Kinematics

↳ the mathematical description of motion

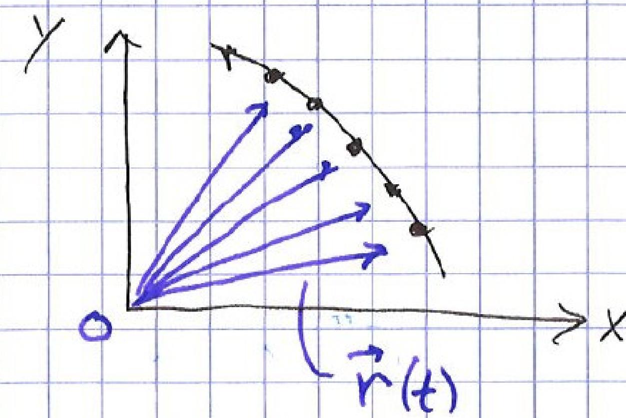
The oldest topic in physics – MECHANICS

- KINEMATICS
- DYNAMICS

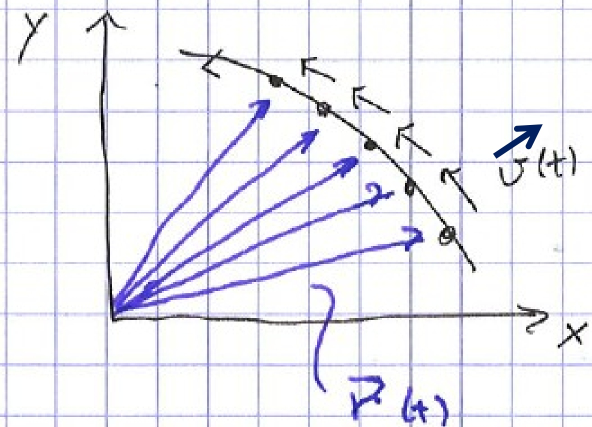
Variables

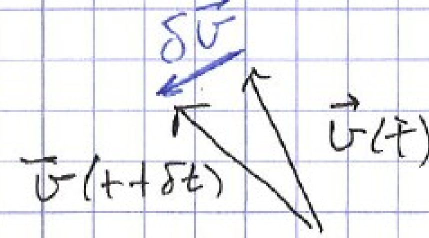
Time	t	[s]
Position	$\vec{r}(t)$	[m]
Velocity	$\vec{v}(t)$	[m/s]
Acceleration	$\vec{a}(t)$	[m/s/s]

These are vectors

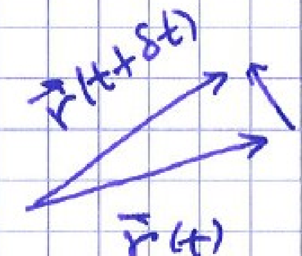


$$\vec{v} = \frac{\delta \vec{r}}{\delta t} \qquad \vec{a} = \frac{\delta \vec{v}}{\delta t}$$





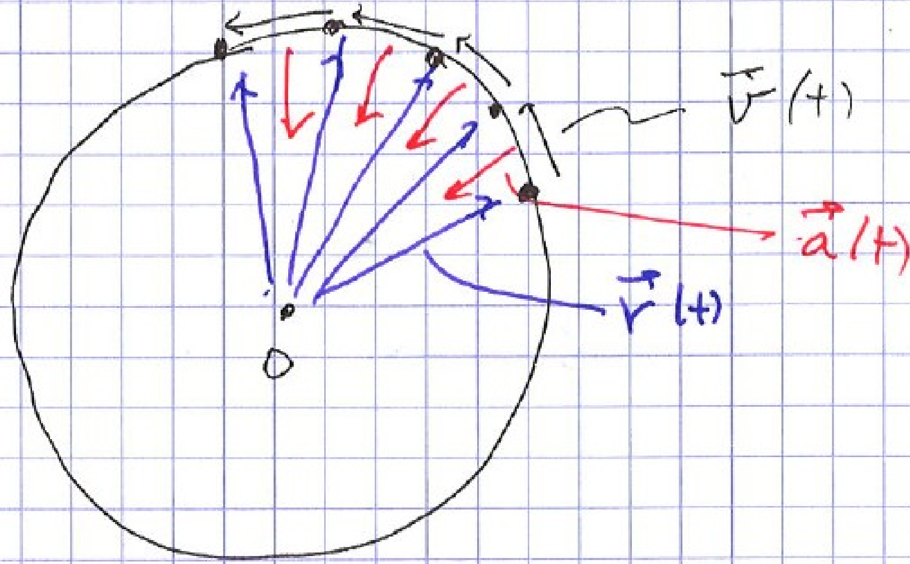
adding vectors:
$\vec{v}(t) + \delta\vec{v} = \vec{v}(t+\delta t)$



$\delta\vec{r} = \vec{v}\,\delta t$

adding vectors: $\mathbf{r}(t) + \delta\mathbf{r} = \mathbf{r}(t + \delta t)$

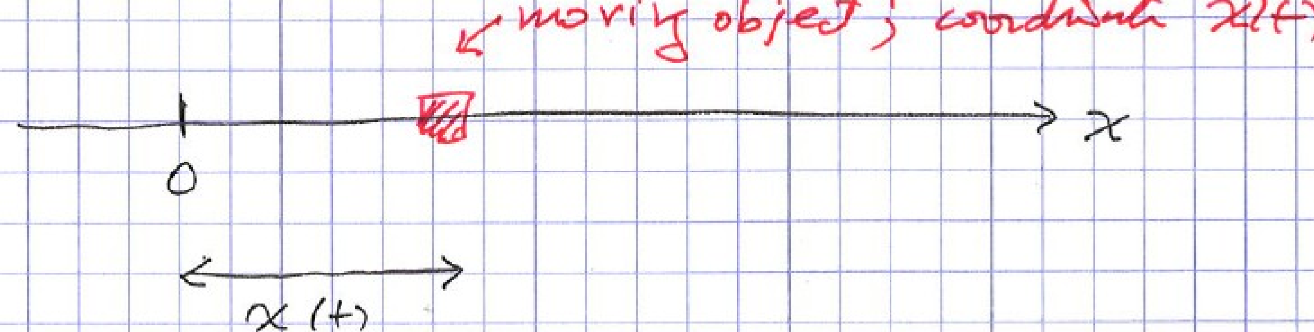
Circular Motion



$$\vec{a}(t) = -\frac{v^2}{r}\,\hat{r}$$

"centripetal acceleration"

Motion along a line



Equations

Constant velocity : $\quad x(t) = x_0 + v_0 t$

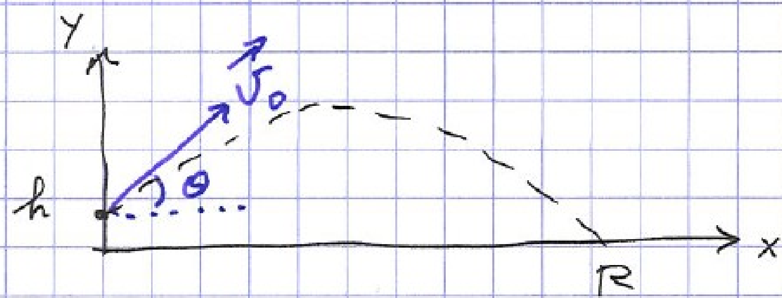
$(\delta x / \delta t = v_0)$

Constant acceleration : $\quad x(t) = x_0 + v_0 t + \frac{1}{2} a_0 t^2$

$(\delta v / \delta t = a_0 ;$ $\quad v(t) = v_0 + a_0 t$

$\delta x / \delta t = v_0 + a_0 t)$

Example: Baseball home run



$\vec{v}_0 = v_{0x}\,\hat{\imath} + v_{0y}\,\hat{\jmath}$

Neglect air resistance.
Then the horizontal (x) motion has constant velocity

$x(t) = x_0 + v_{0x}\, t$

$= 0 + v_0 \cos\theta \cdot t$

The vertical (y) motion has constant acceleration

$y(t) = y_0 + v_{0y} t + \frac{1}{2} a_{0y} t^2$

$y(t) = h + v_0 \sin\theta \cdot t - \frac{1}{2} g t^2$

$g = 9.8\ m/s^2 = 32\ ft/s^2$

Numerical example

Suppose $v_0 = 90\ mph = 132\ ft/s$
and $\theta = 45$ degrees; and $h = 3\ ft$.
Calculate R.

$y(t) = 0 = h + \frac{v_0}{\sqrt{2}} t - \frac{1}{2} g t^2$

$$t = \frac{v_0/\sqrt{2} + \sqrt{(v_0/\sqrt{2})^2 + 2gh}}{g}$$

(CALCULATOR)

$t = 5.9\ s$

$R = \frac{v_0}{\sqrt{2}} t = \underline{547\ ft}$

Makes sense ??? why not.