Phys 2110-3 9/15/10

Note Title 9/15/2010

2D Motion

$x(t), y(t)$ $\quad v_x, v_y \quad a_x, a_y$

Constant Accel $\quad a_x, a_y$ both constant

$$v_x = v_{0x} + a_x t \qquad v_y = v_{0y} + a_y t$$

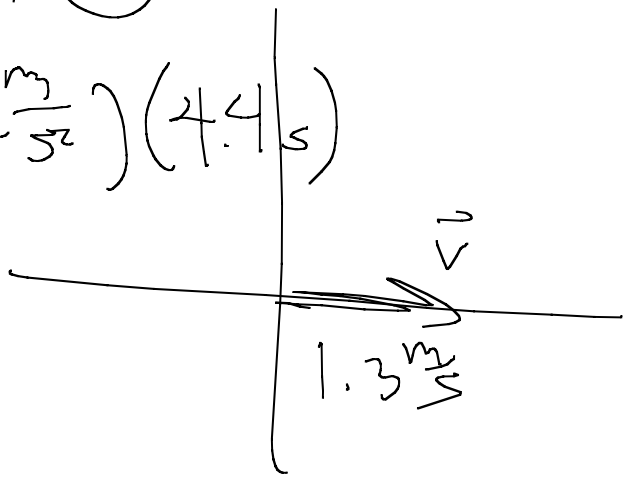
$$x = x_0 + v_{0x} t + \tfrac{1}{2} a_x t^2 \qquad y = y_0 + v_{0y} t + \tfrac{1}{2} a_y t^2$$

3.32 An object is moving in the x dir at $1.3 \frac{m}{s}$; it is subj'd to accel of $\vec{a} = 0.52 \hat{j} \frac{m}{s^2}$. What is velocity vector after 4.4 s of acceleration?

$$v_x = v_{ox} + a_x t = 1.3 \frac{m}{s} + 0$$

$$v_y = v_{oy} + a_y t = 0 + \left(0.52 \frac{m}{s^2}\right)(4.4\,s)$$

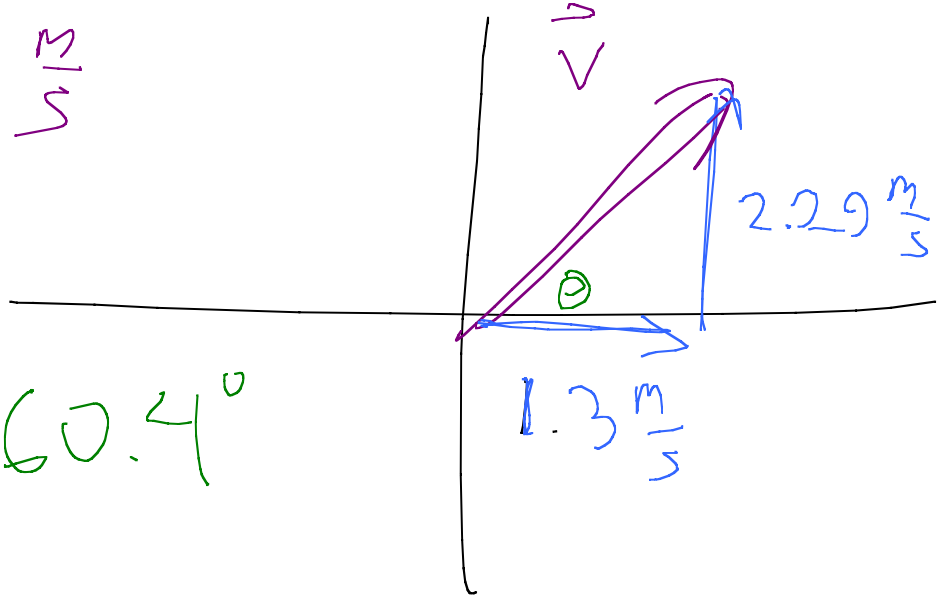
$$v_x = 1.3 \frac{m}{s} \qquad v_y = 2.29 \frac{m}{s}$$



$$v = \sqrt{(1.3)^2 + (2.29)^2} \ \frac{m}{s}$$

$$= 2.63 \ \frac{m}{s}$$

$$\theta = \tan^{-1}\left(\frac{2.29}{1.3}\right) = 60.4^\circ$$



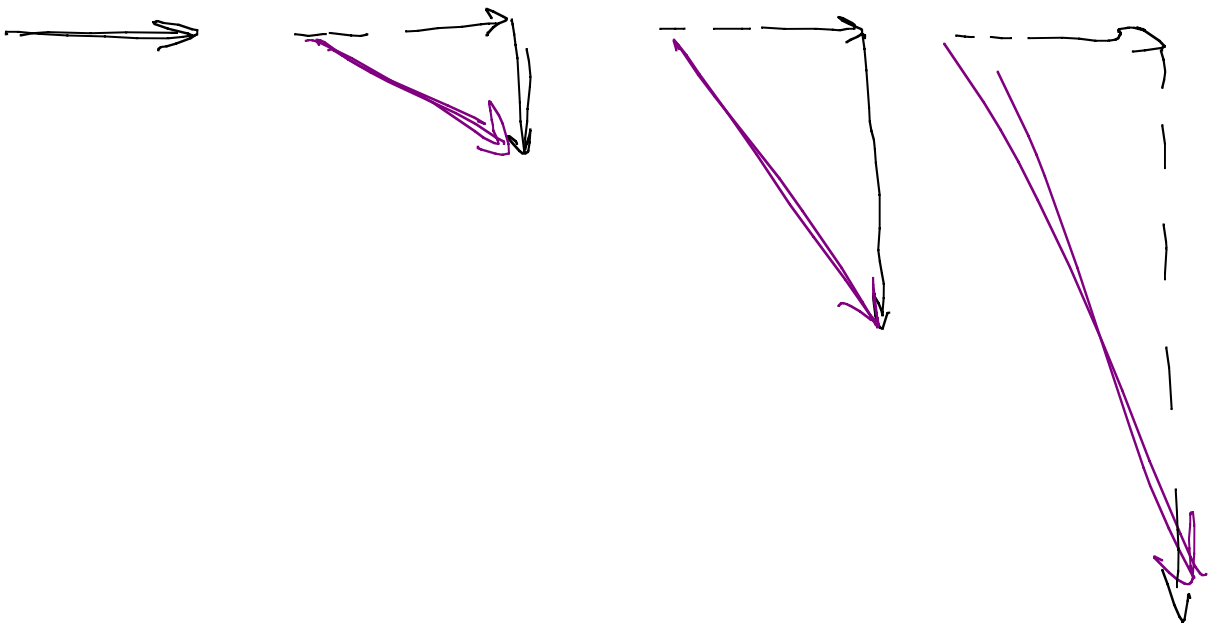
Free-fall

a_x, a_y

$a_y = -9.8 \frac{m}{s^2}$

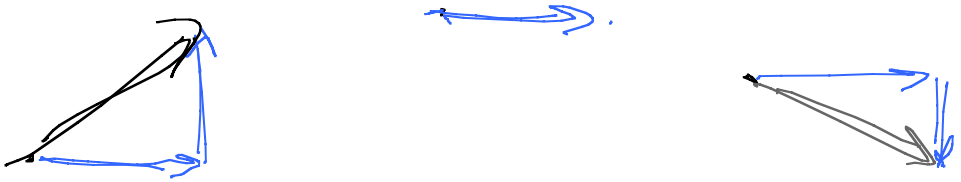
$a_x = 0$

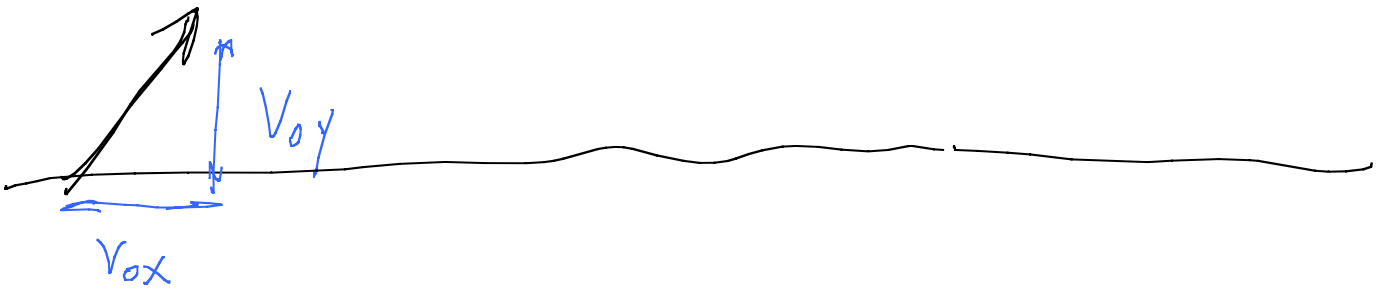
Ignore air!



x coordinate changes regularly
$\sim t$

y coord. changes
$\sim t^2$





3.40 A carpenter tosses a shingle off 8.8 m-high roof giving it an initial horiz. velocity of $11 \frac{m}{s}$.

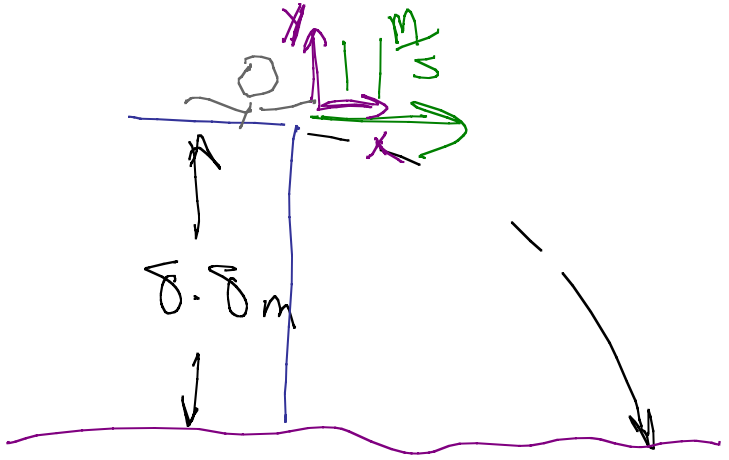
a) How long does it take shingle to reach ground?

b) How far shingle move horizontally in this time?

$$x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$

$$= 0 + 11 \frac{m}{s} t + 0$$

$$= (11 \frac{m}{s}) t$$



$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$= 0 + 0 + \frac{1}{2}\left(-9.8\,\frac{m}{s^2}\right)t^2$$

$$= -\frac{1}{2}\left(9.8\,\frac{m}{s^2}\right)t^2$$

a) t when $y = -8.8\ m$

$$-8.8\ m = -\frac{1}{2}\left(9.8\,\frac{m}{s^2}\right)t^2$$

$$\boxed{t = 1.34\ s}$$

b) $$x = \left(11\,\frac{m}{s}\right)t = \left(11\,\frac{m}{s}\right)(1.34\ s) = \boxed{14.7\ m}$$

3.41 An arrow fired horizontally at $41 \frac{m}{s}$ travels 23 m horizontally before it hits ground. From what height fired?

$$x = \left(41 \tfrac{m}{s}\right) t$$

$$y = -\tfrac{1}{2} g t^2$$

Find time in flight

$$x = 23\,m = \left(41 \tfrac{m}{s}\right) t$$

$$t = 0.561\,s$$

At this time

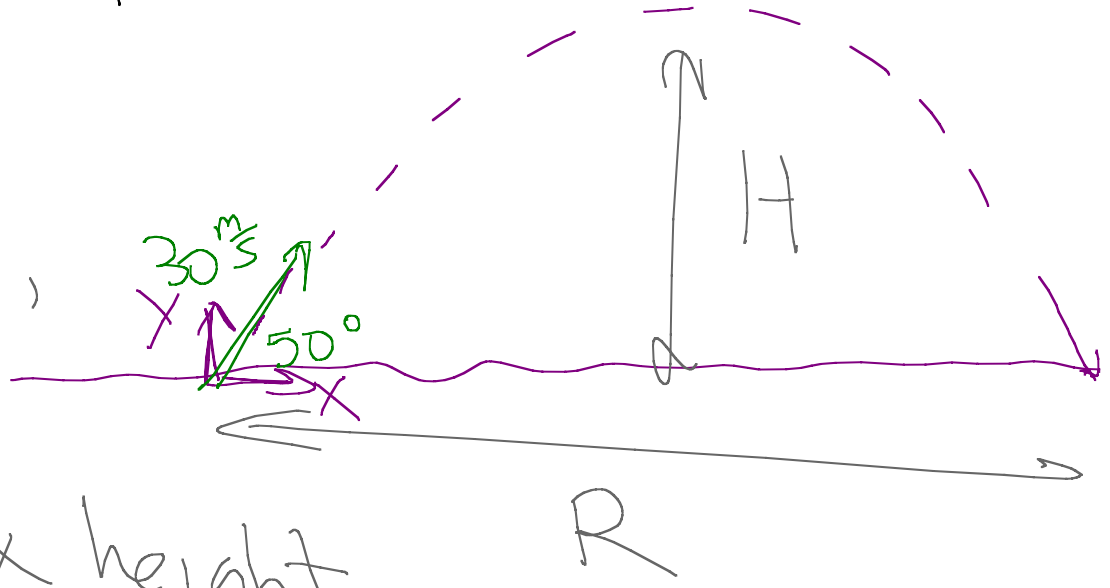
$$y = -\frac{1}{2}\left(9.8\ \frac{m}{s}\right)(0.561\ s)^2$$

$$= -1.54\ m$$

Fired from height of 1.54 m

"Projectile problem"

Projectile fired from ground level, as shown



find ⟹ Range, max height H, time in flight

$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$

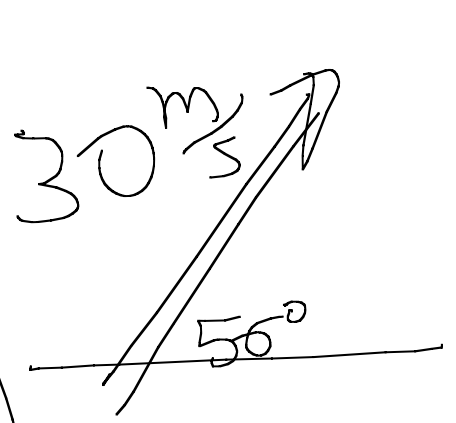
$$= 0 + \left(19.3 \tfrac{m}{s}\right)t + 0$$

$$= \left(19.3 \tfrac{m}{s}\right)t$$

$$v_x = v_{0x} = 19.3 \tfrac{m}{s}$$

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$= 0 + \left(22.98 \tfrac{m}{s}\right)t + \frac{1}{2}\left(-9.8 \tfrac{m}{s}\right)t^2$$



$v_{0x} = 30 \tfrac{m}{s} \cos 50^\circ$

$= 19.28 \tfrac{m}{s}$

v_{0y}

$= 30 \tfrac{m}{s} \sin 50$

$= 22.98 \tfrac{m}{s}$

Range = Value of x when it hits

when does $y = 0$?

$$y = \left(22.98 \frac{m}{s}\right) t - \frac{1}{2}\left(9.8 \frac{m}{s^2}\right) t^2 = 0$$

$$t\left[\left(22.98 \frac{m}{s}\right) - \frac{1}{2}\left(9.8 \frac{m}{s^2}\right) t\right] = 0$$

$$t = 0 \quad \text{or} \quad t = \frac{2\left(22.98 \frac{m}{s}\right)}{\left(9.8 \frac{m}{s^2}\right)} = 4.7\,s$$

What is x at that time?

$$x = \left(19.28 \frac{m}{s}\right)(4.7\,s)$$

$$= 90.4\,m$$

$$R = 90.4\,m$$

What is max ht?

How long to get to max ht?

Max ht: $v_y = 0$

$$v_y = v_{oy} + a_y t$$

$$= \left(22.98 \tfrac{m}{s}\right) + \left(-9.8 \tfrac{m}{s^2}\right) t$$

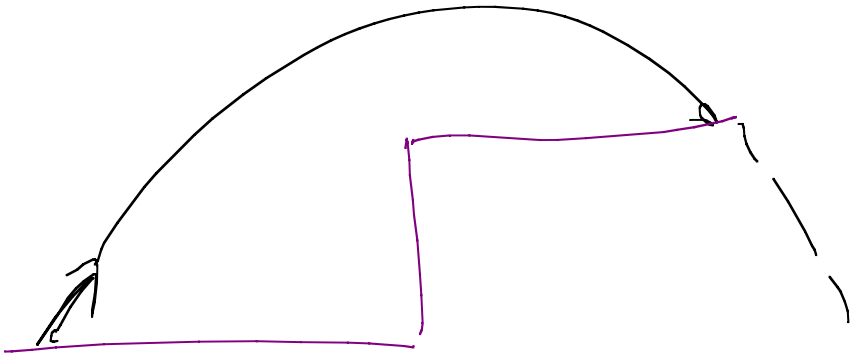
$$= 0$$

$$t = 2.34\,s$$

(Half as long to get to max ht)

$$y = \left(22.98 \tfrac{m}{s}\right)(2.34\,s) - \tfrac{1}{2}\left(9.8 \tfrac{m}{s^2}\right)(2.34\,s)^2$$

$$= 26.9\,m = H$$



$$X = 0 + (V_0 \cos\theta)t + 0$$