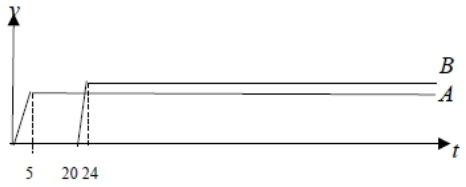
## Mark Scheme

**Q1.**

| Q | Solution | Mark | Notes |
|---|---|---|---|
| a |  | | |
| | Correct shape for sketch for $A$, starting at the origin. | B1 | B0 if solid vertical line at the end of either. |
| | Correct shape for sketch for $B$, must be correct relative to $A$, crossing it and ending at same time.<br>Must be done on the same axes. | B1 | Tram $B$ starts later and acceleration greater. |
| | 5, 20, 24 shown | DB1 | Dependent on previous two marks |
| | | | |
| | | **(3)** | |

| | | | |
|---|---|---|---|
| c | Equate distances from $O$ | M1 | Find both distances at time $t$ seconds and equate, using correct structure – see examples. |
| | $\left(\frac{t+t-5}{2}\right)\times 10=\left(\frac{t-20+t-24}{2}\right)\times 12$<br>**OR**<br>$\left(\frac{1}{2}\times 5\times 10\right)+10(t-5)=\left(\frac{1}{2}\times 4\times 12\right)+12(t-24)$ | A2 | Correct unsimplified equation, –1 each error (up to a maximum of 2) |
| | $t=119.5$ | M1 | Solve for $t$ |
| | Distance $=5\times(6\times 44-30)=1170$ (m) | A1 | Accept 1200 or better |
| | | **(5)** | |
| | | **[13]** | |
| | | | |

**Q2.**

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| (a) | Differentiate $s$ wrt $t$ | M1 | 3.1a |
| | $(v=)\ t^2-5t+6$ | A1 | 1.1b |
| | Equate their $v$ to 0 and solve | M1 | 1.1b |
| | $t=2$ or 3 | A1 | 1.1b |
| | $(a=)\ 2t-5$ | B1ft | 2.1 |
| | $a=$ 1 and $-1$ $(\text{m s}^{-2})$ isw (A0 if extras) | A1 | 1.1b |
| | | (6) | |
| (b) | Attempt to find values of $s$ for $t=2$, 3 *and* 4 oe<br>Correct values are $\left(s_2=\frac{14}{3}, s_3=\frac{9}{2}\ \textit{and}\ s_4=\frac{16}{3}\right)$<br><br>Could be implied by correct values for:<br>$s_2$ , $(s_3-s_2)$ and $(s_4-s_3)$ which are $\frac{14}{3}$, $(-\frac{1}{6})$ and $\frac{5}{6}$ | DM1 | 1.1b |
| | Total distance travelled<br>$=s_2+(s_2-s_3)+s_4-s_3$<br>**OR** $s_2-(s_3-s_2)+s_4-s_3$<br>**OR** $\left[\frac{1}{3}t^3-\frac{5}{2}t^2+6t\right]_0^2-\left[\frac{1}{3}t^3-\frac{5}{2}t^2+6t\right]_2^3+\left[\frac{1}{3}t^3-\frac{5}{2}t^2+6t\right]_3^4$<br>**OR** $\frac{14}{3}\quad-\quad(-\frac{1}{6})\quad+\quad\frac{5}{6}$<br>**OR** $s_2+2(s_2-s_3)+s_4-s_2$<br><br>$(=2s_2-2s_3+s_4)$ oe | M1 | 2.1 |
| | $5\frac{2}{3}$ oe (m) Accept 5.7 or better | A1 | 1.1b |
| | | (3) | |
| | | | (9 marks) |

| Notes: | | |
|---|---|---|
| a | M1 | Differentiate, with at least 2 powers decreasing by 1 |
| | A1 | Correct expression |
| | M1 | Must have attempted to differentiate $s$ to find $v$ and be solving a 3 term quadratic |
| | A1 | Both values needed |
| | B1ft | Follow their $v$ (must be differentiating) |

| | | |
|---|---|---|
| | A1 | cao |
| b | DM1 | This mark is dependent on the 2nd M1 in part (a) and their $t$ values are between 0 and 4.<br>Clear attempt to find all three $s$ values (may integrate their $v$ incorrectly)<br>N.B. No penalty for extra values. |
| | M1 | Complete method using their $s$ values Do NOT condone sign errors. |
| | A1 | Any equivalent fraction, 5.7 or better. |
| | | S.C. Correct answer, with no working, scores all 3 marks,<br>since $\int_0^4 \lvert t^2-5t+6\rvert\ \text{d}t$ entered on a calculator will give $\frac{17}{3}$ |

**Q3.**

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| (a) | (i) Equation of motion for $P$ | M1 | 3.3 |
| | $T - 2mg = 2ma$ | A1 | 1.1b |
| | (ii) Equation of motion for $Q$ | M1 | 3.3 |
| | $5mg - T = 5ma$ | A1 | 1.1b |
| | **N.B.** (allow $(-a)$ in both equations) | **(4)** | |
| (b) | Solve equations for $a$ or use whole system equation and solve for $a$ | M1 | 3.4 |
| | $a = \frac{3g}{7} = 4.2$ | A1 | 1.1b |
| | $v = \sqrt{2 \times \frac{3g}{7} \times h} = \sqrt{8.4h}$ or $v^2 = 2 \times \frac{3g}{7} \times h \ (= 8.4h)$ | M1 | 1.1b |
| | $0 = \frac{6gh}{7} - 2gH$ | M1 | 1.1b |
| | $H = \frac{3h}{7}$ | A1 | 1.1b |
| | Total height = $2h + h + H$ | M1 | 2.1 |
| | Total height = $\frac{24h}{7}$ | A1 | 1.1b |
| | | **(7)** | |
| (c) | e.g. The distance that $Q$ falls to the ground would not be exactly $h$ oe | B1 | 3.5b |
| | | **(1)** | |
| (d) | e.g. The accelerations of the balls would not have equal magnitude (allow 'wouldn't be the same' oe)<br>B0 if they say 'inextensible => acceleration same' | B1 | 3.5a |
| | | **(1)** | |
| | | | **(13 marks)** |

| Notes: | | |
|---|---|---|
| a | M1 | Translate situation into the model and set up the equation of motion for $P$ (must contain $T$ and $a$) |
| | A1 | Correct equation |
| | M1 | Translate situation into the model and set up the equation of motion for $Q$(must contain $T$ and $a$) |
| | A1 | Correct equation |
| | | **N.B.** Allow the above 4 marks if the equations appear in (b). |
| | | If $m$'s are omitted consistently, max (a) M1A0M1A0 (b)M1A0M1M1A1M1A0 |
| b | M1 | Solve for $a$ |
| | A1 | Allow 4.2 ( $m\,s^{-2}$ ) or must be in terms of $g$ only. |
| | | **N.B.** Allow the above 2 marks if they appear in (a). |
| | M1 | Complete method to produce an expression for $v$ or $v^2$ in terms $h$, using their $a$ |
| | M1 | Complete method to produce an expression for $H$ in terms of $h$ ,using $a = -g$ and $v = 0$ |
| | A1 | Correct expression for $H$ |
| | M1 | Complete method to find the total distance |
| | A1 | cao but allow $3.4h$ or better |
| c | B1 | B0 if any incorrect extras are given |
| d | B1 | B0 if any incorrect extras are given or for an incorrect statement e.g. tension is not constant so accelerations will be different |