Projectile Motion

Horizontally - velocity is constant

$$\text{horiz} \rightarrow V = \frac{\Delta d}{\Delta t} \leftarrow \text{horizontal}$$

Vertically - constant acceleration ($a = -9.81 m/s^2$)

vertical

$$a = \frac{\Delta v}{\Delta t} \quad \text{and} \quad V_{ave} = \frac{\Delta d}{\Delta t} \leftarrow \text{vertical}$$

Maybe Useful:

$$\left.\begin{aligned} \Delta d &= v_1 \Delta t + \tfrac{1}{2} a (\Delta t)^2 \\ \Delta d &= v_2 \Delta t - \tfrac{1}{2} a (\Delta t)^2 \\ v_2^2 &= v_1^2 + 2a\Delta d \end{aligned}\right] \text{all vertical!}$$

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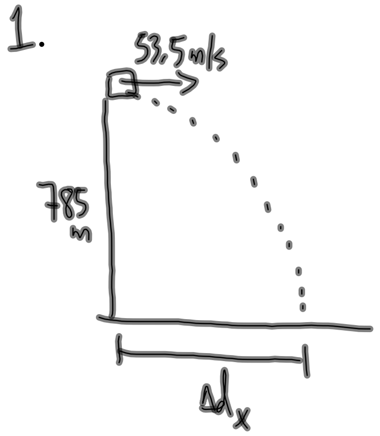
1.



Vertically (constant acceleration)

$\Delta d = -785 m$

$v_1 = 0$

$a = -9.81 m/s^2$

$\Delta t = ?$

$$\Delta d = \cancel{v_1 \Delta t} + \frac{1}{2} a (\Delta t)^2$$

$$\Delta d = \frac{1}{2} a (\Delta t)^2$$

$$\Delta t = \sqrt{\frac{2\Delta d}{a}}$$

$$\Delta t = \sqrt{\frac{2(-785 m)}{-9.81 m/s^2}}$$

$$\boxed{\Delta t \doteq 12.7 s}$$

Horizontally (constant v)

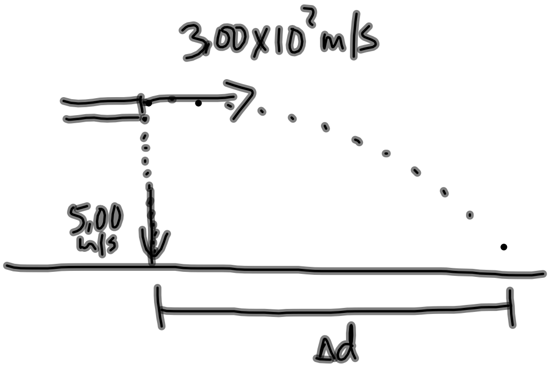
$$V = \frac{\Delta d}{\Delta t}$$

$$\Delta d = v \Delta t$$

$$\Delta d = (53.5 m/s)(12.7 s)$$

$$\boxed{\Delta d \doteq 677 m}$$

8.



Shell Casing (vertically)

$V_1 = 0$

$V_2 = 5.00 \text{ m/s}$

$a = -9.81 \text{ m/s}^2$

$\Delta t = ?$

a) Δd (horizontally) = ?

b) V_2 (vertically) = ?

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

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

$$\Delta t = \frac{-5.00 \text{ m/s} - 0}{-9.81 \text{ m/s}^2}$$

$$\boxed{\Delta t = 0.510 \text{ s}}$$

The bullet is in the air for the same time as the casing, so:

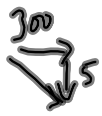
horizontally (v is constant)

$$v = \frac{\Delta d}{\Delta t}$$

$$\Delta d = v \Delta t$$

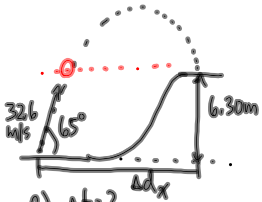
$$\Delta d = (3.00 \times 10^2 \text{ m/s})(0.510 \text{ s})$$

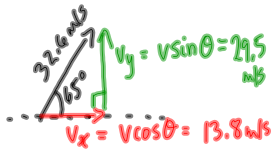
$$\boxed{\Delta d = 153 \text{ m}}$$



b) The vertical velocity of the bullet at impact is 5.00 m/s [down]

Projectiles Launched at Angles





a) $\Delta t = ?$
b) Δd (horiz)
c) v (at impact)

a) vertically (constant acc)

$v_1 = 29.5\,m/s$
$\Delta d = +6.30\,m$
$a = -9.81\,m/s^2$
$\Delta t = ?$

$$\Delta d = v_1(\Delta t) + \frac{1}{2}a(\Delta t)^2$$

$$+6.30\,m = (29.5\,m/s)\Delta t - \frac{9.81\,m/s^2}{2}(\Delta t)^2$$

$$+\frac{9.81\,m/s^2}{2}(\Delta t)^2 - (29.5\,m/s)\Delta t + 6.30\,m = 0$$

① find roots by graphing $y = ax^2 + bx + c$
② use quadratic formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{29.5 \pm \sqrt{(29.5)^2 - 4\left(\frac{9.81}{2}\right)(+6.30)}}{2\left(\frac{9.81}{2}\right)}$$

$$x = \frac{29.5 \pm 27.4}{9.81}$$

on the way up → $x = \frac{29.5 - 27.4}{9.81}$ $\quad \boxed{\cancel{x = 0.216\,s}}$

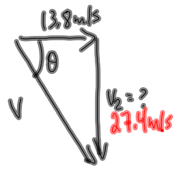
$x = \frac{29.5 + 27.4}{9.81}$ $\quad \boxed{x \doteq 5.80\,s}$

b) horizontally (velocity is constant)

$v = 13.8\,m/s$
$\Delta t = 5.80\,s$
$\Delta d = ?$

$\Delta d = (13.8\,m/s)(5.80\,s)$
$\boxed{\Delta d \doteq 80.0\,m}$

c)



vertically (constant acc)

$v_1 = 29.5\,m/s$
$v_2 = ?$
$a = -9.81\,m/s^2$
$\Delta t = 5.80\,s$

$a = \frac{v_2 - v_1}{\Delta t}$

$v_2 = v_1 + a\Delta t$
$v_2 = 29.5\,m/s - 9.81\,m/s^2(5.80\,s)$
$\boxed{v_2 = -27.4\,m/s}$

$v^2 = 27.4^2 + 13.8^2$
$\boxed{v = 30.7\,m/s}$

$\tan\theta = \frac{27.4\,m/s}{13.8\,m/s}$
$\boxed{\theta = 63.3°}$

The velocity when the ball hits the ground is 30.7 m/s [63.3° below the horizontal]

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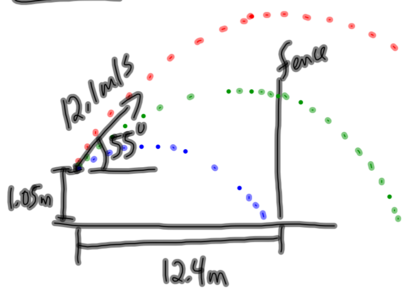

You need to find the height of the ball when it has travelled 12.4m horiz.

$V_x = (12.1\,m/s)\cos 55° = 6.94\,m/s$

$V_y = (12.1\,m/s)\sin 55° = 9.91\,m/s$

To find the time to travel 12.4m horizontally:

$$V_x = \frac{\Delta d_x}{\Delta t}$$

$$\Delta t = \frac{\Delta d_x}{V_x}$$

$$\Delta t = \frac{12.4\,m}{6.94\,m/s}$$

$$\boxed{\Delta t = 1.79\,s}$$

Find the height ($\Delta d_y + 1.05\,m$)

$v_1 = 9.91\,m/s$

$a = -9.81\,m/s^2$

$\Delta t = 1.79\,s$

$\Delta d = ?$

$$\Delta d = v_1 \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$\Delta d = 9.91(1.79) - \frac{9.81}{2}(1.79)^2$$

$$\Delta d = 2.08\,m$$

$$h = 2.08\,m + 1.05\,m = 3.13\,m$$

Since $3.13\,m < 4.8\,m$, the ball hits the fence.

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