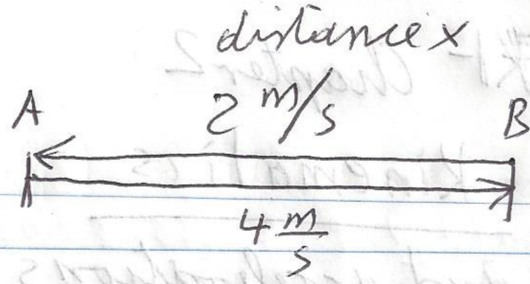


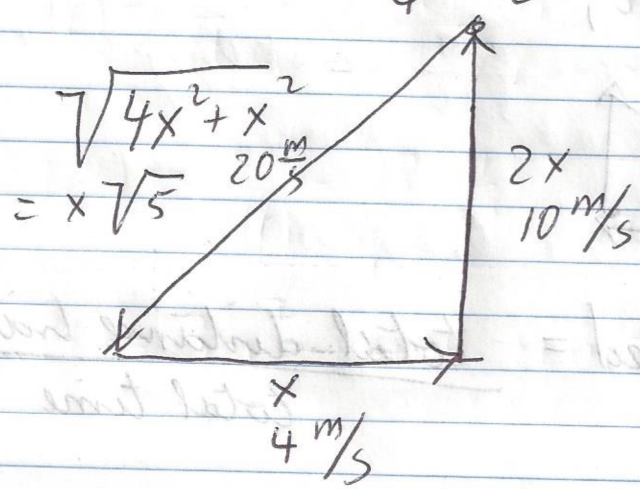
$$v = \frac{x}{t}$$

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

$$\bar{v}_{speed} = \frac{2x}{\frac{x}{4} + \frac{x}{2}}$$

$$= \frac{2}{\frac{1}{4} + \frac{1}{2}} = \frac{2}{\frac{3}{4}} = \frac{8}{3}\ \frac{m}{s}$$

$$= 2.67\ \frac{m}{s}$$



$$\bar{v}_{speed} = \frac{x + 2x + x\sqrt{5}}{\frac{x}{4} + \frac{2x}{10} + \frac{x\sqrt{5}}{20}} =$$

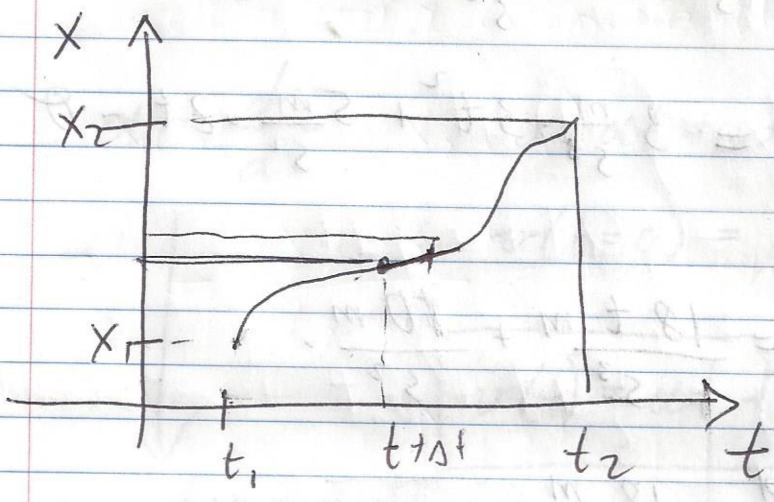
$x(t)$

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{x_1(t_1 + \Delta t) - x_1(t_1)}{\Delta t}$$

$\Delta t = t_2 - t_1$ change in t

Make $\Delta t \to 0$

$$v(t) = \lim_{\Delta t \to 0} \frac{x(t+\Delta t) - x(t)}{\Delta t} = \frac{dx}{dt}$$



$$\bar{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{v_1(t_1+\Delta t) - v_1(t_1)}{\Delta t}$$

number

$$a_1(t) = \lim_{\Delta t \to 0} \frac{v_1(t_1+\Delta t) - v_1(t_1)}{\Delta t} = \frac{dv}{dt}$$

$$a(t) = \frac{dv}{dt}$$

$$J(t) = \frac{da}{dt} \quad \text{jerk}$$

$$x(t) = 3t^3 + 5t^2 - 5$$

$$x(t) = 3\frac{m}{s^3}t^3 + \frac{5m}{s^2}t^2 - 5m$$

$$v(t) = \frac{dx}{dt} = 3\frac{m}{s^3}\cdot 3t^2 + 5\frac{m}{s^2}\cdot 2t - 0$$

$$a(t) = \frac{dv}{dt} = \frac{18\,t\,m}{s^3} + \frac{10\,m}{s^2}.$$

$$J(t) = \frac{da}{dt} = 18\frac{m}{s^3}$$

$$x(t) = 3m\,\cancel{\sin \omega t}\ \sin\left(\frac{5}{s}t\right) \qquad \frac{5}{s} = \omega$$

omega = angular frequency

$$v(t) = \frac{dx}{dt} = 3m\cos\left(\frac{5}{s}t\right)\cdot\frac{5}{s}$$

$$= 15\frac{m}{s}\cos\left(\frac{5}{s}t\right)$$

$$a(t) = \frac{dv}{dt} = 15\frac{m}{s}\left(-\sin\frac{5}{s}t\right)\cdot\frac{5}{s}$$

$$= -75\frac{m}{s^2}\sin\frac{5}{s}t$$

Kinematics: acceleration a = constant.

Can we determine $v(t)$ and $x(t)$ by using just the definitions?

$a = \frac{dv}{dt}$ $\qquad v = at + \text{constant} = v(t)$

$v(t=0) = \text{constant} = v_0$

$$\boxed{v(t) = at + v_0}$$

$dv = a \cdot dt$

$\int dv = \int a \cdot dt$ $\qquad \int dx$

integration symbol.

$v(t) = at + v_0$

$$\int_{v_0}^{v_1} dv = \int_{t_0}^{t_1} a\, dt$$

$v_1 - v_0 = at_1 - at_0$

$v(t) = a t + v_0$

$v(t) = \frac{dx}{dt}$

$\int dx = \int v(t) \cdot dt$

$= \int (a t + v_0)\, dt$

$x(t) = \frac{1}{2} a t^2 + v_0 t + \text{constant}$

$$\boxed{x(t) = \frac{1}{2} a t^2 + v_0 t + x_0}$$

Example: You ride a bike at 20 mph

You accelerate for 5 s with $a = 5 \frac{m}{s^2}$

You start at $x(t=0) = 0$

where are you after 5 seconds?

What is your speed or velocity

$20 \frac{\text{miles}}{\text{hour}} = 20 \cdot \frac{1610 m}{3600 s} = 20 \cdot 0.447$

$= 8.94 \frac{m}{s}$

$x(5s) = \frac{1}{2} \cdot 5 \frac{m}{s^2} \cdot 25 s^2 + 8.94 \frac{m}{s} \cdot 5 s + 0 = 107 m$

$$\boxed{v = at + v_0}$$

$$= 5\frac{m}{s^2} \cdot 5s + 8.94\frac{m}{s}$$

$$= 33.94\frac{m}{s}$$

At what speed are you going @ $x = 60m$?

Find the time first:

$$60m = \frac{1}{2} \cdot 5 \cdot t^2 + 8.94t$$

$$2.5t^2 + 8.94t - 60 = 0$$

$$t = \frac{-8.94 \pm \sqrt{8.94^2 + 4 \cdot 2.5 \cdot 60}}{5}$$

$$= \frac{-8.94 \pm \sqrt{680}}{5}$$

$$= \frac{-8.94 \pm 26.1}{5} = -1.79 \pm 5.22$$

$$= 3.43s$$

$$v = at + v_0$$

$$= 5\frac{m}{s^2} \cdot 3.44s + 8.94 = 26.1\frac{m}{s}$$

Eliminate t from our equations

$$\boxed{\begin{aligned} x &= \frac{1}{2}at^2 + v_0 t + x_0 \\ v &= at + v_0 \end{aligned}}$$

$$t = \frac{v - v_0}{a}$$

$$x - x_0 = \frac{1}{2}a\left(\frac{v - v_0}{a}\right)^2 + v_0\left(\frac{v - v_0}{a}\right) \quad \Big| \cdot 2a$$

$$2a(x - x_0) = (v - v_0)^2 + 2v_0(v - v_0)$$

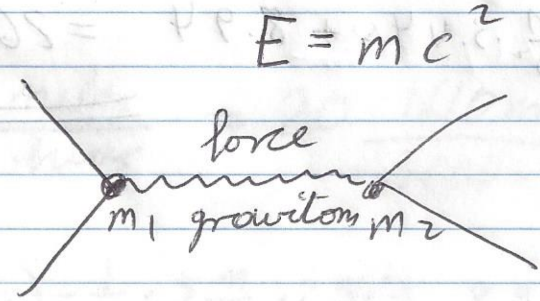
$$(x - x_0)\cdot 2a = v^2 \cancel{- 2vv_0} + v_0^2 \cancel{+ 2v_0 v} - 2v_0^2$$

$$= v^2 - v_0^2$$

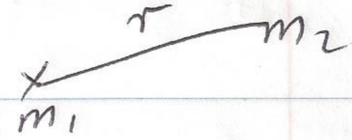
$$\boxed{v^2 = v_0^2 + 2a(x - x_0)}$$

Newton's law of gravitation:
= gravitational attraction between any two objects with a mass or energy.

$$E = mc^2$$



$$F = \frac{G m_1 m_2}{r^2}$$



m_1 is a mass on the surface of the earth

m_2 is the mass of the earth

$$F = m_1 \underbrace{\left(\frac{G m_2}{r^2}\right)}_{g} = m_1 \frac{6.673 \cdot 10^{-11} \cdot 5.99 \cdot 10^{24}}{(6.37 \cdot 10^{6})^2}$$

$$= m_1 \cdot 9.85 \frac{m}{s^2}$$

$$\boxed{g = 9.80 \frac{m}{s^2}}$$