1 A golf ball is hit at an angle of 60° to the horizontal from a point, O, on level horizontal ground. Its initial speed is $20\,\text{m}\,\text{s}^{-1}$. The standard projectile model, in which air resistance is neglected, is used to describe the subsequent motion of the golf ball. At time t s the horizontal and vertical components of its displacement from O are denoted by x m and y m.

(i) Write down equations for x and y in terms of t. **[2]**

(ii) Hence show that the equation of the trajectory is

$$y = \sqrt{3}x - 0.049x^2.$$ **[2]**

(iii) Find the range of the golf ball. **[2]**

(iv) A bird is hovering at position $(20, 16)$.

Find whether the golf ball passes above it, passes below it or hits it. **[2]**

2 A football is kicked with speed $31\,\text{m}\,\text{s}^{-1}$ at an angle of 20° to the horizontal. It travels towards the goal which is 50 m away. The height of the crossbar of the goal is 2.44 m.

(i) Does the ball go over the top of the crossbar? Justify your answer. **[6]**

(ii) State one assumption that you made in answering part **(i)**. **[1]**

3 Fig. 1 shows the speed-time graph of a runner during part of his training.

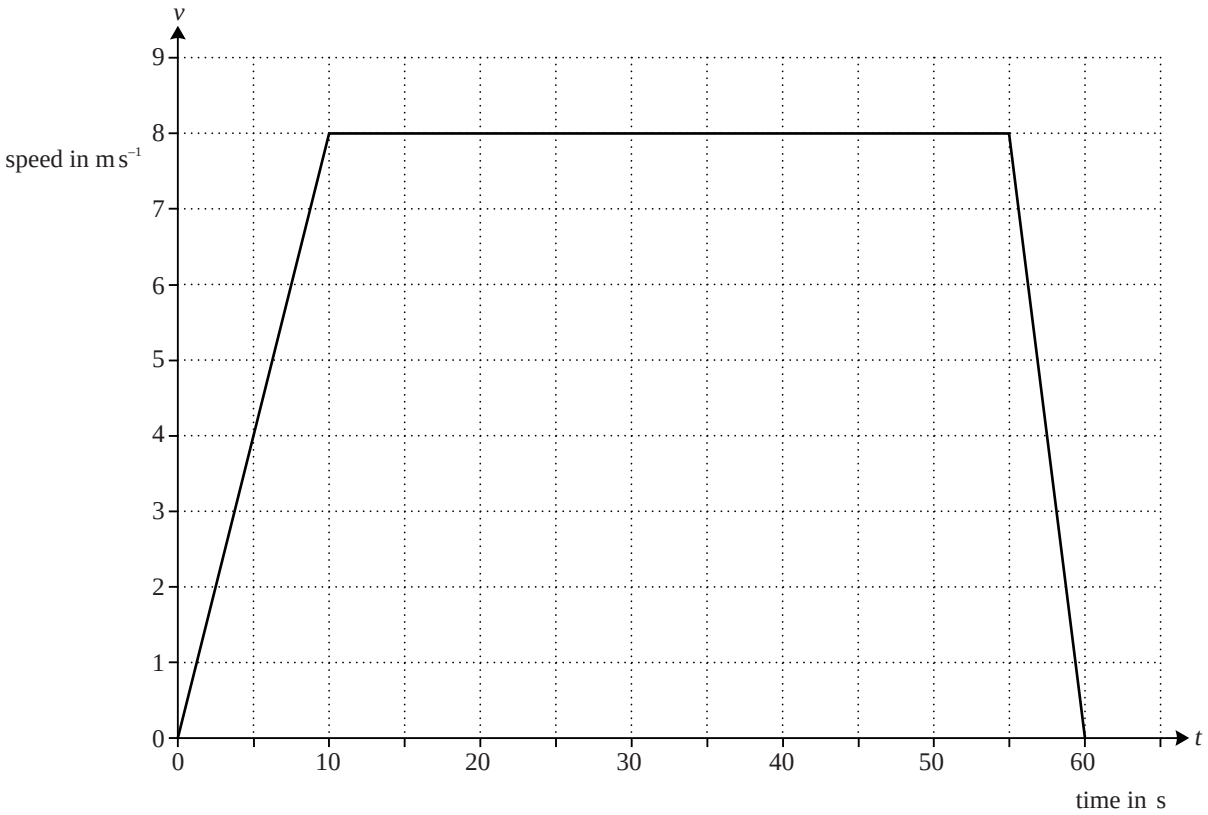

Fig. 1

For each of the following statements, say whether it is true or false. If it is false give a brief explanation.

(*A*) The graph shows that the runner finishes where he started.

(*B*) The runner's maximum speed is $8\,\mathrm{m\,s^{-1}}$.

(*C*) At time 58 seconds, the runner is slowing down at a rate of $1.6\,\mathrm{m\,s^{-2}}$.

(*D*) The runner travels 400 m altogether. **[6]**

4 A pellet is fired vertically upwards at a speed of $11\,\mathrm{m\,s^{-1}}$. Assuming that air resistance may be neglected, calculate the speed at which the pellet hits a ceiling 2.4 m above its point of projection. **[3]**

5 Fig. 5 shows a block of mass 10 kg at rest on a rough horizontal floor. A light string, at an angle of 30° to the vertical, is attached to the block. The tension in the string is 50 N.

The block is in equilibrium.

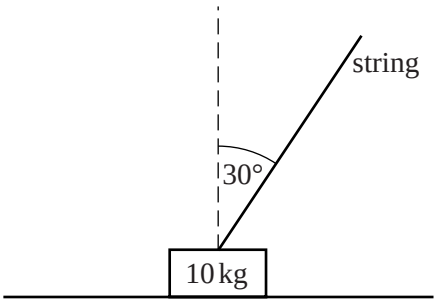

Fig. 5

(i) Show all the forces acting on the block. **[2]**

(ii) Show that the frictional force acting on the block is 25 N. **[2]**

(iii) Calculate the normal reaction of the floor on the block. **[2]**

(iv) Calculate the magnitude of the total force the floor is exerting on the block. **[2]**

6 A small ball is kicked off the edge of a jetty over a calm sea. Air resistance is negligible. Fig. 6 shows

- the point of projection, O,
- the initial horizontal and vertical components of velocity,
- the point A on the jetty vertically below O and at sea level,
- the height, OA, of the jetty above the sea.

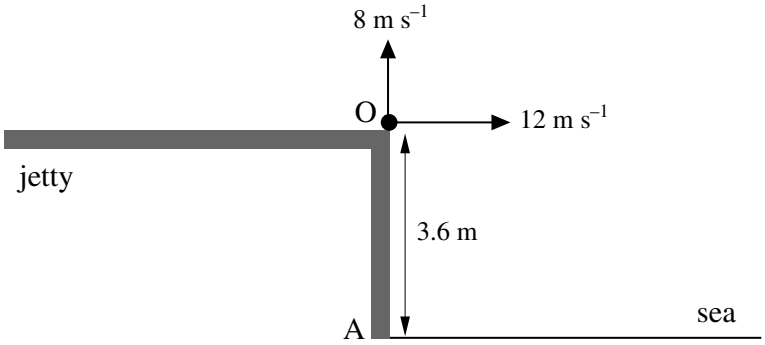

Fig. 6

The time elapsed after the ball is kicked is t seconds.

(i) Find an expression in terms of t for the height of the ball above O at time t. Find also an expression for the horizontal distance of the ball from O at this time. **[3]**

(ii) Determine how far the ball lands from A. **[5]**

7 Fig. 4 shows a particle projected over horizontal ground from a point O at ground level. The particle initially has a speed of $32\,\text{m}\,\text{s}^{-1}$ at an angle α to the horizontal. The particle is a horizontal distance of 44.8 m from O after 5 seconds. Air resistance should be neglected.

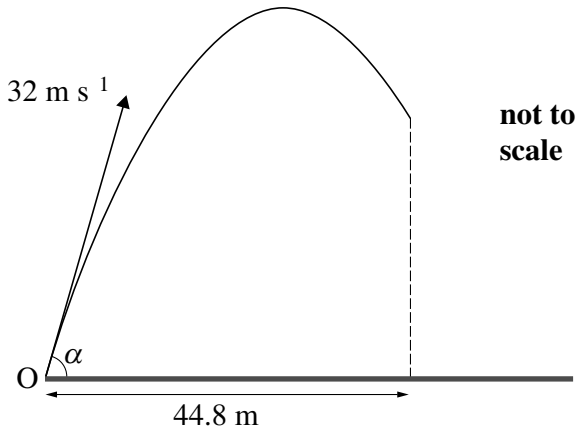

Fig. 4

(i) Write down an expression, in terms of α and t, for the horizontal distance of the particle from O at time t seconds after it is projected. **[1]**

(ii) Show that $\cos\alpha = 0.28$. **[2]**

(iii) Calculate the greatest height reached by the particle. **[4]**