**4** A golfer hits a ball, from ground level on a horizontal surface. The initial velocity of the ball is $21\ \text{ms}^{-1}$ at an angle of 60° above the horizontal. Assume that the ball is a particle and that no resistance forces act on the ball.

(a) Find the maximum height of the ball. *(4 marks)*

(b) Find the range of the ball. *(4 marks)*

(c) Find the speed of the ball at its maximum height. *(2 marks)*

| Question | Solution | Marks | Total Marks | Comments |
|---|---|---|---|---|
| 4 (a) | $0^2 = (21\sin 60°)^2 + 2\times(-9.8)h$ | M1 A1 | | M1: equation for $h$ |
| | $h = 16.9$ m to 3sf | M1 A1 | **(4)** | M1: solving for $h$ |
| (b) | $0 = 21\sin 60°t - 4.9t^2$ | | | |
| | $t = 0$ or $t = \dfrac{21\sin 60°}{4.9}$ | M1 A1 | | M1: attempt to find time of flight |
| | $\text{Range} = 21\cos 60° \times \dfrac{21\sin 60°}{4.9}$ | | | |
| | $= 39.0$ m to 3 sf | M1 A1 | **(4)** | M1: attempt to calculate range |
| (c) | $V = 21\cos 60° = 10.5\text{ms}^{-1}$ | M1 A1 | **(2)** | |
| | | TOTAL | **10** | |

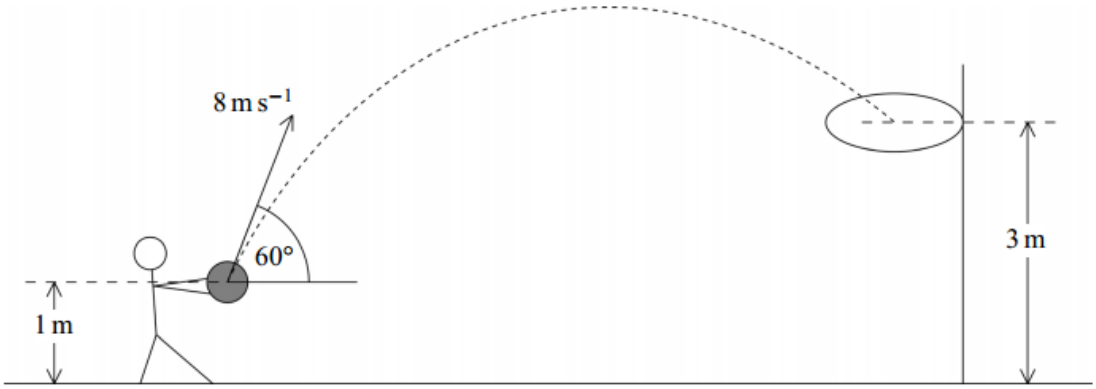
**5** A javelin is modelled as a particle. Assume that only gravity acts on the javelin after it has left the thrower's hand. The initial velocity of the javelin is $20\ \text{ms}^{-1}$ at an angle of $40°$ above the horizontal.

(a) Find the range of the javelin on horizontal ground if the height of release is ignored.
*(6 marks)*

(b) The javelin is actually released at a height of 2 metres. Find the range of the javelin in this case.
*(6 marks)*

| Question Number | Solution | Marks | Total Marks | Comments |
|---|---|---|---|---|
| 5. (a) | $0 = 20\sin 40°t - 4.9t^2$ | M1 A1 | | M1: forming the equation for the vertical motion with $h = 0$ |
| | $t = 0$ or $t = \dfrac{20\sin 40°}{4.9} = 2.624$ s | m1A1 | | m1: finding a value of $t$ |
| | $R = 20\cos 40° \times \dfrac{20\sin 40°}{4.9}$ | m1 | | m1: attempting to find the range |
| | $= 40.2$ m (accept 40.1) | A1 | **(6)** | |
| 5. (b) | $0 = 20\sin 40°t - 4.9t^2 + 2$ | M1 A1 | | M1: vertical equation containing a "2" |
| | $t = 2.7709$ or $-0.147$ | m1 A1 | | m1: solving for $t$ |
| | $R = 20\cos 40° \times 2.7709$ | M1 | | M1: attempting to find the range |
| | $= 42.5$ m (accept 42.4) | A1 | **(6)** | |
| | | TOTAL | **(12)** | |

**6** A ball is thrown so that it passes through the centre of a basket ball hoop, as shown in the diagram.




The ball is thrown from a height of 1 metre and the hoop is at a height of 3 metres above the ground. The initial velocity of the ball is $8\,\text{m s}^{-1}$ at an angle of 60° above the horizontal.

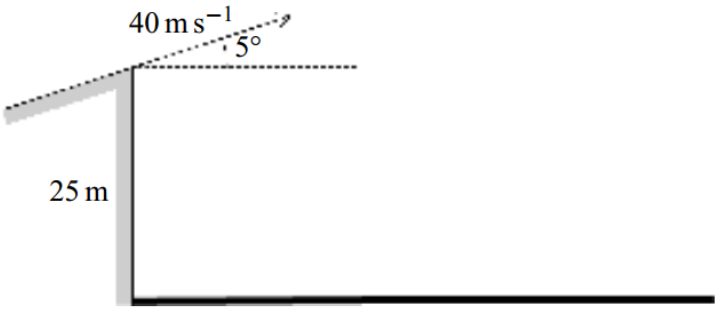
(a) Find the maximum height of the ball above the ground. *(4 marks)*

(b) Find the time that it takes for the ball to reach the centre of the hoop. *(6 marks)*

(c) Find the horizontal distance from the initial position of the ball to the centre of the hoop. *(2 marks)*

| | | | | |
|---|---|---|---|---|
| 6(a) | $0=(8\sin 60°)^2+2\times(-9.8)s$ | M1A1 | | Equation for vertical motion |
| | $s=2.45$ | A1 | | Height above initial position |
| | $h=2.45+1=3.45\,\text{m}$ | A1 | 4 | Correct height |
| (b) | $2=8\sin 60°t-4.9t^2$ | M1 | | Forms vertical equation |
| | | A1A1 | | Correct equation |
| | $t=\dfrac{8\sin 60°\pm\sqrt{(8\sin 60°)^2-4\times4.9\times2}}{2\times4.9}$ | | | |
| | $=1.01$ or $0.404$ | m1 | | Solving equation |
| | | A1 | | Correct solutions |
| | 1.01 seconds | A1 | 6 | Correct time |
| (c) | $d=1.01\times8\cos 60°=4.04\,\text{m}$ | M1 | | Method for finding the range |
| | | A1 | 2 | Correct range |
| | **Total** | | **12** | |

**6** In a film a stunt-man drives a car off the top of a vertical cliff. The top of the cliff is 25 metres above the level of the sea. When it leaves the cliff the car is travelling at $40\,\text{m s}^{-1}$ at an angle of 5° above the horizontal. The diagram shows the cliff and the initial velocity of the car.




Model the car as a particle and assume that, while it is in the air, it moves under the influence of gravity alone.

(a) Show that the car hits the sea approximately 2.64 seconds after it leaves the top of the cliff. *(6 marks)*

(b) Find the horizontal distance of the car from the cliff when the car hits the sea. *(2 marks)*

(c) Find the speed of the car when it hits the sea. *(5 marks)*

| Question Number and part | Solution | Marks | Total marks | Comments |
|---|---|---|---|---|
| 6(a) | $-25 = 40\sin 5°t - 4.9t^2$ | M1 | | Equation for vertical motion |
| | | A1 | | LHS correct |
| | $4.9t^2 - 40\sin 5°t - 25 = 0$ | A1 | | RHS correct |
| | | m1 | | Solving quadratic equation |
| | $t = \dfrac{40\sin 5° \pm \sqrt{(40\sin 5°)^2 - 4\times 4.9\times(-25)}}{2\times 4.9}$ | A1 | | Correct method |
| | $= 2.642$ or $-1.931$ | | | |
| | Hits water after 2.64 seconds | A1 | 6 | Selecting 2.64 |
| (b) | $x = 40\cos 5°\times 2.642 = 105$ m | M1 | | Equation for horizontal motion |
| | | A1 | 2 | Correct range |
| (c) | $v_x = 40\cos 5°$ | M1 | | Horizontal component at impact |
| | $v_y = 40\sin 5° - 9.8\times 2.642$ | M1 | | Vertical component at impact |
| | | A1 | | Vertical component correct |
| | $v = \sqrt{(40\cos 5°)^2 + (40\sin 5° - 9.8\times 2.642)^2}$ | | | |
| | $= 45.7\ \text{ms}^{-1}$ | M1 | | Finding magnitude |
| | | A1 | 5 | Correct final answer |
| | **Total** | | **13** | |