# Physics 200 — Day 5

yet more projectile motion!

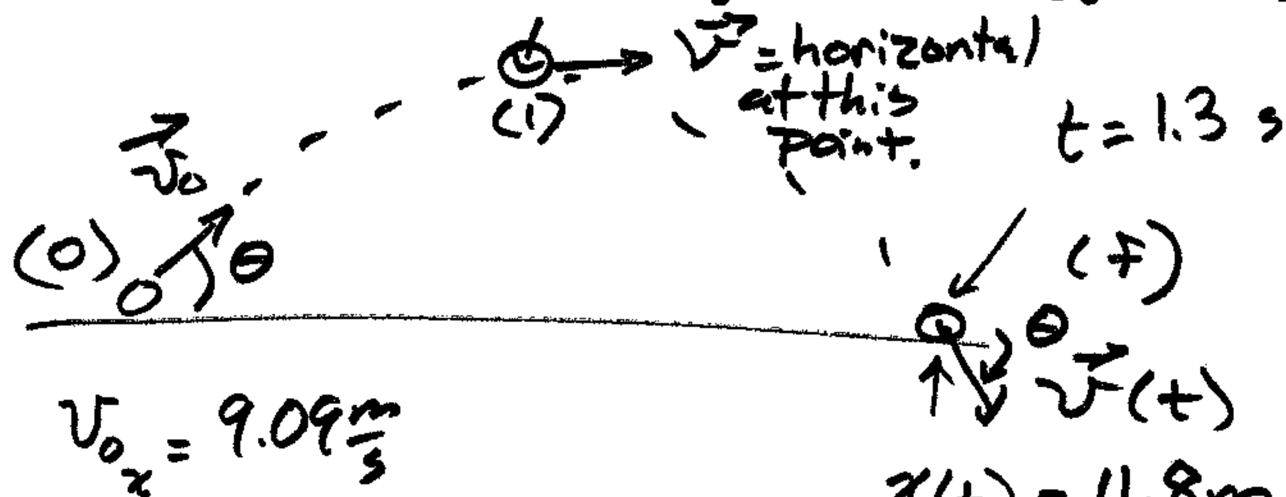
Also, circular, uniformly.

$\vec{a} = 0\hat{x} - g\hat{y}$

$\vec{a} = (0, -g)$

$g = 9.8 \frac{m}{s^2}$

$t = 1.3\ s$




$v_{0x} = 9.09 \frac{m}{s}$

$v_{0y} = 6.37 \frac{m}{s}$

To find $H_{max}$, Set $v_y(t) = 0$

or $v_{y_1} = 0$

(I) $v(t) = v_0 + at$

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

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

$$(\mathrm{III})_y \quad \underset{0}{v_{y_1}^2} = v_{0y}^2 - 2g(H^*_{max} - \underset{0}{y_0})$$

$$0 = v_{0y}^2 - 2gH_{max}$$

$$2gH_{max} = v_{0y}^2$$

$$H_{max} = \frac{v_{oy}^2}{2g} = \frac{(6.37\,m/s)^2}{2(9.8\,m/s^2)} = 2.07\,m$$

$t_1 = \star$ What time is it at $H_{max}$?

use $(\mathrm{I})_y$ $\quad v_{1_y} = v_{o_y} + a_y t_1$

$$0 = v_{oy} - g t_1$$

$$g t_1 = v_{oy}$$

$$t_1 = \frac{v_{oy}}{g} = \frac{6.37\,\frac{m}{s}}{9.8\,m/s^2} = 0.65\,s$$

Note: $t_1$ is half the full time of flight by symetry:

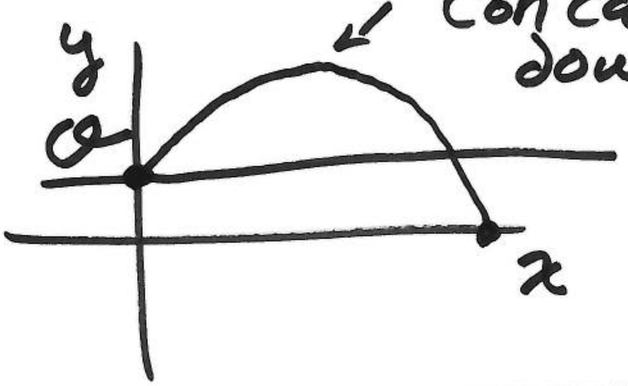

Note: Can show path is a parabola.

Set $x_0 = 0$ $\quad y_0 = 0$.

$(\mathrm{II})_x$ $\quad x(t) = v_{ox} t$ $\longrightarrow$ solve $t$ $\quad$ sub.

$(\mathrm{II})_y$ $\quad y(t) = v_{oy} t - \frac{1}{2} g t^2$ $\qquad t = \frac{x(t)}{v_{ox}}$

$$y(t) = \frac{v_{oy}}{v_{ox}} \cdot x(t) - \frac{1}{2}\frac{g}{v_{ox}^2} x^2(t)$$




Parabolic Path

$y = ax - bx^2$

concave down

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Consider a small hill, or tossing ball from shoulder height.

$+y$

$y_0 = 1.4m$

$v_0 = 5.8\,\frac{m}{s}$

$\theta = 65°$ above horizontal

$a_x = 0$

$a_y = -g$

$y_0$

$y = 0$

$+\hat{x}$

$y(t) = 0$

$v_y(t)$

$y_0 = 1.4$ m above ground.

find: when and where does ball hit ground. with what $\vec{v}$.

$t = ⋆$

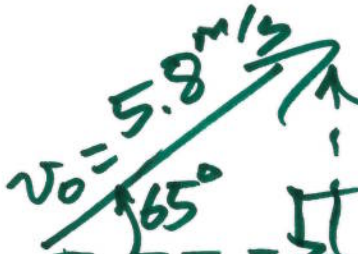
$x(t) = ⋆$

$v_x(t) = ⋆$

$v_y(t) = ⋆$

$y_0 = +1.4m$

$x_0 = 0$




$v_{oy} = 5.8\frac{m}{s} \sin 65°$

$= 5.26\,m/s$

$v_{ox} = 5.8\frac{m}{s} \cos 65°$

$= 2.45\frac{m}{s}$

$\cos 65° = \frac{adj}{hyp} = \frac{v_{ox}}{v_0}$

$(\mathrm{I})_x \quad v_x(t) = v_{0x} + a_x t$

$\star \qquad = 2.45\frac{m}{s} + 0\, t$

thus $\boxed{v_x = 2.45\frac{m}{s}}$ unchanging.

$(\mathrm{II})_x \quad x(t) = x_0 + v_{0x}\, t$

$\star \quad 0 \quad ✓ \quad \star$

$(\mathrm{III})_y: \quad v_y^2(t) = v_{0y}^2 - 2g\,(y(t) - y_0)$

$\star \qquad = \left(5.26\frac{m}{s}\right)^2 - 2\left(9.8\frac{m}{s^2}\right)(0 - 1.4m)$

$v_y^2(t) = \left[(5.26)^2 + (2 \times 9.8 \times 1.4)\right]\frac{m^2}{s^2}$

$27.7 + 27.4$

$\boxed{v_y(t) = -7.43\frac{m}{s}}$

down

$(\mathrm{I})_y \quad v_y(t) = v_{0y} - g\,t$

$✓ \quad ✓ \quad ✓ \;\star$

$-7.43\frac{m}{s} = 5.26\frac{m}{s} - 9.8\frac{m}{s^2}\, t$

$\frac{(-7.43 - 5.26)\frac{m}{s}}{(-9.8)\frac{m}{s^2}} = \boxed{t = 1.3s}$

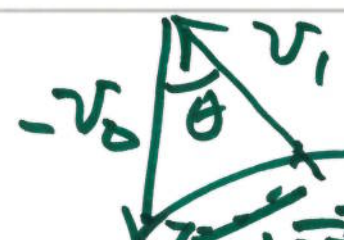
$x(t) = \cancel{x_0}^{\,0} + 2.45\frac{m}{s}\,(1.3s) = \boxed{3.2m}$

Can continue to find max. H. Set $v_{y_1} = 0$

Brief into to <u>uniform</u> <u>circular</u> motion
- constant <u>speed</u>.
- Constant radius


$$\vec{a} = \frac{\vec{v}_1 - \vec{v}_0}{\Delta t}$$

<u>show</u>: $\boxed{a = \frac{v^2}{r}}$ toward center of circle.




$\Delta\vec{v} = v\cdot\theta$ also by arclength

$\phi = 90° - \theta$

$$v = \frac{\overbrace{r\cdot\theta}^{\text{arclength}}}{t} \rightarrow \theta = \frac{vt}{r}$$

radians

$$a = \frac{\Delta v}{t} = \frac{v\cdot\theta}{t}$$

$$a = \frac{v\, v\, \cancel{t}}{\cancel{t}\, r} = \boxed{\frac{v^2}{r}}$$

Centripetal acceleration

$a_c = v^2/r$ points toward <u>center</u> of circle.

will use a <u>lot</u> with forces!