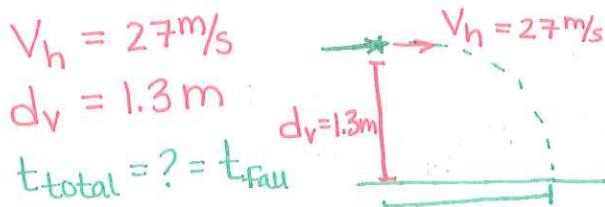


POTTER PROJECTILES! (PP)

1. Harry Potter fires a spell from his wand horizontally with a velocity of 27 m/s from a position 1.3 m off the ground.
- How long does it take to strike the ground (assuming gravity works in the land of wizards)?
 - What horizontal distance does it cover before striking the ground?



$$\text{a. } d_v = V_h t + \frac{1}{2} a t^2 \Rightarrow d_v = \frac{1}{2} g t_{\text{fall}}^2$$

$$t_{\text{fall}} = \sqrt{\frac{2d_v}{g}}$$

$$= \sqrt{\frac{2(1.3 \text{ m})}{9.80 \text{ m/s}^2}}$$

$$t_{\text{fall}} = 0.52 \text{ s}$$

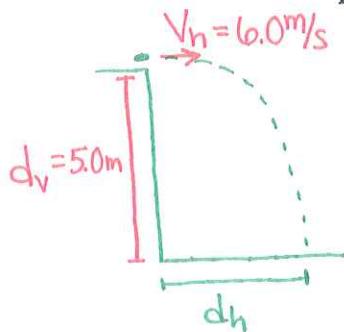
$$\text{b. } d_h = ?$$

$$d_h = V_h \cdot t_{\text{total}}$$

$$= (27 \text{ m/s})(0.52 \text{ s})$$

$$d_h = 14 \text{ m}$$

2. A Bertie Bott Flavored Bean rolls off a platform that is 5.0 m above the ground. The bean's velocity as it leaves the platform is 6.0 m/s.
- How much time will pass from when the bean leaves the platform to when it hits the ground?
 - How far away from the base of the platform will the bean hit the floor?



a. $t_{\text{fall}} = t_{\text{total}} = ?$

$$V_h = 6.0\text{m/s} \quad d_v = 5.0\text{m}$$

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

$$t_{\text{fall}} = \sqrt{\frac{2(5.0\text{m})}{9.80\text{m/s}^2}}$$

$$t_{\text{fall}} = 1.0\text{s}$$

b. $d_h = ?$

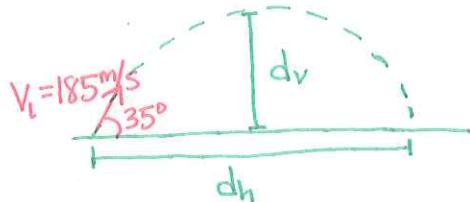
$$V_h = 6.0\text{m/s} \quad d_h = V_h \cdot t_{\text{total}}$$

$$t_{\text{tot}} = 1.0\text{s} \quad = (6.0\text{m/s})(1.0\text{s})$$

$$d_h = 6.0\text{m}$$

3. Dobby launches himself over a wall. He is fired over level ground at an angle of 35.0° to the horizontal with an initial velocity of 185 m/s .

- What is Dobby's maximum height?
- How long is Dobby in the air?
- How far away does Dobby land?



$$V_h = V_i \cos \theta \quad V_v = V_i \sin \theta$$

$$V_h = (185 \text{ m/s}) \cos 35.0^\circ \quad V_v = (185 \text{ m/s}) \sin 35.0^\circ$$

$$V_h = 152 \text{ m/s} \quad V_v = 106 \text{ m/s}$$

a. $y_2^0 = V_i + at \Rightarrow -V_{iv} = gt$

$$V_{iv} = 106 \text{ m/s} \quad t_{up} = \frac{-V_{iv}}{g} = \frac{-106 \text{ m/s}}{-9.80 \text{ m/s}^2}$$

$$\underline{t_{up} = 10.8 \text{ s}}$$

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

$$= \frac{1}{2} (9.80 \text{ m/s}^2) (10.8 \text{ s})^2$$

$$\boxed{d_v = 572 \text{ m}}$$

b. $t_{total} = t_{up} + t_{down} = ?$

$$t_{up} = 10.8 \text{ s}$$

$$= 10.8 \text{ s} + 10.8 \text{ s}$$

$$t_{up} = t_{down}$$

$$\boxed{t_{total} = 21.6 \text{ s}}$$

c. $d_h = ?$

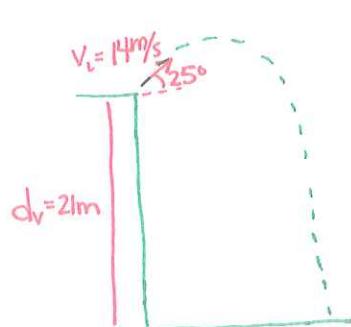
$$V_h = 152 \text{ m/s} \quad d_h = V_h \cdot t_{total}$$

$$t_{tot} = 21.6 \text{ s}$$

$$= (152 \text{ m/s})(21.6 \text{ s})$$

$$\boxed{d_h = 3280 \text{ m}}$$

4. Hermione throws a bottle with a potion in it off of a cliff at a 25° angle with a velocity of 14 m/s to Ron waiting down below. If the cliff is 21 m high:
- How high above the cliff does the bottle go?
 - How long is it in the air?
 - How far does it go horizontally before striking the ground? Hint: Make a sketch illustrating the horizontal and vertical components of distance and show your work in finding the magnitude of each component.
 - What are the vertical and horizontal components of velocity just before it hits the ground? What is the actual velocity of the bottle before it hits?



$$V_h = V_i \cos \theta \\ = (14 \text{ m/s}) \cos 25^\circ$$

$$\underline{V_h = 13 \text{ m/s}}$$

$$V_{v_i} = V_i \sin \theta \\ = (14 \text{ m/s}) \sin 25^\circ$$

$$\underline{V_v = 5.9 \text{ m/s}}$$

a. $d_v = ?$

$$V_{v_i} = 5.9 \text{ m/s}$$

$$V_{v(t_{\text{top}})} = 0 \text{ m/s}$$

$$V_2' = V_i + at \Rightarrow -V_i = gt_{\text{up}} \Rightarrow t_{\text{up}} = \frac{-V_{v_i}}{g}$$

$$t_{\text{up}} = \frac{-5.9 \text{ m/s}}{-9.80 \text{ m/s}^2} = \underline{0.60 \text{ s}}$$

$$d_v = V_{v_i} t + \frac{1}{2} g t^2$$

$$= (5.9 \text{ m/s})(0.60 \text{ s}) + \frac{1}{2} (-9.80 \text{ m/s}^2)(0.60 \text{ s})^2$$

$$\boxed{d_v = 1.8 \text{ m}}$$

b. $t_{\text{total}} = ? = t_{\text{up}} + t_{\text{down}}$ $t_{\text{up}} = 0.60 \text{ s}$ $d_v = 1.8 \text{ m} + 21 \text{ m} = \underline{23 \text{ m}}$

$$d_v = \frac{1}{2} g t_{\text{down}}^2 \Rightarrow t_{\text{down}} = \sqrt{\frac{2d_v}{g}} = \sqrt{\frac{2(23 \text{ m})}{(-9.80 \text{ m/s}^2)}} = \underline{2.2 \text{ s}}$$

$$t_{\text{total}} = 0.60 \text{ s} + 2.2 \text{ s} \Rightarrow \boxed{t_{\text{total}} = 2.85 \text{ s}}$$

c. $d_h = V_h \cdot t_{\text{total}}$
 $= (13 \text{ m/s})(2.85 \text{ s})$

$$\boxed{d_h = 36 \text{ m}}$$

d. Vertical

$$V_2 = V_1 + g t_{\text{down}}$$

$$= (-9.80 \text{ m/s}^2)(2.2 \text{ s})$$

$$V_{2v} = -22 \text{ m/s}$$

horizontal

$$V_h = \text{constant}$$

$$V_h = 13 \text{ m/s}$$

$$V = \sqrt{V_h^2 + V_v^2}$$

$$= \sqrt{(13 \text{ m/s})^2 + (-22 \text{ m/s})^2}$$

$$\underline{V = 26 \text{ m/s}}$$

$$\theta_v = \tan^{-1} \left(\frac{V_v}{V_h} \right)$$

$$= \tan^{-1} \left(\frac{22 \text{ m/s}}{13 \text{ m/s}} \right)$$

$$\theta_v = 59^\circ$$

$$\boxed{V_{\text{final}} = 26 \text{ m/s} @ 59^\circ \text{ S of E}}$$