Lecture 4

Physics Phriday !

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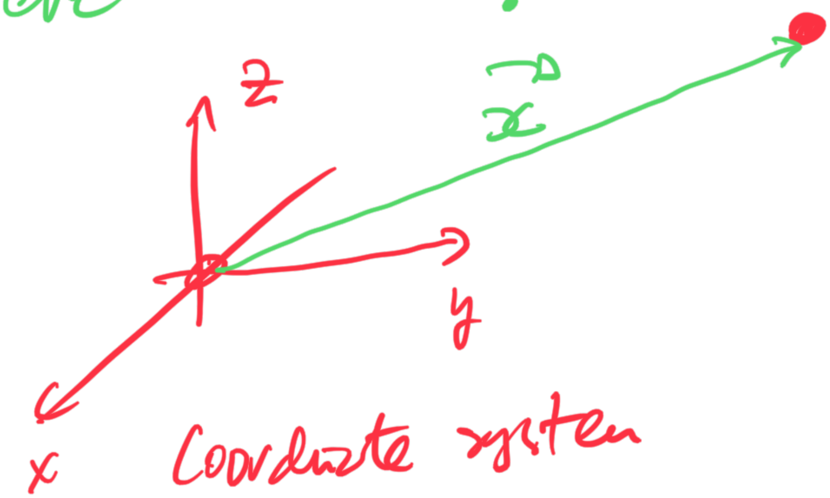
Asking Questions !

physical quantity → scalar
→ vector.

Kinematics

"motion" → cinema

Where is it?



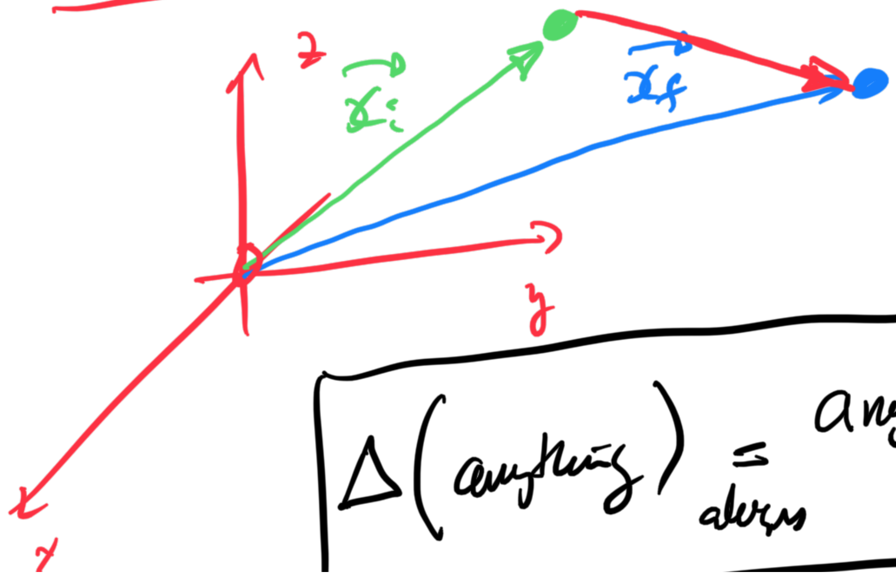
Coordinate system

$\vec{x}(t) \equiv$ position vector (m)

(x, y, z)

How far has it moved from its original position?

$\vec{x}_f - \vec{x}_i$



$= \Delta\vec{x}$

$$\boxed{\Delta(\text{anything}) \underset{\text{always}}{=} \text{anything}_f - \text{anyt}}$$

$\Delta \vec{x} \equiv$ change in position.

$\equiv$ displacement

$\vec{x}$ vs. $\Delta \vec{x}$

not the same!

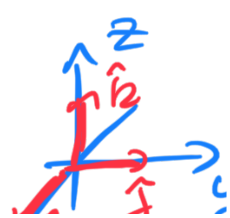
How fast is it moving?

and in what direction

velocity $\boxed{\vec{v}(t)}$ m/s

How is the position changing in time?

$$\vec{v}(t) \equiv \frac{d\vec{x}(t)}{dt}$$



$v(t) \qquad dt$

$$\vec{x} = 3.0\,\hat{i} + 4.0\,t^2\,\hat{j} + 2.5\,t^3\,\hat{k}$$

$$\frac{d\vec{x}}{dt} = 8.0\,t\,\hat{j} + 7.5\,t^2\,\hat{k}$$

$\vec{v}(t)$

$$\vec{a} = \frac{d\vec{v}}{dt} = \underbrace{8.0\,\hat{j} + 15.0\,t\,\hat{k}}_{\text{not constant}}$$

How is velocity changing in time?

$$\vec{a}(t) = \frac{d\vec{v}}{dt}$$

acceleration

Is it speeding up? Is

if slowing down ?

$\vec{x}(t)$

$\vec{v}(t)$

$\underbrace{\vec{a}(t)}_{\text{at a particular time.}}$

instantaneous.

$$\Delta\vec{x} = \underbrace{\overset{t_f}{\vec{x}_f} - \overset{t}{\vec{x}_i}}_{\text{over a time interval.}}$$

average quantity.

time-averaged quantity

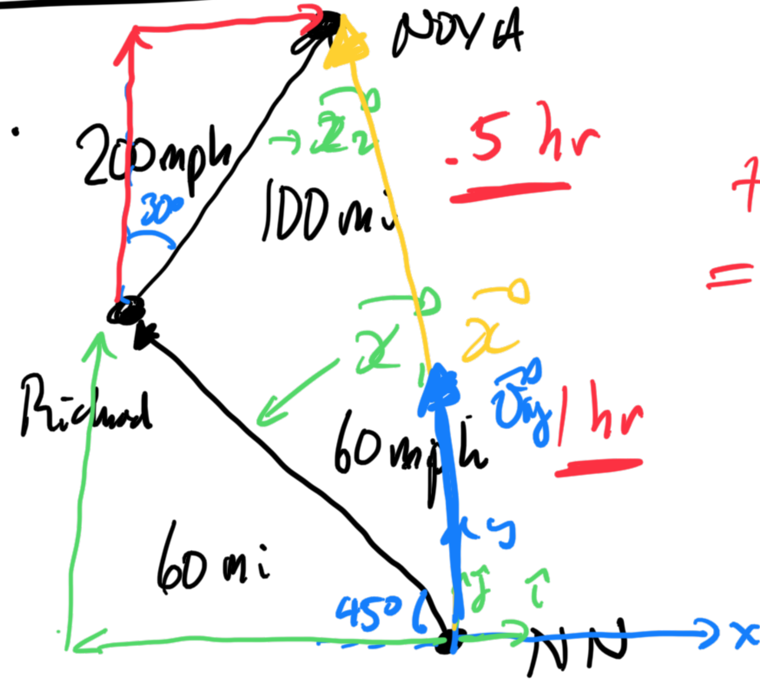
$$\vec{V}_{avg} = \frac{\Delta\vec{x}}{\Delta t}$$

Average Velocity

$$\vec{V}_{average} = \frac{\Delta\vec{x}}{\Delta t} = \frac{\vec{x}_f - \vec{x}_i}{t_f - t}$$

$$\neq \vec{v}(t)$$

Example.



total time = 1.5 hours

① Choose a coordinate system.

② Break down into x and y components.

$$\vec{x}_1 = -60\cos 45^\circ\,\hat{i} + 60\sin 45^\circ\,\hat{j}$$

$$\vec{x}_2 = 100\cos 30^\circ\,\hat{j}$$

$+\ \underline{100 \sin 30^\circ}\ \hat{\imath}$

$$\vec{x} = \vec{x}_1 + \vec{x}_2$$

$$= \overset{7.57}{\left(-60\cos 45^\circ + 100\sin 30^\circ\right)}\ \hat{\imath}$$

$$+ \overset{92.43}{\left(60\sin 45^\circ + 100\sin 30^\circ\right)}$$

what is average velocity?

$$\vec{v}_{avg} = \frac{\Delta \vec{x}}{\Delta t} = \frac{\vec{x}_f - \vec{x}_i}{t_f - t_i}$$

start : NN $\quad \vec{x}_i = 0$

$t_i = 0$

find : NOVA $\quad \vec{x}_f = \vec{x}$

$t_f = 1.5$ hours.

$$\vec{v}_{avg} = \frac{7.57\,\hat{i} + 92.43\,\hat{j}}{1.5 - 0}$$

$$\boxed{\vec{v}_{avg} = 5.0 \text{ mph}\,\hat{i} + 61.6 \text{ mph}\,\hat{j}}$$

Useless !!

$\boxed{\text{Average Speed}}$

Instantaneous Speed

$$S \equiv |\vec{v}(t)|$$

$\vec{v}$ = 100 mph NW

S = 100 mph

Average Speed

$$s_{avg} \equiv \frac{\text{Total Distance}}{\text{Total Time}}$$

$$= \frac{60\text{ mi} + 100\text{ mi}}{1.0\text{ hr} + 0.5\text{ hr}}$$

$$= \frac{160\text{ mi}}{1.5\text{ hr}}$$

$$\boxed{s_{avg} = 106.7\text{ mph}}$$

$$|\vec{v}_{avg}| = \sqrt{5.0^2 + 61.6^2}$$

$$= 61.8\text{ mph}$$

Trip 1 $\rightarrow$ 60 mph

200 mph

Trip 2 → 200 mph

What is the average speed?

~~$S_{avg} = \frac{60\,mph + 200\,mph}{2} = \frac{260\,mph}{2} = 130\,mph$~~

Q11.

$$r = k(E)^a(\rho)^b(t)^c$$

r: m

k: x

E: $\frac{kg\,m^2}{s^2}$

ρ: $\frac{kg}{m^3}$

t: s

$$m = \left(\frac{kg\,m^2}{s^2}\right)\left(\frac{kg}{m^3}\right)(s)$$

$$m = \frac{kg^a\, m^{2a}}{s^{2a}} \cdot \frac{kg^b}{m^{3b}} \cdot s^c$$

$$m^1 = kg^{a+b} \cdot m^{2a-3b} \cdot s^{c\ldots}$$

$$\boxed{\begin{aligned} a+b &= 0 \\ 2a-3b &= 1 \\ c-2a &= 0 \end{aligned}}$$

$$a = \frac{1}{5},\quad b = \frac{-1}{5},\quad c = \frac{2}{5}$$

$1/\ldots \quad 1/ \quad 2/\ldots$

$$r = k E^{1/5} \rho^{-1/5} t^{2/5}$$

$$r^5 = k^5 \frac{E t^2}{\rho}$$

$$\boxed{E = \frac{\rho r^5}{k^5 t^2}}$$