| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1 | [$T\cos 45 + T\cos 45 = 2.5\cos 45$] | M1 | For resolving horizontally |
| | $T = 1.25$ N | A1 | |
| | [$2.5\sin 45 = mg$] | M1 | For resolving vertically |
| | Mass of ring = 0.177 kg | A1 | Allow $m = \sqrt{2}/8$ |
| | **First alternative method for Q1** | | |
| | [$2.5 = T + mg\cos 45$] | M1 | Resolve forces along BR |
| | [$T = mg\cos 45$] | M1 | Resolve forces perpendicular to BR and eliminate $T$ or $m$ |
| | $T = 1.25$ N | A1 | |
| | Mass of ring = 0.177 kg | A1 | Allow $m = \sqrt{2}/8$ |
| | **Second alternative method for Q1** | | |
| | $\frac{2T\cos 45}{\sin 135} = \frac{2.5}{\sin 90} = \frac{mg}{\sin 135}$ or $\frac{2.5 - T}{\sin 135} = \frac{T}{\sin 135} = \frac{mg}{\sin 90}$ | M1 | Attempt to apply Lami's theorem, |
| | | M1 | All three terms of Lami attempted |
| | $T = 1.25$ N | A1 | |
| | Mass of ring = 0.177 kg | A1 | Allow $m = \sqrt{2}/8$ |
| | | 4 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2 | $R = 5g \cos 6$ | **B1** | |
| | $[F = 0.3 \times 5g \cos 6]$ | **M1** | Use of $F = \mu R$ |
| | $[T = 5g \sin 6 + F]$ | **M1** | For resolving along the plane |
| | $T = 20.1$ N (20.14425...) | **A1** | |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 3(i) | Acceleration = –1 m s$^{-2}$ | **B1** | Allow deceleration = 1 m s$^{-2}$ |
| | | **1** | |
| 3(ii) | [$V$/4 = 1 or ($V$ + 2)/6 = 1] | **M1** | Use of gradient of line between $t$ = 4 and $t$ = 10 or use of similar triangles to find $V$ |
| | $V$ = 4 | **A1** | |
| | | **2** | |
| 3(iii) | [Distance = Area = ½ (6 + 2) × 2 = 8] | **M1** | Attempt distance travelled in first 6 seconds |
| | Distance $AB$ = 3 × 8 = 24 m | **A1** | |
| | [½ × ($T$ – 6) × 4 = 24] | **M1** | Attempt to find the distance travelled from $t$ = 6 to $t$ = $T$ and set up an equation for $T$ |
| | $T$ = 18 | **A1** | |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4(i) | $T = 0.7g$ | B1 | |
| | $R = 0.4g \times {}^4/_5$ [ $= {}^{16}/_5 = 3.2$] | B1 | Normal reaction on particle $P$ |
| | [$X + 0.4g \times {}^3/_5 - F - T = 0$] | M1 | Attempt to resolve forces along the plane |
| | $X = 6.2$ | A1 | **AG** |
| | | **4** | |
| 4(ii) | [$0.7g - T = 0.7a$]<br>[$T - 0.8 - 0.4g \times {}^3/_5 - F = 0.4a$]<br>[$0.7g - 0.8 - 0.4g \times {}^3/_5 - F = (0.7 + 0.4)a$] System | M1 | For using Newton's 2nd law for both particle $P$ and particle $Q$ or the system equation |
| | | A1 | Both equations correct or system equation correct |
| | | M1 | Solve either the system equation or solve two simultaneous equations to find $a$ |
| | $a = 2$ m s$^{-2}$ | A1 | |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 5(i) | [$1.2T^{1/2} - 0.6T = 0$] | **M1** | Attempt to find time of maximum $v$, set $a = 0$ and solve for $T$ |
| | $T^{1/2} = 2 \rightarrow T = 4$ | **A1** | |
| | | **2** | |
| 5(ii) | [$\mathrm{d}a/\mathrm{d}t = 0.6t^{1/2} - 0.6$] | **M1** | Attempt to differentiate $a$ |
| | $t = 1$ | **A1** | Solve $\mathrm{d}a/\mathrm{d}t = 0$ and find $t$ |
| | [$v = 0.8t^{3/2} - 0.3t^2$ (+ $C$)] | **M1** | Attempt to integrate $a$ to find $v$ |
| | | **A1** | Correct integration |
| | [$C = 1$] | **M1** | Use $v = 1$ at $t = 0$ either finding $C$ or by using limits as $v(1) - v(0) = [0.8(1)^{3/2} - 0.3(1)^2] - [0.8(0)^{3/2} - 0.3(0)^2]$ |
| | Velocity when acceleration is max is 1.5 ms$^{-1}$ | **A1** | $v = 1.5$ |
| | | **6** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6(i) | Power = 350 × 15 = 5250 W | **B1** | Allow 5.25 kW |
| | | **1** | |
| 6(ii) | | **B1** | Using Driving force DF = $P/15$ |
| | DF + 1200$g$ sin 1 – 350 = 1200 × 0.12 | **M1** | For using Newton's 2nd law down the slope |
| | $P$ = 4270 W (4268.56...) | **A1** | |
| | | **3** | |
| 6(iii) | [1200$g$ sin 1 – 350 = 1200$a$] | **M1** | Using Newton's 2nd law down the slope |
| | | **A1** | Correct equation |
| | [$18^2 = 20^2 + 2as$] | **M1** | Using constant acceleration formulae with a complete method to find distance, $s$, travelled. |
| | Distance travelled $s$ = 324 m (324.39) | **A1** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6(iii) | **Alternative method for Q6(iii)** | | |
| | PE loss = $1200g \times s \sin 1$<br>KE loss = $\frac{1}{2} \times 1200 \times (20^2 - 18^2)$ | **M1** | Attempt either PE loss or KE loss |
| | | **A1** | Both PE loss and KE loss correct |
| | $[1200g \times s \sin 1 + \frac{1}{2} \times 1200 \times (20^2 - 18^2) = 350s]$ | **M1** | Apply work-energy equation to the car |
| | Distance travelled $s$ = 324 m (324.39) | **A1** | |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(i) | At liquid surface, speed = $0 + g \times 0.8$ [= 8]<br>or<br>$0.3g \times ½ (0 + v) \times 0.8 = ½ (0.3) v^2 \rightarrow v = 8$ | **B1** | Using constant acceleration equation $v = u + at$<br>or<br>PE loss = KE gain |
| | PE lost in water = $0.3g \times 1.25$ [ = 3.75] | **B1** | |
| | [$½ \times 0.3 \times (8^2 - v^2) + 0.3g \times 1.25 = 1.2$] | **M1** | Using work-energy for downward motion in the tank<br>PE loss + KE loss = Work done against resistance |
| | $v = 9$ m s$^{-1}$ | **A1** | |
| | **Alternative method for Q7(i)** | | |
| | Height above tank = $½ \times g \times 0.8^2$ [= 3.2] | **B1** | |
| | Total PE loss = $0.3g \times (3.2 + 1.25)$ [= 13.35] | **B1** | |
| | [$0.3g \times (3.2 + 1.25) = ½ \times 0.3 \times v^2 + 1.2$] | **M1** | Work-energy equation for the total downward motion |
| | $v = 9$ m s$^{-1}$ | **A1** | |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(ii) | $[-0.3g - 1.8 = 0.3a]$ | M1 | Using Newton's 2nd law for the upward motion in the tank |
| | $a = -16$ | A1 | |
| | $[1.25 = 7T + ½ \times (-16) \times T^2]$ | M1 | Using constant acceleration equations to find the time, $T$, for the particle to travel from the bottom to the surface of the liquid |
| | $T = 0.25$ (or 0.625, on the way down) | A1 | |
| | [$v$ at surface $= 7 + (-16) \times 0.25 = 3$] | B1 | Using $v = u + aT$ or equivalent to find $v$ at surface |
| | $[0 = 3 - gt \rightarrow t = 0.3]$ | M1 | Attempt to find the time, $t$, taken for the particle to travel from the surface to reach maximum height using their $v \neq 7$ |
| | Total time $= T + t = 0.55$ s | A1 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(ii) | **Alternative method for Q7(ii)** | | |
| | [$-0.3g - 1.8 = 0.3a$] | **M1** | Using Newton's 2nd law for the upward motion in the tank |
| | $a = -16$ | **A1** | |
| | $v^2 = 7^2 + 2 \times (-16) \times 1.25 = 9 \rightarrow v = 3$ | **B1** | Using constant acceleration equations to find $v$ at the surface |
| | $1.25 = ½ (7 + 3) \times T$<br>or $3 = 7 + (-16) \times T$ | **M1** | Using $s = ½ (u + v) \times T$ or $v = u + aT$ to find the time, $T$, for the particle to travel from the bottom to the surface of the liquid |
| | $T = 0.25$ | **A1** | |
| | [$0 = 3 - gt \rightarrow t = 0.3$] | **M1** | Attempt to find the time, $t$, taken for the particle to travel from the surface to reach maximum height using their $v \neq 7$ |
| | Total time = $T + t = 0.55$ s | **A1** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(ii) | **Second Alternative method for Q7(ii)** | | |
| | [½ × 0.3 × ($7^2 - v^2$) = 0.3$g$ × 1.25 + 1.8 × 1.25] | **M1** | Work-energy equation for motion from bottom to surface |
| | | **A1** | Correct equation |
| | $v = 3$ | **B1** | Find $v$ at surface from rearrangement of work-energy |
| | [1.25 = ½ (7 + 3) × $T$] | **M1** | Using $s = ½ (u + v) \times T$ to find the time $T$, for the particle to travel from the bottom to the surface of the liquid |
| | $T = 0.25$ | **A1** | |
| | [0 = 3 – 10$t$ → $t$ = 0.3] | **M1** | Attempt to find the time, $t$, taken for the particle to travel from the surface to reach maximum height using their $v \neq 7$ |
| | Total time = $T + t$ = 0.55 s | **A1** | |
| | | **7** | |