

A particle is launched from a point on a horizontal plane with initial velocity  $U \text{m s}^{-1}$  at an angle of elevation  $\alpha$ . The particle moves freely under gravity until it strikes the plane. The greatest height of the particle is h m.

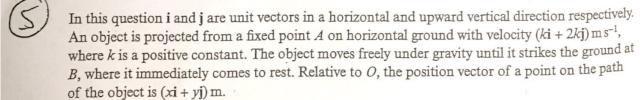
Show that 
$$h = \frac{U^2 \sin^2 \alpha}{2g}$$

- A particle is projected from a point with speed  $21 \,\mathrm{m\,s^{-1}}$  at an angle of elevation  $\alpha$  and moves freely under gravity. When the particle has moved a horizontal distance  $x \,\mathrm{m}$ , its height above the point of projection is  $y \,\mathrm{m}$ .
  - a Show that  $y = x \tan \alpha \frac{x^2}{90 \cos^2 \alpha}$
  - **b** Given that y = 8.1 when x = 36, find the value of  $\tan \alpha$ .
- A projectile is launched from a point on a horizontal plane with initial speed Um s<sup>-1</sup> at an angle of elevation  $\alpha$ . The particle moves freely under gravity until it strikes the plane. The range of the projectile is Rm.
  - a Show that the time of flight of the particle is  $\frac{2U\sin\alpha}{g}$  seconds.
  - b Show that  $R = \frac{U^2 \sin 2\alpha}{g}$  \* Use the fact that  $\sin 2\kappa = 2 \sin \kappa \cos \kappa$
  - c Deduce that, for a fixed u, the greatest possible range is when  $\alpha = 45^{\circ}$ .
  - d Given that  $R = \frac{2U^2}{5g}$ , find the two possible values of the angle of elevation at which the projectile could have been launched.
- A particle is projected from a point with speed U at an angle of elevation  $\alpha$  above the horizontal and moves freely under gravity. When it has moved a horizontal distance x, its height above the point of projection is y.

a Show that 
$$y = x \tan \alpha - \frac{gx^2}{2U^2} (1 + \tan^2 \alpha)$$
 (5 marks)

An athlete throws a javelin from a point P at a height of  $2 \,\mathrm{m}$  above horizontal ground. The javelin is projected at an angle of elevation of  $45^{\circ}$  with a speed of  $30 \,\mathrm{m}\,\mathrm{s}^{-1}$ . By modelling the javelin as a particle moving freely under gravity,

- b find, to 3 significant figures, the horizontal distance of the javelin from P when it hits the ground (5 marks)
- c find, to 2 significant figures, the time elapsed from the point the javelin is thrown to the point it hits the ground. (2 marks)



a Show that 
$$y = 2x - \frac{gx^2}{2k^2}$$
 (5 marks)

Given that AB = Rm and the maximum vertical height of the object above the ground is Hm,