SUPER STAR PROJECTILE PROBLEMS (STPP) ANSWER KEY

1. A movie director is shooting a scene that involves dropping a stunt dummy out of an airplane and into a swimming pool. The plane is 10.0 m above the ground, traveling at a velocity of 22.5 $^{m}/_{s}$ in the positive x direction. The director wants to know where in the plane's path the dummy should be dropped so that it will land in the pool.
   a. Find the time required for the dummy to reach the ground.
   b. Determine the horizontal distance the dummy will travel in that time.
   c. Determine the instantaneous velocity of the dummy as it hits the water. (Velocity's overall magnitude and direction, not just the components)

$V_h = 22.5\ m/s$ $V_{V(i)} = 0$

$a_h = 0$ $a_v = g$

$d_h = ?$ $d_v = 10.0m$

$t = ?$

a. $t = ?$

$d_v = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2 d_v}{g}}$

$t = \sqrt{\frac{2(10.0m)}{9.80\,m/s^2}}$

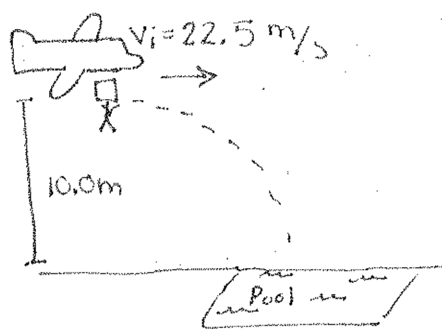
$\boxed{t = 1.43s}$ 3 s.f.

b. $d_h = ?$

$d_h = V_h \cdot t_{total}$

$= (22.5\ m/s)(1.43s)$

$\boxed{d_h = 32.1\ m}$



c. $V_f = ?$

$V_h = \text{constant} = 22.5\ m/s$

$V_f = \sqrt{V_h^2 + V_{V(f)}^2}$

$= \sqrt{(22.5\,m/s)^2 + (14\,m/s)^2}$

$\boxed{V_f = 26.5\ m/s\ @\ 32°}$

$V_{V(f)} = g \cdot t_{down} = (9.80\,m/s^2)(1.43s)$

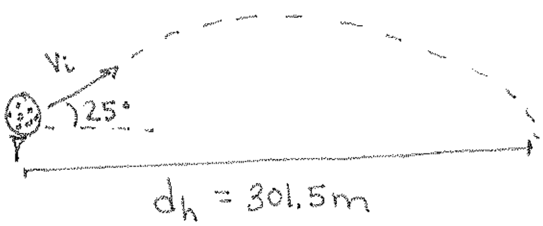
$V_{V(f)} = 14\,m/s$

$\theta = \tan^{-1}\left(\frac{V_{V(f)}}{V_h}\right)$

$= \tan^{-1}\left(\frac{14\,m/s}{22.5\,m/s}\right)$

$\theta = 31.9°$

2. A golfer can hit a golf ball a horizontal distance of over 300.0 m on a good drive. What **maximum height** would a 301.5 m drive reach if it were launched at an angle of 25.0° to the ground?



$V_i = ?$ $\quad a_h = 0$ $\quad a_v = g$

$\theta = 25.0°$ $\quad d_h = 301.5\,m$ $\quad d_v = ?$

$$\text{range} = d_h = \frac{V_i^2 \sin(2\theta)}{g}$$

$$V_i = \sqrt{\frac{d_h \cdot g}{\sin(2\theta)}} = \sqrt{\frac{(301.5\,m)(9.80\,m/s)}{\sin(2 \cdot 25.0°)}}$$

$$V_i = 62.11\,m/s$$

$$V_h = V_i \cdot \cos\theta = (62.11\,m/s)\cos 25°$$

$$V_h = 56.29\,m/s$$

$$d_h = V_h \cdot t_{total} \Rightarrow t_{total} = \frac{d_h}{V_h}$$

$$t_{total} = \frac{301.5\,m}{56.29\,m/s}$$

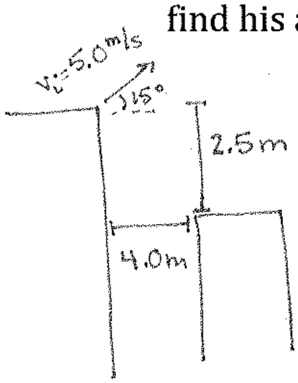
$$t_{total} = 5.357\,s \qquad \Rightarrow t_{up} = \frac{1}{2} t_{total} = 2.678\,s$$

$$d_v = \frac{1}{2} g\, t_{up}^2$$

$$= \frac{1}{2}(9.80\,m/s^2)(2.678\,s)^2$$

$$\boxed{d_v = 35.15\,m}$$

3. In a scene in an action movie, a stuntman jumps from the top of one building to the top of another building 4.0 m away. After a running start, he leaps at an angle of 15° with respect to the flat roof while traveling at a speed of 5.0 $^{m}/_{s}$. Will he make it to the other roof, which is 2.5 m shorter than the building he jumps from? (Hint—you need to find his actual vertical displacement and compare to the known)



$V_i = 5.0\ m/s$ $\quad V_h = V_i \cos\theta = \underline{4.8\ m/s}$ $\quad V_{v(i)} = V_i \sin\theta = \underline{1.3\ m/s}$

$\theta = 15°$ $\quad a_h = 0$ $\quad a_v = g$

$d_h = ?$ $\quad d_v = ?$

$\downarrow$

compare to 4.0m

$$t_{up} = \frac{V_{v(initial)}}{g} = \frac{1.3\ m/s}{9.80\ m/s^2}$$

$$\underline{t_{up} = 0.13\ s}$$

$$d_{v(up)} = \frac{1}{2} g\, t_{up}^2 = \frac{1}{2}(9.80\ m/s^2)(0.13\ s)^2$$

$$d_{v(up)} = 0.085\ m$$

$$d_{v(down)} = 0.085\ m + 2.5\ m = \underline{2.6\ m}$$

$$d_{v(down)} = \frac{1}{2} g\, t_{down}^2 \Rightarrow t_{down} = \sqrt{\frac{2 d_v}{g}} = \sqrt{\frac{2\,(2.6\ m)}{9.80\ m/s^2}}$$

$$\underline{t_{down} = 0.73\ s}$$

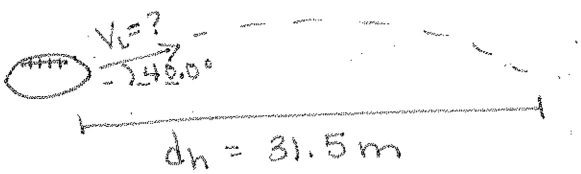
$$t_{total} = t_{up} + t_{down} = 0.13\ s + 0.73\ s = \underline{0.86\ s}$$

$$d_h = V_h \cdot t_{total} = (4.8\ m/s)(0.86\ s)$$

$$\underline{d_h = 4.1\ m!}$$

$\boxed{\text{He makes the jump!}}$

4. A quarterback throws the football to a receiver who is 31.5 m down the field. If the football is thrown at an initial angle of 40.0° to the ground, at what initial speed must the quarterback throw the ball to be caught at the same height? What is the ball's highest point during its flight?



a. $V_i = ?$

$$\text{range} = d_h = \frac{V_i^2 \sin(2\theta)}{g}$$

$$V_i = \sqrt{\frac{d_h \cdot g}{\sin(2\theta)}}$$

$$V_i = \sqrt{\frac{(31.5\,m)(9.80\,m/s^2)}{\sin(2 \cdot 40.0°)}}$$

$$\boxed{V_i = 17.7\ m/s}$$

b. $d_v = ?$

$$t_{up} = \frac{V_{v(i)}}{g} = \frac{V_i \cdot \sin\theta}{g}$$

$$= \frac{(17.7\,m/s)\sin(40.0°)}{9.80\,m/s^2}$$

$$t_{up} = 1.16\,s$$

$$d_v = \tfrac{1}{2} g t^2$$

$$= \tfrac{1}{2}(9.80\,m/s^2)(1.16\,s)^2$$

$$\boxed{d_v = 6.61\,m}$$