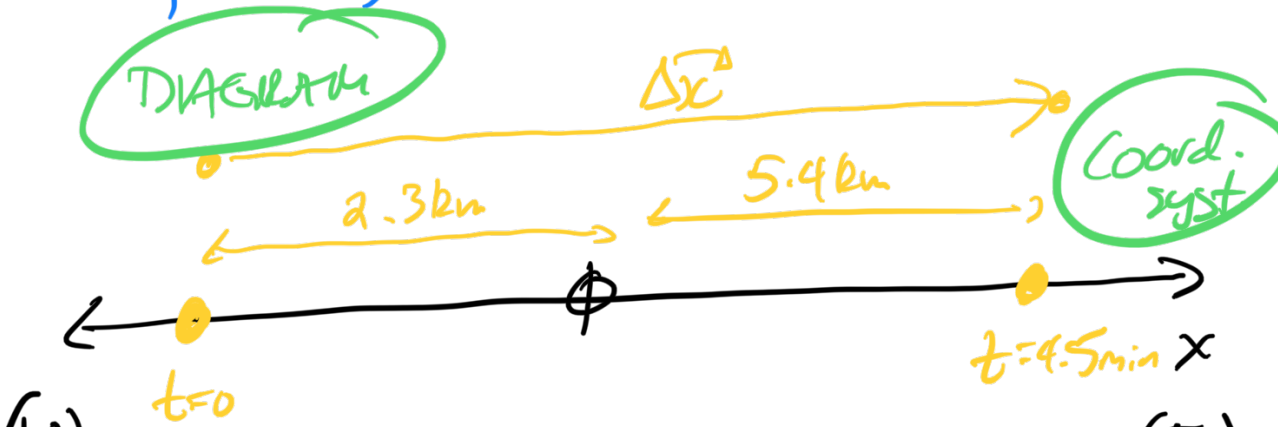
Physics 201 - Lecture 7

2D Motion

① Projectile Motion
② Relative Motion
③ Un.form Circular Motion

Vectors + Motion in 1D with constant acceleration.

#7, #3, #1,



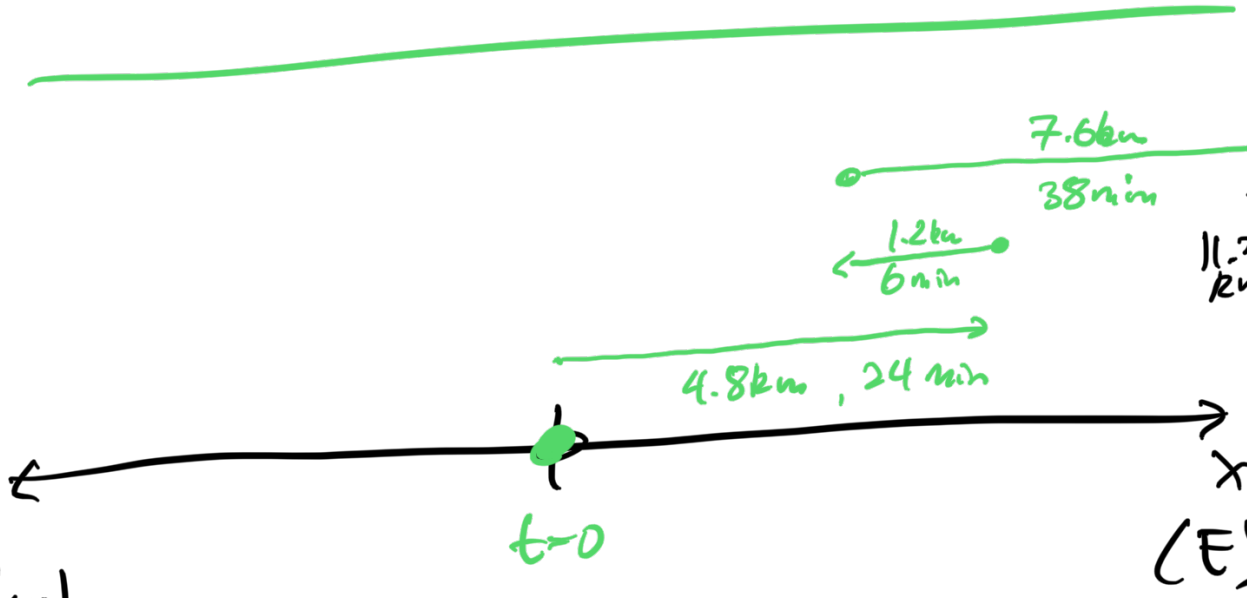
(W) (E)

a) $\vec{x}_i = -2.3\,\text{km}\,\hat{i}$ $\vec{x}_f = +5.4\,\text{km}\,\hat{i}$

b) $\Delta\vec{x} = \vec{x}_f - \vec{x}_i$

$= 5.4\,\text{km}\,\hat{i} - (-2.3\,\text{km}\,\hat{i}$

$= 7.7\,\text{km}\,\hat{i}$



$\Delta\vec{x}_1 = +4.8\,\text{km}\,\hat{i}$

$\Delta\vec{x}_2 = -1.2\,\text{km}\,\hat{i}$

$\Delta\vec{x}_3 = +7.6\,\text{km}\,\hat{i}$

$\Delta\vec{x}$ $\Delta\vec{x}_1 + \Delta\vec{x}_2 + \Delta\vec{x}_3$

$$\Delta x_{\substack{\text{entire} \\ \text{trip}}} = (4.8 - 1.2 + 7.6)\,\hat{i}$$

$$= \underline{11.2\ \text{km}\ \hat{i}}$$

$$\boxed{+11.2} \quad \text{km}$$

b) $$\vec{V}_{avg} \equiv \frac{\Delta \vec{x}}{\Delta t} = \frac{11.2\ \text{km}\ \hat{i}}{1.133\ \text{hours}.}$$

$$\Delta t = 24\ \text{min} + 6\ \text{min} + 38\ \text{min}$$

$$= 68\ \text{min}$$

$$= 1.133\ \text{hours}.$$

$$\vec{V}_{avg} = 9.88\ \frac{\text{km}}{\text{hr}}\ \hat{i}$$

$$\boxed{9.88} \quad \frac{\text{km}}{\text{hr}}$$

#7.

$\vec{v}(10) = +8.2\,\hat{i}$ ← "initial"

$\vec{v}(20) = -2.4\,\hat{i}$ ← "final"

a) $\vec{a} = \dfrac{d\vec{v}}{dt} = \dfrac{\Delta\vec{v}}{\Delta t}$

if $\vec{a}$ is constant

$= \dfrac{\vec{v}(20) - \vec{v}(10)}{20 - 10}$

$= \dfrac{-2.4\,\hat{i} - 8.2\,\hat{i}}{10\ s}$

$= \dfrac{-10.6\,\hat{i}}{10}$

$$\vec{a} = -1.06\,\hat{i}$$

$$-1.06$$

b) "its initial velocity" at $t = 0$

$$\vec{V}(0) = ?$$

$$\vec{V}_f = \vec{V}_i + \vec{a}\,t$$

V_f: $\vec{V}(10) = 8.2\,\hat{i}$

V_i: $t = 0$

a: $-1.06\,\hat{i}$

t: 10

$$8.2\,\hat{i} = \vec{V}_i - 1.06\,\hat{i}\,(10)$$

$$8.2\hat{i} = \vec{V_i} - 10.6\hat{i}$$

$$\vec{V_i} = 18.8\,\hat{i}$$

(c) t when its velocity is zero.

$$\vec{V_f} = \vec{V_i} + \vec{a}\,t$$

$$0 = 18.8\hat{i} - 1.06\hat{i}\,t$$

$$1.06\hat{i}\,t = 18.8\hat{i}$$

$$t = \frac{18.8\,\hat{i}}{1.06\,\hat{i}}$$

$$t = 17.7\,s$$

Projectile Motion.

→ things flying through the air.

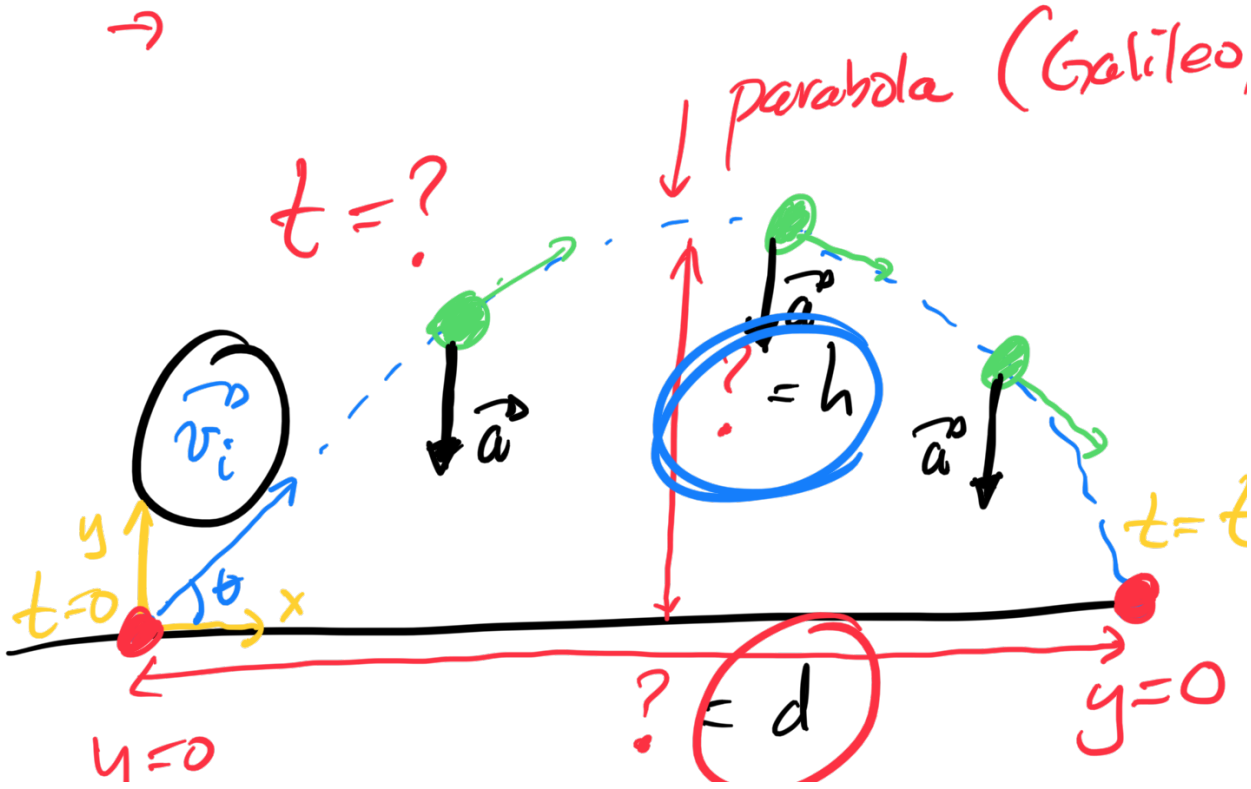
→ on earth

→ ignore air resistance ✓

→ basketball

→ bullets

→



1st concept - one force → gravity.

$$|\vec{a}| = -9.8\ m/s^2$$

$\vec{a} = -9.8\,\hat{j}$ ← break into x and y components

2nd Concept

$\vec{a}$

X

Y

① $a_x = 0$ | $a_y = -9.8\ m/s^2$

$= -g$

$\vec{v_i}$

② $V_{ix} = v_i \cos\theta$ ✓ $V_{iy} = V_i \sin\theta$ ②

③ $\Delta x = d$ ✓ $\Delta y = 0$ ③

$t = ?$ ← $V_{fy} = ?$

$t = ?$

Concept 3: TIME is same! in the x and y directions.

$a_y,\ v_{iy},\ \Delta y$

t

$\Delta y = v_{iy} t + \frac{1}{2} a_y t^2$

$0 = (v_i \sin\theta) t - 4.9 t^2$ $\left(-\frac{g}{2}\right)$

$0 = t\left(v_i \sin\theta - 4.9 t\right)$ (g)

Either $t = 0$, or

$t = \frac{2 v_i \sin\theta}{g}$ ☺

$v_i \sin\theta - \frac{g}{2} t = 0$

$v_i \sin\theta = \frac{g}{2} t$

Both of those are

$t = \frac{2 v_i \sin\theta}{g}$

$\Delta x = v_{ix} t + \frac{1}{2} a_x t^2$

$\Delta x = (v_i \cos\theta)\left(\frac{2 v_i \sin\theta}{g}\right)$

$\Delta x = \frac{2 v_i^2 \sin\theta \cos\theta}{g}$

d

$v_i \sin\theta = \frac{g}{2}t$

$2v_i \sin\theta = gt$

$\frac{2v_i \sin\theta}{g} = t$

Correct!!

$$d = \frac{2v_i^2 \sin\theta\cos\theta}{g}$$

$$\sin(2\theta) = 2\sin\theta\cos\theta$$

$$\boxed{d = \frac{v_i^2}{g}\sin 2\theta}$$

① What angle should I launch at to get max. distance.

$\theta = 45°$

↓

$2\theta = 90°$

$\sin(2\theta) = \sin(90°) = 1$

② Compare $\theta = 30°$ to $\theta = 60$

$2\theta = 60°$ $\quad$ $2\theta = 120°$

$\sin(60°) = \underline{0.866}$ $\quad$ $\sin(120°) = \underline{0.8}$