2022 Ph H2 Q1

Section: Our Dynamic Universe
Topic: Projectiles

Question Summary

A football is kicked from the penalty spot, 11 m from the goal, at **17.0 m s⁻¹** and **24.0°** to the horizontal.
The ball hits the crossbar.
We calculate:

1. Horizontal and vertical velocity components.

2. Time to reach the crossbar.

3. Height at the crossbar.

4. Whether the ball would still hit the crossbar if kicked slower.

(a)(i) Velocity components

✅ **Answer:**

- $u_h = 15.5\,\text{ms}^{-1}$

- $u_v = 6.9\,\text{ms}^{-1}$

Working:

$$u_h = u\cos\theta = 17.0\cos 24 = 15.5\,\text{ms}^{-1},$$

$$u_v = u\sin\theta = 17.0\sin 24 = 6.9\,\text{ms}^{-1}.$$

(a)(ii) Time to crossbar

The horizontal distance $d = 11\,\text{m}$.

$$t = \frac{d}{u_h} = \frac{11}{15.5} = 0.71\,\text{s}.$$

(a)(iii) Height at crossbar

Vertical displacement:

$$s = u_v t + \frac{1}{2}at^2,$$

where $a = -9.8\,\text{ms}^{-2}$.
$$s = 6.9(0.71) + 0.5(-9.8)(0.71^2) = 4.9 - 2.5 = 2.4\,\text{m}.$$

So $h = 2.4\,\text{m}$.

(b) Slower kick

Answer: The ball would **pass under** the crossbar.
Reason: A smaller initial vertical velocity means the ball does not rise to the same height, so at 11 m it would be lower than 2.4 m.

Quick Tips

- Always resolve the velocity into horizontal and vertical components first.

- Horizontal motion: constant speed.

- Vertical motion: use $s = ut + \frac{1}{2}at^2$.