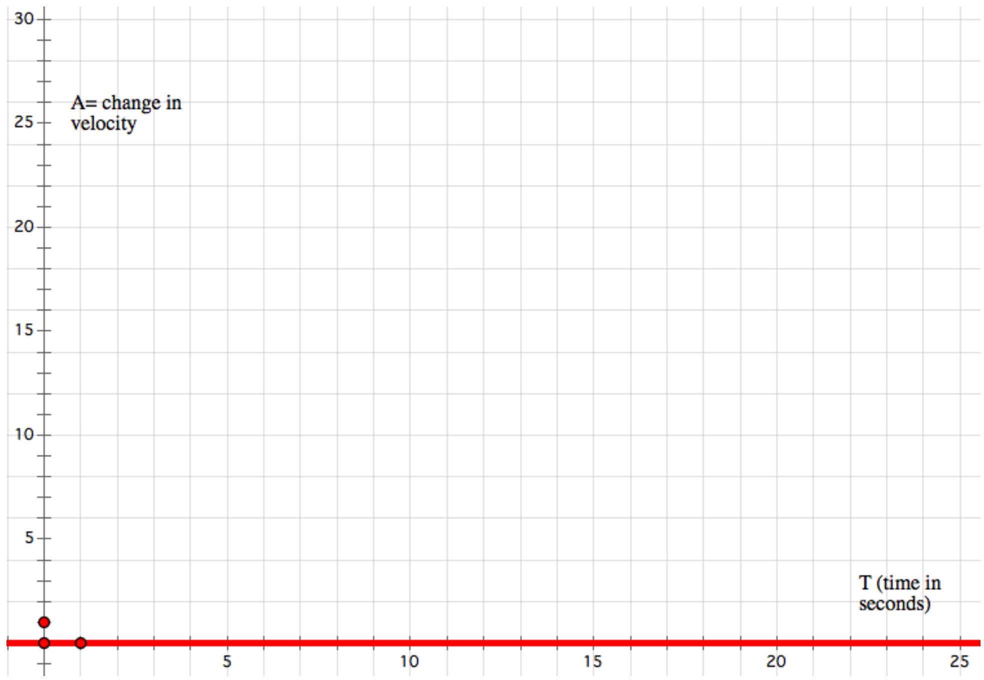
Velocity vs Time Graph



The line is at 15 on the y axis because over time the vehicle is traveling constantly at 15.

On an Acceleration vs. Time graph it would look like this.

Acceleration vs Time Graph



Acceleration is a change in velocity. Since the velocity is constant there is no a**cceleration.**

Your car still stops the same way as it did before, so if you need to, just look back on the first scenario for the math. What changes when you text is that you might not realize that you need to stop until it's too late. This means that you need the same distance to stop but won't have it. Here are some calculations to show how this works.

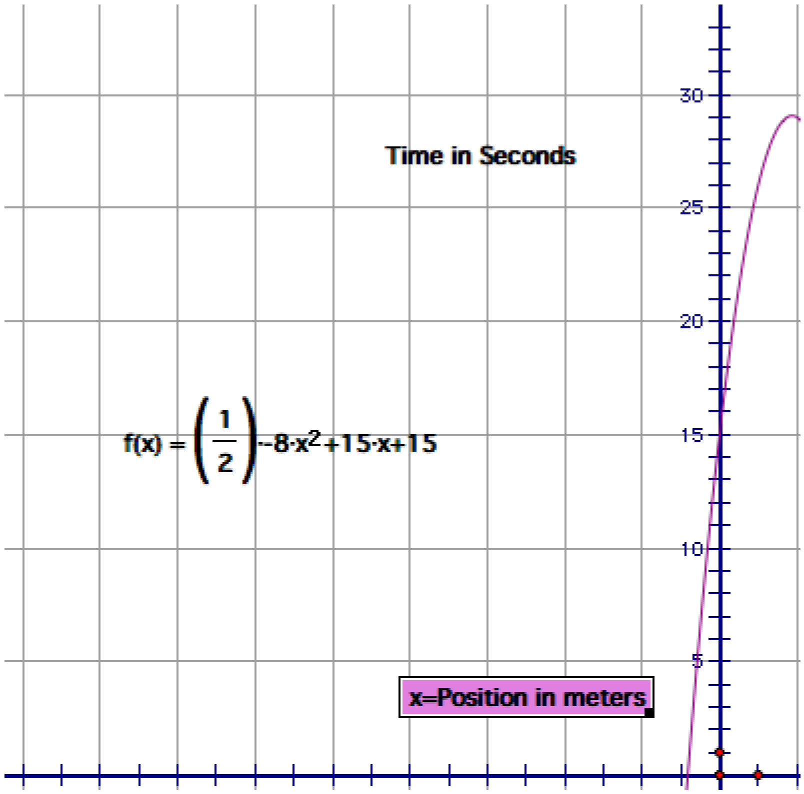
To determine how much distance it will take for you to stop we can use the same equation as we did before. $x_f = 1/2at^2 + v_0t + x_0$ The difference here is that x_0 will no longer be equal to 0. So the equation solves out the same way as it did before except we add some distance. So say you look down for one second and then look back up. Since you have been traveling at 15m/s for one second you have travelled 15 meters. This means that we have to add 15 meters the original distance required to stop.

$x_f = 14.1 + 15$

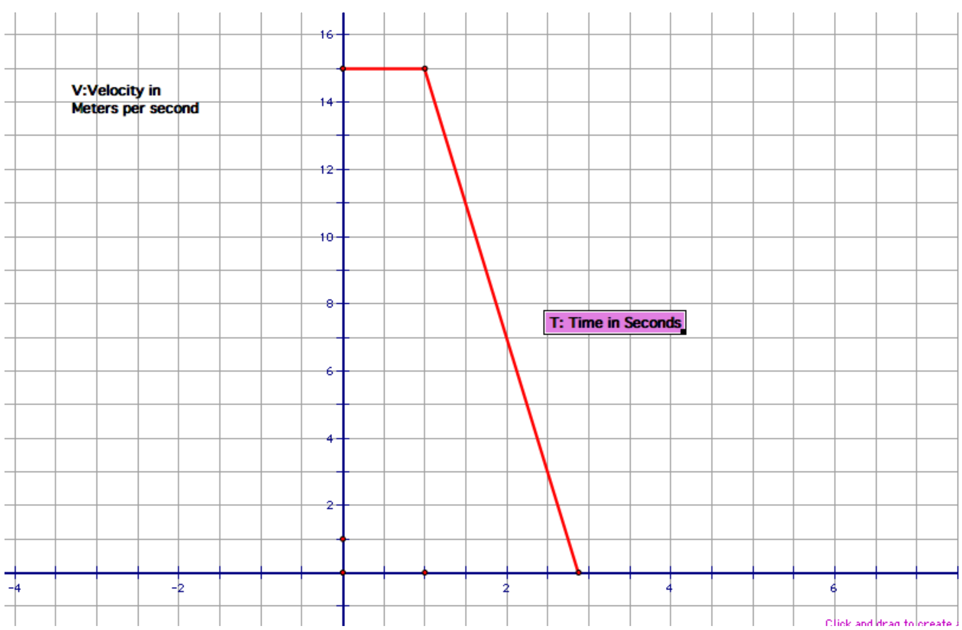
$x_f = 29.1$

The same is true for the time calculation. We would add the one additional second to 1.875. This means that it would take your vehicle 2.875 seconds to stop.

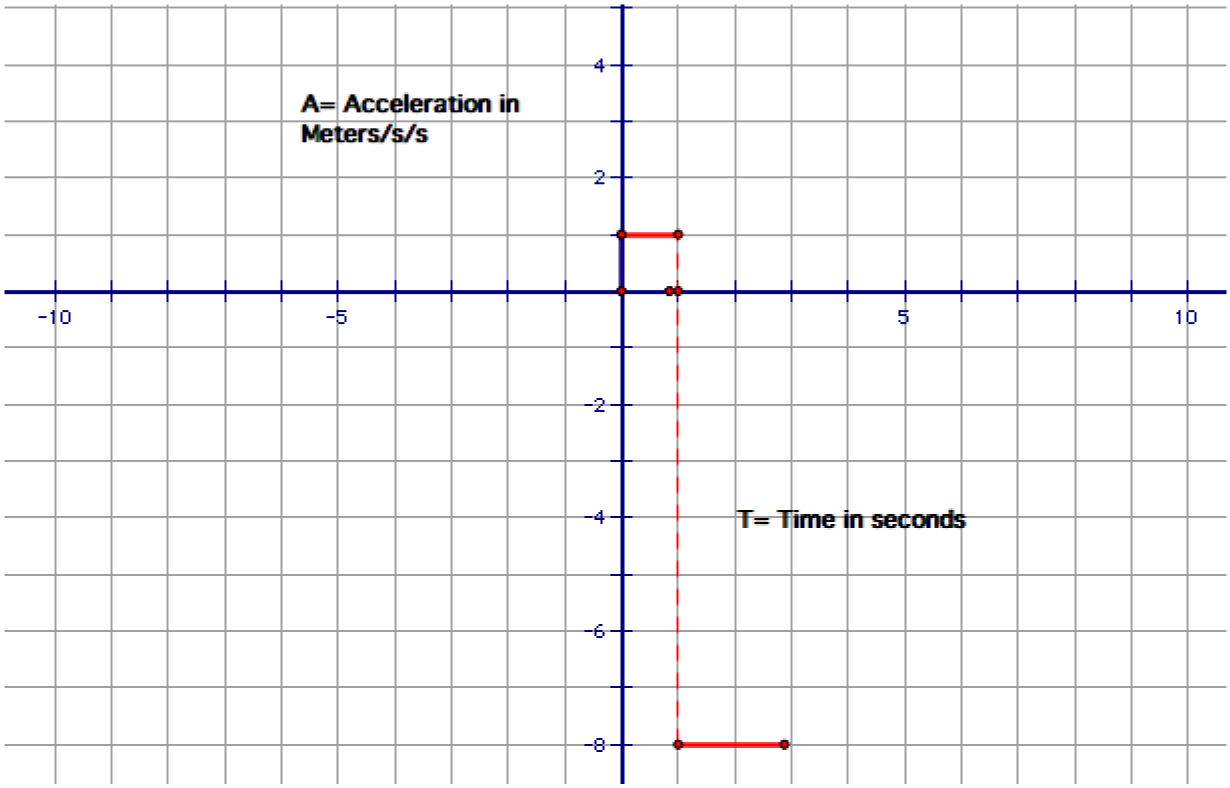
On a Position vs Time graph the motion would look like this



On a velocity vs time graph the motion would look like this.



On an acceleration vs time graph it would look like this.



Important things to know about you and your vehicle.

So as some people may know texting and driving is not really prohibited. However some people choose to do it anyway.

Cited Sources

Elert, Glenn. "Coefficients of Friction for Ice."*http://hypertextbook.com/*. Hyper Text Book, 09 Mar 2013. Web. 9 Mar 2013. <http://hypertextbook.com/facts/2004/GennaAbleman.shtml>.

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