1. At time $t = 0$, a particle is projected vertically upwards with speed u m s_{-1} from a point 10 m above the ground. At time T seconds, the particle hits the ground with speed 17.5 m s^{-1}. Find

(a) the value of u,

(3)

(b) the value of T.

(4)
(Total 7 marks)

2. A ball is projected vertically upwards with speed 21 m s^{-1} from a point A, which is 1.5 m above the ground. After projection, the ball moves freely under gravity until it reaches the ground. Modelling the ball as a particle, find

(a) the greatest height above A reached by the ball,

(3)

(b) the speed of the ball as it reaches the ground,

(3)

(c) the time between the instant when the ball is projected from A and the instant when the ball reaches the ground.

(4)
(Total 10 marks)

1. (a) $v^2 = u^2 + 2as \Rightarrow 17.5^2 = u^2 + 2 \times 9.8 \times 10$ A1
Leading to $u = 10.5$ A1 3

(b) $v = u + at \Rightarrow 17.5 = -10.5 + 9.8T$ M1A1ft
$T = 2\frac{6}{7}$ (s) DM1A1 4

Alternatives
$s = \left(\frac{u+v}{2}\right)T \Rightarrow 10 = \left(\frac{17.5 + -10.5}{2}\right)T$ M1A1ft
$\frac{20}{7} = T$ DM1A1 4

OR $s = ut + \frac{1}{2}at^2 \Rightarrow -10 = 10.5t - 4.9t^2$ M1A1ft
Leading to $T = 2\frac{6}{7}, \left(-\frac{5}{7}\right)$ Rejecting negative DM1A1 4

(b) can be done independently of (a)
$s = vt - \frac{1}{2}at^2 \Rightarrow -10 = -17.5t + 4.9t^2$ M1A1
Leading to $T = 2\frac{6}{7}, \frac{5}{7}$ DM1
For final A1, second solution has to be rejected. $\frac{5}{7}$ leads to a negative u. A1 4

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2. (a) $v^2 = u^2 + 2as \Rightarrow 0^2 = 21^2 - 2 \times 9.8 \times h$ M1A1
$h = 22.5$ (m) A1 3

(b) $v^2 = u^2 + 2as \Rightarrow v^2 = 0^2 + 2 \times 9.8 \times 24$ or equivalent M1A1
(= 470.4)
$v \approx 22$ (m s^{-1}) accept 21.7 A1 3

(c) $v = u + at \Rightarrow -\sqrt{470.4} = 21 - 9.8t$ or equivalent M1A2(1,0)
– 1 each error
$t \approx 4.4$ (s) accept 4.36 A1 4

[10]

1. There were various approaches that could be applied successfully to answer this question. Those who fully understood the implications of projecting from above ground level could achieve full marks by the most direct method although sign errors were not uncommon. Another popular approach was to split the motion into two stages (to and from the highest point) in both part (a) to find the initial velocity, and in part (b) to find the whole time. Although this required more working, there tended to be fewer sign errors. Premature approximation occasionally led to inaccuracy in the final answer. The weakest candidates sometimes only considered motion to or from the highest point. It should be noted that the rubric requires g = 9.8 to be used and not 9.81, which was penalised.

2. Successful candidates used appropriate formulae and took care over signs. A significant number used energy methods.

In part (a), many candidates were able to get to the answer using only one equation but many used two or even more and there were many sign errors. These comments apply also in the second and third parts, where candidates often "dived in" and used the first formula that came to mind instead of stopping to think – all three parts could be done using only one equation. Candidates sometimes lost marks due to over–accurate answers being given after using g as 9.8m s^{-2}.