Uniform Acceleration

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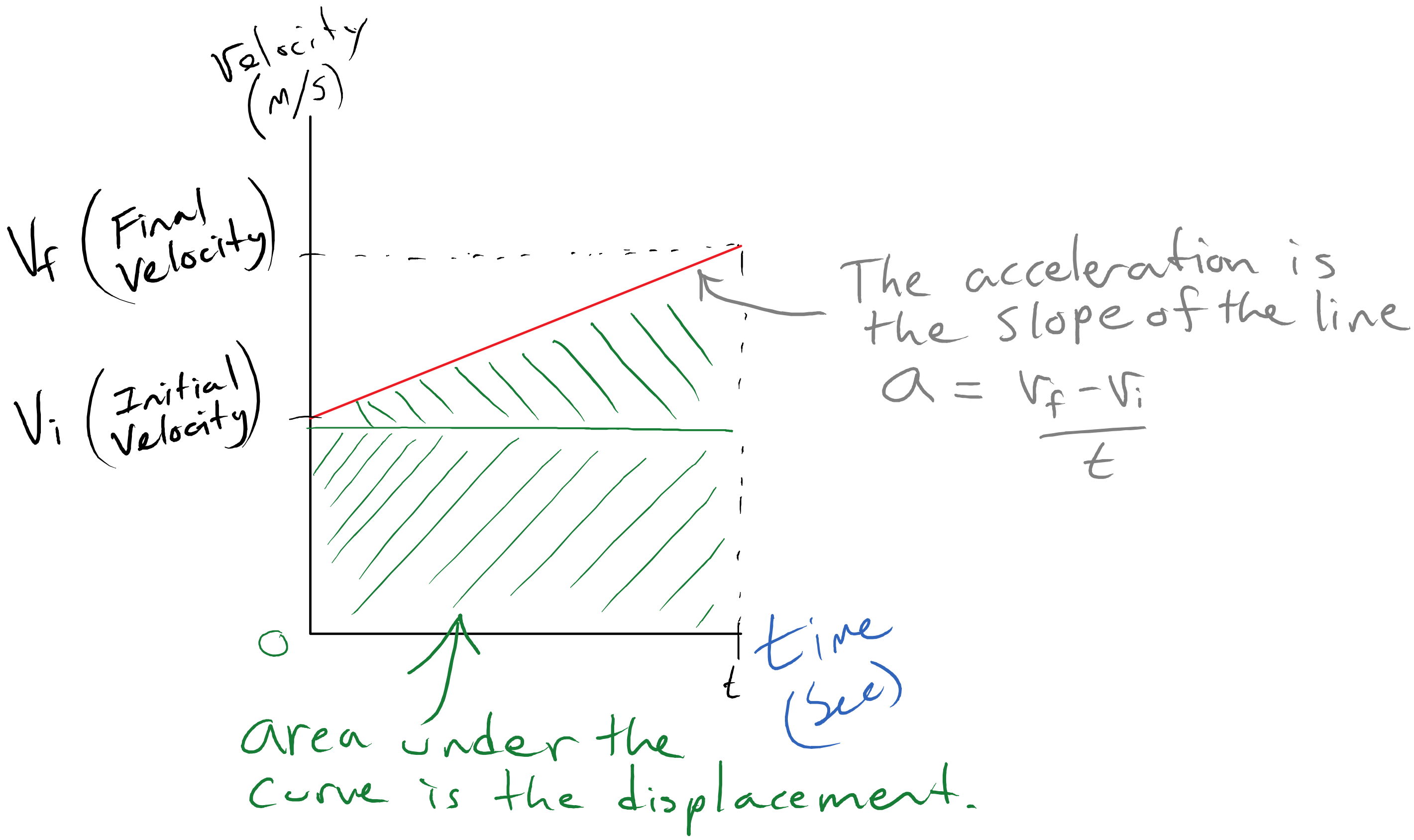
The change in velocity over a period of time is referred to as the acceleration of an object.

Acceleration
Symbol: $\vec{a}$
SI Unit: meter per square seconds (m/s^2 direction)



Below are all the kinematic formula's we will be using. We can derive most of them from the graph above. (But I won't ask you to do this)

$$\vec{d} = \vec{v}t \qquad \vec{v}_{ave} = \frac{\vec{v}_f + \vec{v}_i}{2}$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t \qquad \vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$

$$\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d} \qquad \vec{d} = \frac{\vec{v}_f + \vec{v}_i}{2}t$$

Solving Problems
There are three key steps in analyzing the problem and solving it.

Step 1: Draw a picture
This helps you visualize what is going on and will help you understand if there is any tricky

bits to the question.

Step 2: Write down the knowns and unknowns

A problem will always contain a number of known values some of these may be explicitly told to you ie (the velocity of the space cow is 33 m/s towards the sun), and others are implicitly told to you ie (said space cow started its journey from rest).

Step 3: Identify which equations you can use and solve.

This is just doing the grunt work. Practice makes perfect.

$v_i = 0$

Example: Mr. Horncastle enters his Van in a drag race. The race is 1200m long. From a complete stop he is able to finish the race in 33 seconds. What is his final velocity and acceleration?

1200m

$V_i = 0 m/s$

$V_f =$

$d = 1200 m$

$t = 33 s$

$a =$

$d = \frac{v_f + v_i}{2} t$

$1200 = \left(\frac{v_f + 0}{2}\right)(33)$

$\frac{2(1200)}{33} = v_f$

$73 m/s = v_f$

Wow! That's a bit fast →

$\boxed{260 Km/hr = v_f}$

$d = v_i t + \frac{1}{2} a t^2$

$1200 = \frac{1}{2} a (33)^2$

$\frac{2(1200)}{33^2} = a$

$\boxed{2.20 m/s^2 = a}$

Acceleration due to Gravity

On Earth objects fall due to the force of gravity. This force accelerates all objects on the surface of the earth down at a rate of $9.8 m/s^2$. We call this rate "g" the gravitational field strength at the surface of the earth.

<u>All objects fall at $9.8 m/s^2$ regardless of how heavy they are!</u>

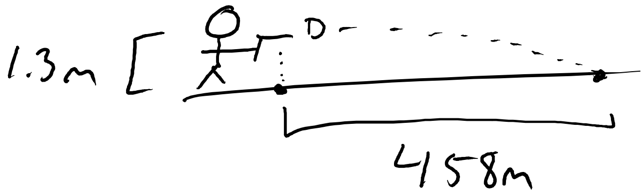
https://www.youtube.com/watch?v=E43-CfukEgs

The gravitational field strength is different for each planet, moon, or celestial object and changes as you move further or closer towards the object. (More on this in Dynamics)

$g_{earth} = 9.8 m/s^2$
$g_{moon} = 1.6 m/s^2$
$g_{mars} = 3.7 m/s^2$
$g_{jupiter} = 23 m/s^2$

Mr. Wong fires a hand gun horizontally with a velocity of 890m/s at a height of 1.3m above the ground.

The moment the bullet fires he drops the gun. The bullet hits the ground 458m in front of the gun. What hits the ground first the bullet or the gun?



Bullet Horizontal

$v = 890 m/s$

$d = 458 m$

$t =$

$t = \frac{d}{v}$

$= \frac{458}{896}$

$t = 0.515 s$

Gun

$v_i = 0 m/s$

$v_f =$

$d = -1.3 m$

$a = -9.8 m/s^2$

$t =$

$d = \cancel{v_i t} + \frac{1}{2}at^2$

$-1.3 = \frac{1}{2}(-9.8)t^2$

$\sqrt{\frac{2(-1.3)}{-9.8}} = t$

$0.515 s = t$

This is because the vertical and horizontal variables don't affect each other. The acceleration of gravity only affects the vertical velocity and displacement. Look at the variables for the vertical components of the Bullet.

Bullet Vertical

$v_i = 0 m/s$

$v_f =$

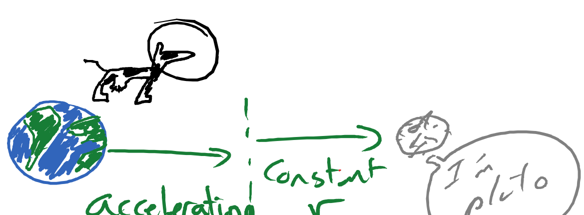
$d = 1.3 m$

$a = -9.8 m/s^2$

$t =$

These are the same as the guns initial conditions, so we will get the same outcome.

Example: A space cow leaves earth from rest using an ion propelled rocket. If the ion rocket can provide a thrust acceleration of $0.05 m/s^2$ and has a max speed of 90,000m/s. How quickly could the space cow get to Pluto? (Pluto is 7.5 billion km away from earth)



$v_i = 0 m/s$

$v_f = 90{,}000 m/s$

$a = 0.05 m/s$

$t =$

$v_f = v_i + at$

$90000 = \cancel{0} + (0.05)t$

$v_f^2 = \cancel{v_i^2} + 2ad$

$\frac{90000^2}{2(0.05)} = \frac{2(0.05)d}{2(0.05)}$

$a = 0.05\,m/s$
$t =$
$d =$

$90000 = \cancel{0}+(0.05)t$

$\frac{90000}{0.05} = t$

$\underline{1.80\times10^{6}\,s = t}$

$\frac{90000^2}{2(0.05)} = \frac{2(0.05)d}{2(0.05)}$

$\underline{8.1\times10^{10}\,m = d}$

Constant v

$v = 90\,000\,m/s$
$d = 7.5\times10^{12}\,m - 8.1\times10^{10}\,m = 7.419\times10^{12}\,m$
$t =$

$$t = \frac{d}{v} = \frac{7.419\times10^{12}\,m}{90000\,m/s}$$
$$= \underline{8.24\times10^{7}\,s}$$

$$t_{total} = 1.8\times10^{6} + 8.24\times10^{7} = 8.42\times10^{7}\,s = \underline{\underline{2.7\,years}}$$

Jerry flips a coin into the air giving it an initial velocity of 5.3m/s up.

1. What is the maximum height the coin reaches above Jerry?

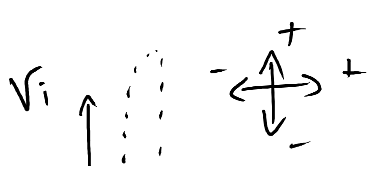
To max height
$v_i = 5.3\,m/s$
$v_f = 0\,m/s$
$d =$
$t =$
$a = -9.8\,m/s^2$

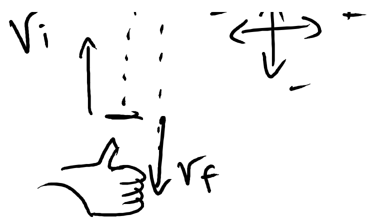
$v_f^2 = v_i^2 + 2ad$
$0^2 = 5.3^2 + 2(-9.8)d$
$\frac{-5.3^2}{2(-9.8)} = d$
$\boxed{1.4\,m = d}$

1. What is the velocity of the coin just before Jerry catches it on its way back down?

$v_i = 5.3\,m/s$
$v_f =$
displacement → $d = 0\,m$
$a = -9.8\,m/s^2$
$t =$

$v_f^2 = v_i^2 + 2ad$
$= 5.3^2 + 2(-9.8)(0)$
$v_f^2 = 5.3^2$
$v_f = \pm 5.3\,m/s$





v_f should be negative

$\therefore\ v_f = -5.3\ m/s$