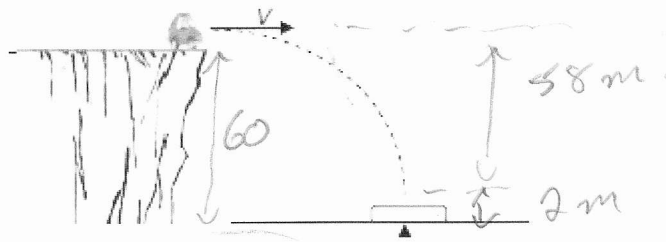


Review Problems - Projectile Solutions

1. A stunt car drives off a 60 m high, level cliff with a speed of 60 km/h. How from the base of the cliff should the centre of a 2 m high crash mat be placed to ensure the car and more importantly the driver survive the fall? [Ans: $\Delta d_x \geq 57$ m]



① COMPONENTS.

$$V_{iy} = 0 \quad V_{ix} = 60 \text{ km/h} = 16.7 \text{ m/s.}$$

② HOW LONG DOES IT TAKE TO DROP 58 m.

USE $V_{iy} = 0$, $a = +9.81$, $\Delta d_x = 58 \text{ m}$.

$$\Delta d_x = V_{iy} \Delta t + \frac{1}{2} a \Delta t^2.$$

$$58 = 0 + 4.91 \Delta t^2 \Rightarrow$$

$$\Delta t^2 = 11.8$$

$$\boxed{\Delta t = 3.44 \text{ s}}$$

③ HOW FAR DOES THE CAR TRAVEL IN 3.44 s IN THE HORIZONTAL DIRECTION.

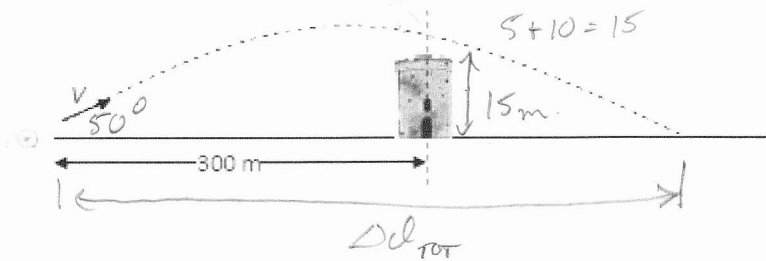
$$\Delta d_x = V_{ix} \Delta t$$

$$\Delta d_x = (16.7)(3.44).$$

$$\boxed{\Delta d_x = 57.4 \text{ m}}$$

Review Problems - Projectile Solutions

2. A cannon is discharged towards a castle tower (near the time when the ancient world was meeting the modern world). The cannon ball flies 5 m above the top of the 10 metre tall tower and lands on level ground (same level as cannon) behind the tower. The cannon was positioned 300 m from the tower and was angled at 50° to the horizontal. What was the muzzle velocity of the cannon ball? How far behind the tower did it land? (Ans: $V \approx 56 \frac{m}{s}$; $\Delta d \approx 15 \text{ m}$) Hint: up + and right +



① USE COMPONENTS.

$$V_{iy} = V \sin 50^\circ = 0.77V$$

$$V_{ix} = V \cos 50^\circ = 0.64V$$

② SOLVE AT 300m, 15m HEIGHT.

$$\begin{aligned} \Delta d_y &= 15 \text{ m} \\ V_{iy} &= 0.77V \\ a &= -9.81 \end{aligned}$$

$$\begin{aligned} \Delta d_x &= 300 \text{ m} \\ V_{ix} &= 0.64V \end{aligned}$$

USE: $\Delta d_y = V_{iy} \Delta t + \frac{1}{2} a \Delta t^2$

$$15 = 0.77V \Delta t + \frac{1}{2} (-9.81) \Delta t^2$$

USE $\Delta d_x = V_x \Delta t$

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

③ $15 = 0.77V \Delta t - 4.91 \Delta t^2$

③ $\Delta t = \frac{300}{0.64V} = \frac{468.8}{V}$

③ TWO EQUATIONS, TWO UNKNOWN'S.

SUBSTITUTE Δt (EQU'N B) TO SOLVE FOR V (EQU'N A)

$$15 = 0.77V \Delta t - 4.91 \Delta t^2$$

$$15 = 0.77V \left(\frac{468.8}{V} \right) - 4.91 \left(\frac{468.8}{V} \right)^2$$

$$15 = 361 - \frac{1.08 \times 10^6}{V^2}$$

$$-346 = -\frac{1.08 \times 10^6}{V^2}$$

$$V^2 = \frac{1.08 \times 10^6}{346}$$

$$V^2 = 3103 \Rightarrow \boxed{V = 55.7}$$

④ FIND LANDING TIME.

$$\Delta d_y = V_{iy} \Delta t + \frac{1}{2} a \Delta t^2$$

$$0 = 0.77V \Delta t - 4.91 \Delta t^2$$

$$0 = 0.77(55.7) \Delta t - 4.91 \Delta t^2$$

$$0 = 42.9 \Delta t - 4.91 \Delta t^2$$

$$0 = \Delta t (42.9 - 4.91 \Delta t)$$

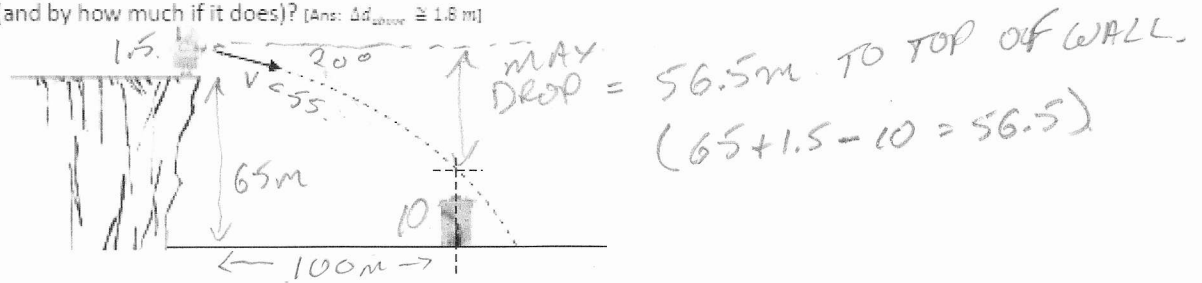
$$\Delta t = 0 \text{ s OR } \Delta t = 8.76 \text{ s}$$

⑤ FIND Δd_x TOTAL $\sqrt{313 \text{ m}}$

$$\begin{aligned} \Delta d_x &= V_x \Delta t \\ &= 0.64(55.7)(8.76) \end{aligned}$$

Review Problems - Projectile Solutions

3. A 1.5 m tall archer is standing on a 65 m cliff. Trying to maximize impact force while clearing a castle wall below he fires his arrow with a speed of 55 m/s at an angle of 20° below the horizontal. The castle wall is 100 m from the cliff and is 10 m high. Does the arrow clear the castle wall (and by how much if it does)? [Ans: $\Delta d_{\text{clear}} \approx 1.8 \text{ m}$]



① COMPONENTS.

$$V_{iy} = 55 \sin 20^\circ \\ = 18.8 \text{ m/s}$$

$$V_{ix} = 55 \cos 20^\circ \\ = 51.7 \text{ m/s}$$

② FIND HOW LONG IT TAKES TO TRAVEL 100 m IN HORIZONTAL DIRECTION.

$$\text{USE } \Delta d_x = V_{ix} \Delta t \quad \text{OR} \quad \Delta t = \frac{\Delta d_x}{V_{ix}} = \frac{100}{51.7} \\ \Delta t = \underline{\underline{1.93 \text{ s}}}$$

③ FIND HOW FAR IT DROPS IN 1.93 SECONDS.

$$\text{USE } a = +9.81, V_{iy} = 18.8, \Delta t = 1.93$$

$$\Delta d = V_{iy} \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta d = (18.8)(1.93) + \frac{1}{2} (9.81)(1.93)^2$$

$$\Delta d = 36.3 + 18.1$$

$$\Delta d = \underline{\underline{54.4 \text{ m}}}$$

④ THE DROP OF 54.4 m IS LESS THAN THE MAX DROP OF 56.5 m
SO IT CLEARS THE WALL.
BY. $56.5 - 54.4 = \underline{\underline{2.1 \text{ m}}}$