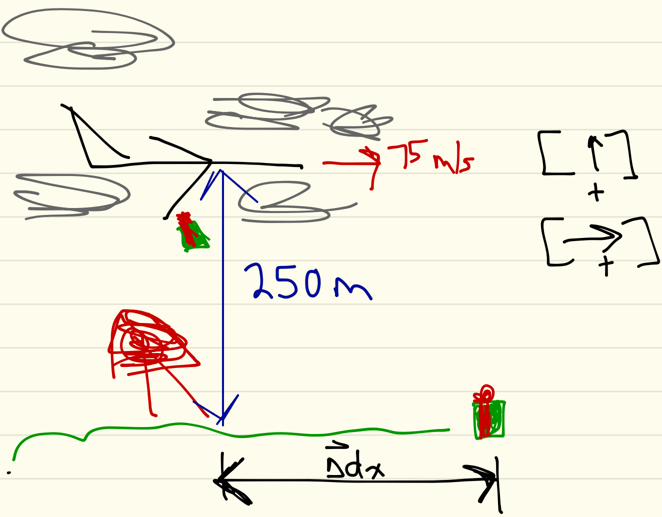
Example #3

A plane flying horizontally at 75 m/s drops a supply box when it is directly over a tower 250m below.

a) How far from the tower does the box land?
b) What is its velocity when it hits the ground?



Horizontal

$V_x = 75\ m/s$
↘ constant

Vertical

$\vec{V}_{iy} = 0\ m/s$
$\vec{a} = -9.8\ m/s^2$
$\vec{\Delta d}_y = -250\ m$

Required $\vec{\Delta d}x$
Impact Velocity (velocity when it hits the grand)

Analysis: Δt is same in x & y.

$$\vec{V}_f = \vec{V}_{fx} + \vec{V}_{fy}$$

Steps: **Vertical**

$$V_{fy}^2 = \cancel{V_{iy}^2}^{\,0} + 2a\Delta d$$

$$V_{fy}^2 = 2\left(-9.8\frac{m}{s^2}\right)(-250m)$$

$$V_{fy}^2 = 4900\frac{m^2}{s^2}$$

$$V_{fy} = \sqrt{4900\ m^2/s^2}$$

$$\boxed{V_{fy} = 70\ m/s\ [\downarrow]}$$

$v_{fy} = \overset{0}{\cancel{v_{iy}}} + a\Delta t$

$-70\,m/s = -9.8\,\frac{m}{s^2}\,\Delta t$

$\Delta t = \frac{-70\,m/s}{-9.8\,m/s^2}$

$\Delta t = 7.1\,s$

$\Delta t = 7.14\,s$

↑

use for calculations.

Horizontal

$\vec{v}_x = 75\,m/s\,[\rightarrow]$

$\Delta t = 7.14\,s$

$\Delta\vec{d}_x = ?$

$\Delta\vec{d}_x = 75\,\frac{m}{\cancel{s}}[\rightarrow] \times 7.14\,\cancel{s}$

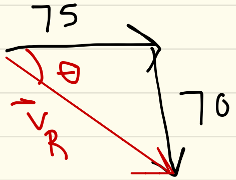
$\Delta\vec{d}_x = 535.5\,m$

$\Delta\vec{d}_x = 540\,m[\rightarrow]$

Impact Velocity

$\vec{v}_x = 75\,m/s$ →

$\vec{v}_y = 70\,m/s$ ↓



$\tan\theta = \frac{70}{75}$

$\theta = \tan^{-1}\left(\frac{70}{75}\right)$

$\theta = 43^\circ$

$|\vec{v}_R| = \sqrt{70^2 + 75^2}$

$|\vec{v}_R| = \sqrt{10\,525}$

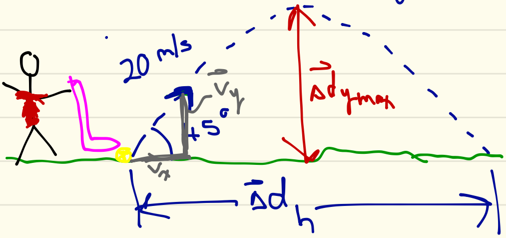
$|\vec{v}_R| = 103\,m/s$

$|\vec{v}_R| = 1.0\times10^2\,m/s$

- Find Velocity
- $1.0\times10^2\,m/s$ [43° from horiz]

Pg. 81 #7

* Assume 2 sig digs



Given

Vertical [↑ +]

$$\vec{v}_{1y} = 20\,m/s(\sin 45^\circ)\,[\uparrow]$$
$$\vec{v}_{1y} = 14.1\,m/s\,[\uparrow]$$
$$\vec{a}_y = 9.8\,m/s^2\,[\downarrow]$$
$$= -9.8\,m/s^2$$
$$\vec{\Delta d}_{y\,Total} = 0\,m$$

Horizontal [→ +]

$$\vec{v}_x = 20\,\frac{m}{s}(\cos 45^\circ)\,[\rightarrow]$$
$$\vec{v}_x = 14.1\,m/s\,[\rightarrow]$$

$\vec{v}_x$ is constant.

Required: max height reached by ball
horizontal distance ball travels in the air

Analysis:
- At max height $\vec{v}_y = 0\,m/s$
- Ball takes an equal amount of time to come down as it does to go up.
- time of flight is same for x & y

Max Height

$\vec{v}_{2y} = 0\,m/s$

$\vec{v}_{1y} = 14.1\,m/s\,[\uparrow]$

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

$\Delta\vec{d}_{y_{max}} = ?$

$\Delta t = ?$

$v_{2y} = v_{1y} + a\Delta t$

$0\,m/s = 14.1\,m/s + (-9.8\,m/s^2)\Delta t$

$-14.1\,m/s = (-9.8\,m/s^2)\Delta t$

$\Delta t = \frac{-14.1\,m/s}{-9.8\,m/s^2}$

$\boxed{\Delta t = 1.44\,s}$

$\Delta d_y = \left(\frac{v_1 + v_2}{2}\right)\Delta t$

$= \left(\frac{14.1\frac{m}{s} + 0\frac{m}{s}}{2}\right)1.44s$

$= \left(7.05\frac{m}{s}\right)(1.44s)$

$\Delta d_y = 10.2\,m$

$\therefore$ Max Height $= 1.0\times10^{1}\,m$

Horizontal Distance

$\Delta t = 1.44s \times 2$

$= 2.88s$

$\vec{v}_x = 14.1\,m/s\,[\rightarrow]$

$\Delta\vec{d}_x = ?$

$\Delta\vec{d}_x = \vec{v}_x\,\Delta t$

$\Delta\vec{d}_x = 14.1\,m/s\,[\rightarrow] \times 2.88s$

$\boxed{\Delta\vec{d}_x = 41\,m}$

Quiz Practice

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Projectile Motion Practice

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