# Kinematics

This is the branch of physics that is concerned with the motion of objects on a human scale.

s m kg

We're going to look at how far something will go when you throw it, launch it, drive it, drop it!

There are a few variables of interest to us in these types of problems:

d, x, y = are used to define the distance of displacement travelled. 'd' is used for a general distance. x,y imply a direction on a cartesian plane. SI unit is the meter (m)

t = time. SI unit is the second (s)

v = Velocity. This is similar to speed, but it includes a direction. For example, if your direction changes -- your velocity changes. Your speed can be constant though. SI units $\frac{m}{s}$.

a = Acceleration. This is a measure of how much your velocity is changing. Think of it as increasing (decreasing) your velocity. Velocity is measured in $\frac{m}{s}$ and acceleration changes it every second. ∴ the units of acceleration are $\frac{(\frac{m}{s})}{s} = \frac{m}{s^2}$. It is a change in meters per second each second.

The last thing that you need to understand is subscripts. We use these a ton in physics. Get comfortable with them quick! The three most common for this section are 0 - naught. i - initial. f - final.
$v_0$, $v_i$, $v_f$.

$\frac{m/s}{s} = \frac{m}{s^2} = m s^{-2}$ ✓

distance vs displacement
speed vs velocity

Kamloops is about 1 hours away when you drive an average speed of 100 km/hr. How far away is Kamloops?

K : 100 km

100 x 10^3 m

$d = vt$

$100 = 100(1)$

Vernon is 150 km away from Barriere. How long will it take to drive from Vernon to Kamloops?

Sf. $1.8 \times 10^3$ s

1.8 ks

$(150 - 100) = 100t$

$50 = 100t$

$(d_f - d_i) = vt$

$\frac{50}{100} = t$

$t = \frac{1}{2}$ hour

These questions rely on having a constant velocity. What if we are accelerating? The space shuttle has an acceleration of about 5.25$\frac{m}{s^2}$. What is its velocity after one minute?

Jerk

$\frac{\frac{m}{s}}{s} \cdot s$

$v = at$

$v = 5.25(60)$

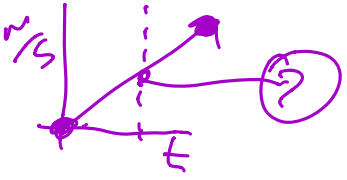
$v = 315 \frac{m}{s}$

How far will the shuttle have travelled after one minute? Remember: the velocity is not constant. The shuttle is clearly accelerating. IF acceleration is constant, we can use the average velocity.

$d = vt$ $\quad v = at$

$d = a t t$

$d = a t^2$




$(d_f - d_i) = \left(\frac{v_0 + v_f}{2}\right) t$

$d_f - 0 = \left(\frac{0 + 315}{2}\right) 60$

$df = 9450\ m$

Key Terms:

Falls: $v_0$= 0, a = 9.8 $\frac{m}{s^2}$ [down]

Dropped: same as falls

Stops: $v_f = 0$

Rest: one of your velocities is zero TO REST : $v_f = 0$
AT REST : $v_o = 0$

A brave physics student is riding his motorcycle down the street at 54km/hr when Gandolf steps in front and yells "You shall not pass!" The student brings his bike to a stop in 3 seconds. What is the acceleration? How far did he travel while braking?

$54\ \frac{km}{hr} \cdot \frac{1000m}{1\ km} \cdot \frac{1\ hr}{3600s} = 15\ m/s$

$V = at$

$15 = a(3)$

$\frac{15}{3} = a$

$5\ m/s^2 = a$

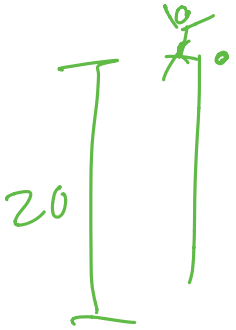
$d = vt$

$d = v_{avg}\ t$

$d = \left(\frac{15+0}{2}\right) 3$

$22.5\ m$

The Incredible Hulk throws a car down 20 m cliff with an initial velocity of 10m/s. What is the velocity of the car as it hits the ground? How long will it take? What if we changed the car to a toaster?




$V_0 = 10\ m/s \quad t = ? \quad d = 20$

$d = v_0 t + \frac{a t^2}{2}$

$-20 = -10t - \frac{9.81 t^2}{2}$

$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\frac{9.8}{2}t^2 + 10t - 20 = 0$

A B C

hint: $t = 1.24$ s.

There are a couple other equations for this unit that can help you.

$$v_f^{\,2} = v_0^{\,2} + 2ad$$

$$d = d_0 + v_0 t + \frac{at^2}{2}$$

# Homework

If a car moves with an average speed of 60.0 km/h for an hour, it will travel a distance of 60.0 km.

A. How far would it travel if it moved at this rate for 4 hours?
B. For 10 hours?
C. Would it be possible for the car that starts from rest to attain an average speed of 60 km/h and never exceed a reading of 60 km/h on the speedometer?

"She moves at a constant speed in a constant direction." Say the same sentence in fewer words.

The speedometer of a car moving to the east reads 100 km/h. It passes another car that moves to the west at 100 km/h. Do both cars have the same speed? Do they have the same velocity?

During a certain period of time, the speedometer of a car reads a constant 60 km/h. Does this indicate a constant speed? A constant velocity?

What is the velocity of an airplane that flies 602 m [East] in 2.50 s?

A spaceship traveled at $2.1 \times 10^6$ km in 2.7 days. What was the velocity of the spaceship in km/days and km/h? In SI units?

A particular car can go from rest to 90.0 km/h in 10.0 s. What is its acceleration?

A car accelerates at -2.0 $m/s^2$. If its initial velocity is 24 m/s [West], what will its velocity be 8.0 s later?