| Question | Scheme | Marks | Notes |
|---|---|---|---|
| **2.(a)** | M($C$) $140(a-2)+30(2a-2)=120$ x 4<br>M($G$) $50(a-2)+30a=120(6-a)$<br>M($D$) $4\times50+30(2a-6)=140(6-a)$<br>M($B$) $140a=120(a-6)+50(2a-2)$<br>M($A$) $50\times2+120\times6=140a+30\times2a$ | M1 | Moments or alternative complete method to form an equation in $a$ only.<br>Dimensionally correct. Condone sign error(s)<br>No missing/additional terms<br>Condone a common factor of $g$ |
| | | A1 | At most one error |
| | $(200a=820)$ | A1 | Correct unsimplified equation in $a$ |
| | $a=4.1$ | A1 | |
| | | (4) | |
| **(b)** | $(\uparrow)$, $(2R=170\Rightarrow)R=85$ | B1 | Or a correct second moments equation in their $a$ to achieve 2 equations in 2 unknowns |
| | M($A$) $85\times2+85\times x = 140\times a+30\times2a$<br>M($C$)<br>$85(x-2)=140\times(a-2)+(2a-2)\times30$<br>M($G$) $85\times(a-2)+30\times a=85(x-a)$<br>M($E$) $30(2a-x)+85(x-2)=140(x-a)$<br>M($B$) $85\times(2a-2)+85(2a-x)=140\times a$ | M1 | Moments equation with equal reactions in $a$ or their $a$. Dimensionally correct.<br>No missing/additional terms.<br>Condone sign error(s)<br>Accept alternative complete method to form an equation in a different horizontal distance to $E$<br>Condone incorrect $R$, $R\neq120, R\neq50$<br>Condone a common factor of $g$ |
| | | A1ft | At most one error<br>Follow their $a$ and their $R\neq120, R\neq50$ |
| | | A1ft | Correct unsimplified equation in $AE$<br>Follow their $a$ and their $R\neq120, R\neq50$ |
| | $AE=\frac{130}{17}$ m (7.6 m or better) | A1 | |
| | | | If they find a different $x$, e.g. $CE=5.6$ and go no further, they score 4/5. |
| | | (5) | |
| | | **[9]** | |
| | | | A candidate who has a common factor of $g$ throughout can score 8/9 |

| | | |
|---|---|---|
| **6. (a)** | $x$ is greatest when rod is about to tip about $B$ *i.e.* $R_A = 0$ (can be implied) | B1 |
| | $M(B),\ 2W(x-2l) = W\frac{1}{2}l$ | M1 A1 |
| | $x = 2.25l$ | **DM**1 A1 (5) |
| **(b)** | Use of $R_A = 2W$ in an equation | M1 |
| | $M(B),\ 2W(2l-x) + W\frac{1}{2}l = 2W.2l$ | M1 A1 A1 |
| | $x = 0.25l$ | A1 (5) |
| | | **10** |

**NOTES**

**Question 6(a)**

B1 for $x$ greatest when $R_A = 0$ (usually implied in moments equation) or correct use of $R_A \geq 0$.

First M1 for an equation in $x$ and $l$ ONLY (usually moments about $B$ but could come from two equations). Allow if there is $W$ (uncancelled) in each term. (M0 if $R_A$ term included unless it subsequently becomes zero)

First A1 for a correct equation –again allow even if $W$ has not been cancelled.

Second M1, dependent on previous M, for solving for $x$ in terms of $l$.

Second A1 for $x = 2.25l$.

**N.B.** If '$l$' omitted consistently and then inserted at end award full marks. If not inserted then can score max B1M1A0M1A0

**Question 6(b) Scheme change**

First M1 for use of $R_A = 2W$ in any equation (vertical resolution or moments) or for correct use of $R_A \leq 2W$.

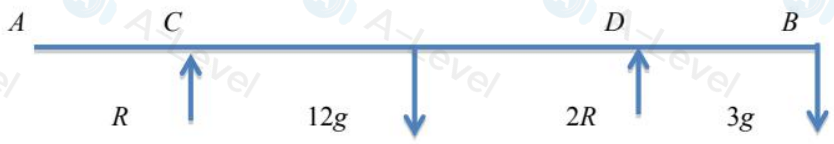
Second M1 for an equation in $x$ and $l$ ONLY (usually moments about $B$ but could come from two equations). Allow if there is $W$ (uncancelled) in each term.

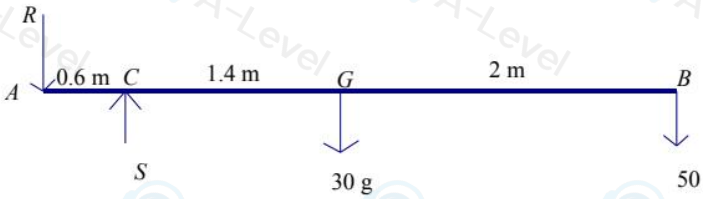
A2 for the equation, again allow even if $W$ has not been cancelled, -1 each error.

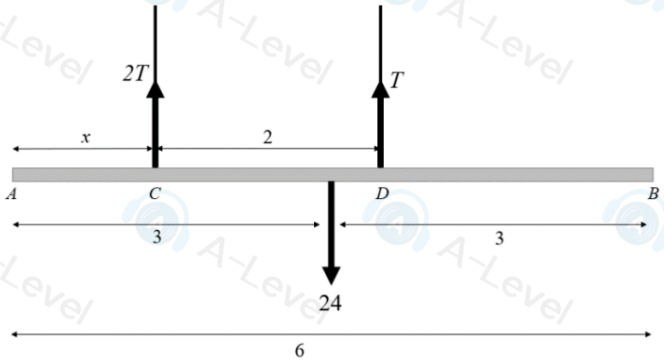
Third A1 for $x = 0.25l$.

**N.B.** If '$l$' omitted consistently and then inserted at end award full marks. If not inserted then can score max M1M1A0A0A0.

| Question Number | Scheme | Marks |
|---|---|---|
| **4(a)** | $M(C),\ Mg\times4.5+1.2g\times2=4g\times1.5$ | M1A1 |
| | $M=0.8$ oe | A1 (3) |
| | Other possible equations:<br>$(\uparrow),\ Y=4g+1.2g+Mg$<br>$M(A),\ 5Y=1.2g\times3+4g\times6.5+Mg\times0.5$<br>$M(B),\ 1.5Y=1.2g\times3.5+Mg\times6$<br>$M(G),\ 2Y+Mg\times2.5=4g\times3.5$<br>from which $Y$ would need to be eliminated. | |
| **4(b)** | $M(E),\ R_C\times0.6=1.2g\times2.6$ | M1A1 |
| | $R_C=5.2g$ isw | A1 (3) |
| | Other possible equations:<br>$(\uparrow),\ Xg+1.2g=R_C$<br>$M(C),\ Xg\times0.6=1.2g\times2$<br>$M(A),\ 1.2g\times3+Xg\times5.6=R_C\times5$<br>$M(B),\ 1.2g\times3.5+Xg\times0.9=R_C\times1.5$<br>$M(G),\ Xg\times2.6=R_C\times2$<br>from which $Xg$ would need to be eliminated. (Note that $X=4$)<br>$Xg$ may appear as a single letter. | |
| | | **(6)** |
| | **Notes** | |
| **4(a)** | M1: For an equation in $M$ only, with correct number of terms, condone sign errors and missing $g$'s | |
| | A1: Correct equation | |
| | A1: cao | |
| **4(b)** | M1: For an equation in $R_C$ only, with correct number of terms, condone sign errors and missing $g$'s | |
| | A1: Correct equation | |
| | A1: $\frac{26g}{5}$, 51 or 51.0 | |

| Question Number | Scheme | Marks |
|---|---|---|
| **3.** | <br>$(\uparrow)$ $R+2R=12g+3g$<br>$M(A)$, $2Rx+3R=12g.4+3g.8$<br>$x=5.7$ | M1 A2<br>M1 A2<br>A1 **7** |
| | | |
| | **Notes** | |
| | First M1 for either a vertical resolution (with correct of terms) or a moments equation (all terms dim correct and correct no. of terms)<br>First A1 and Second A1 for a correct equation in $R$ (or $S$ where $S = 2R$) only or $R$ and $x$ only or $S$ and $x$ only. (-1 each error , A1A0 or A0A0)<br>Second M1 for either a vertical resolution (with correct of terms) or a moments equation (all terms dim correct and correct no. of terms)<br>Third A1 and Fourth A1 for a correct equation in $R$ (or $S$ where $S = 2R$) only or $R$ and $x$ only or $S$ and $x$ only. (-1 each error, A1A0 or A0A0)<br>Fifth A1 for $x = 5.7$ oe<br>**N.B. On ePen, first 3 marks are for a vertical resolution, if it appears, second 3 marks are for a moments equation.**<br>**If no vertical resolution, award marks as they appear for the (two) moments equation(s).**<br>**(i)** In a moments equation, if $R$ and $2R$ (or $S$ and $0.5S$) are interchanged, treat as 1 error.<br>**(ii)** Ignore diagram if it helps the candidate.<br>**(iii)** If an equation is correct but contains both $R$ and $S$, treat as 1 error.<br>**(iv)** Full marks possible if all $g$'s omitted.<br>**(v)** For inconsistent omission of $g$, penalise each omission.<br><br>$M(B)$, $R\times 5+S(8-x)=12g\times 4$<br>$M(C)$, $S(x-3)=12g\times 1+3g\times 5$<br>$M(D)$, $R(x-3)+3g(8-x)=12g(x-4)$<br><br>**N.B. If they use a different variable, other than *x, for a length, with it clearly marked on the diagram,* they can score all the marks for any moments equation.** | |

| Question Number | Scheme | Marks | Notes |
|---|---|---|---|
| **4.(a)** |  | | |
| | $M(A)$ (30g x 2) + (50g x 4) = 0.6 $S$ | M1 | Moments equation. Requires all terms and dimensionally correct. Condone sign errors. Allow M1 if g missing |
| | $M(C)\ (0.6\times R)=(1.4\times 30\text{g})+(3.4\times 50\text{g})$<br>$M(G)\ (2\times R)=(1.4\times S)+(2\times 50\text{g})$<br>$M(B)\ (4\times R)+(2\times 30g)=(3.4\times S)$ | A1 | Correct unsimplified equation |
| | $(\uparrow)\ R+30g+50g=S$<br>$(R+784=S)$ | M1 | Resolve vertically. Requires all 4 terms. Condone sign errors |
| | | A1 | Correct equation (with $R$ or their $R$) |
| | NB: The second M1A1 can also be earned for a second moments equation | | |
| | $R=3460$ or 3500 or $\frac{1060g}{3}$ (N) Not 353.3g | A1 | One force correct |
| | $S=4250$ or 4200 or $\frac{1300g}{3}$ (N) Not 433.3g | A1 | Both forces correct<br>If both forces are given as decimal multiples of $g$ mark this as an accuracy penalty A0A1 |
| | | (6) | |
| **4.(b)** | $M(C)$ (30g x 1.4) + ($M$g x 3.4) = 0.6 x 5000 | M1 | Use $R=5000$ and complete method to form an equation in $M$ or weight. Needs all terms present and dimensionally correct. Condone sign errors.<br>Accept inequality.<br>Use of $R$ and $S$ from (a) is M0 |
| | | A1 | Correct equation in $M$ (not weight)<br>$(\text{implied by } M=77.68)$ |
| | $M=77$ kg | A1 | 77.7 is A0 even is the penalty for over-specified answers has already been applied |
| | | (3) | |
| **4.(c)** | The weight of the diver acts at a point. | B1 | Accept "the mass of the diver is at a point". |
| | | (1) | |
| | | **[10]** | |

| QUESTION NUMBER | SCHEME | MARKS |
|---|---|---|
| **1** |  | |
| | Form a moments equation<br>M($A$): $(2T\times x)+T(x+2)=(24\times 3)$ | M1 A1 |
| | Form a second equation<br><br>vert $3T=24$ | M1 |
| | Alternative moments equations in $x$ and $T$<br>M($C$): $24(3-x)=T\times 2$<br>M($G$): $2T(3-x)=T(x-1)$<br>M($D$): $(2T\times 2)=24\times(x-1)$<br>M($B$): $2T(6-x)+T(4-x)=(24\times 3)$<br>M($C$): $\frac{24x}{6}\times\frac{x}{2}+2T=\frac{24(6-x)}{6}\times\frac{(6-x)}{2}$ | |
| | $T=8\,(\text{N})$ | A1 |
| | $x=\frac{7}{3}$ accept 2.3 or better | A1 |
| | | **(5)** |
| | **Notes for question 1** | |
| **M1** | Forms a moments equation in $x$ and $T$ only with the correct no. of terms. Allow consistent extra $g$' s.<br>M0 if no $x$. | |
| **A1** | Correct unsimplified moments equation. Where two moments equations are used, award this mark for the first correct equation. | |
| **M1** | Resolves vertically to give equation in $T$ only or a second moments equation in $x$ and $T$ (M0 if no $x$.). Must be dimensionally correct with the correct no. of terms. | |
| **A1** | Correct value for tension at $D$ | |
| **A1** | Correct value for $x$. Accept 2.3 or better<br><br>**N.B.** If $T$ and $2T$ the wrong way round or they use $24g$, can score max M1A0M1A0A0. | |

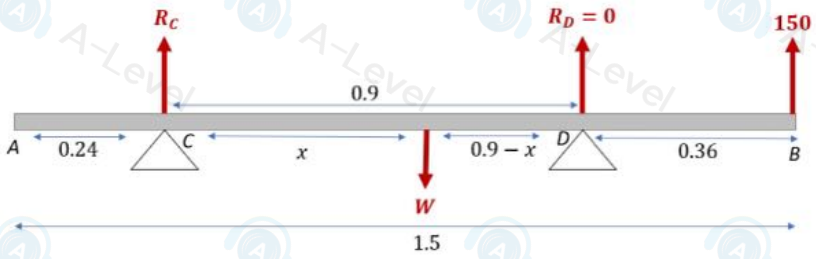
| Question Number | Scheme | Marks |
|---|---|---|
| **2(a)** | **N.B.** Consistent use of extra $g$'s in **two** equations can score the A marks for the equations and could score full marks for part (a).<br>**N.B.** If they assume that the rod is uniform, can only score marks for a vertical resolution.<br>R$(\uparrow)$: $0.5R_C + R_C = 60 + 12$ (N.B. $R_A = \frac{1}{2}R_C$) | M1A1 |
| | Possible moments equations:<br>M$(A)$: $60x + (12\times 5) = R_C \times 3$<br>M$(B)$: $(2\times R_C) + \left(\frac{1}{2}R_C \times 5\right) = 60(5-x)$<br>M$(C)$: $(\frac{1}{2}R_C \times 3) + (12\times 2) = 60(3-x)$<br>M$(G)$: $12(5-x) + \frac{1}{2}R_C x = R_C(3-x)$ | M1A1 |
| | Eliminate $R_C$ and solve for $x$ ($AG$) | **DM1** |
| | $x = 1.4$ m | A1 (6) |
| **(b)** | (i) the weight of the parcel acts at $B$ | B1 |
| | (ii) the plank remains straight | B1 (2) |
| | (or equivalent statements) | **[8]** |
| | | |
| | **Notes for qu 2** | |
| | **N.B. If $R$ and $\frac{1}{2}R$ are reversed, max score is M1A1 (resolution) M1A0 (moments)** | |
| **2a** | First M1 for first equation, correct no. of terms, dim correct, condone sign errors and allow $R$ and $S$ at this stage and for moments equations allow a different length variable | |
| | First A1 for a correct resolution in one unknown or moments equation in two unknowns | |
| | Second M1 for second equation, correct no. of terms, dim correct, condone sign errors and allow $R$ and $S$ at this stage and for moments equations allow a different length variable | |
| | Second A1 for a correct resolution in one unknown or moments equation in two unknowns | |
| | Third DM1, dependent on both previous M marks, for eliminating and solving for $AG$ | |
| | Third A1 for 1.4 (m) oe | |
| | | |
| **2b (i)** | First B1 e.g. mass is concentrated **at *B*** B0 if incorrect extras | |
| **(ii)** | Second B1 e.g. the plank doesn't buckle or bend B0 if incorrect extras | |

| Question Number | Scheme | Marks |
|---|---|---|
| 4. | $R_D = 0$ for scenario 1 or $R_C = 0$ for scenario 2 | B1 |
| | Scenario 1<br>$\text{M}(C) \quad (150 \times 1.26) = Wx$ | M1<br>A1 |
| | Scenario 2<br>$\text{M}(D) \quad (225 \times 0.36) = W \times (0.9 - x)$ | M1<br>A1 |
| | Solve simultaneously for $W$ (or $x$)<br>e.g. $0.81W = 243$ | dM1 |
| | $W = 300$ | A1 |
| | $x = 0.63$ | A1 |
| | | **(8)** |

**NOTES**

| | |
|---|---|
| **B1** | **N.B.** B0 means there are no other marks available.<br>$R_D = 0$ for scenario 1 seen on a diagram or implied by working.<br>OR: $R_C = 0$ for scenario 2 seen on a diagram or implied by working. |
| **M1** | Complete method to form an equation in $W$ and a consistent unknown distance *only*, for scenario 1. All equations used must be dimensionally correct and have the correct no. of terms but condone sign errors.<br>(M0 if $R_D = 0$ is never used) |
| **A1** | Correct unsimplified equation in $W$ and $x$ or their defined unknown distance. |
| **M1** | Complete method to form an equation in $W$ and a consistent unknown distance *only,* for scenario 2. All equations used must be dimensionally correct and have the correct no. of terms but condone sign errors.<br>(M0 if $R_C = 0$ is never used) |
| **A1** | Correct unsimplified equation in $W$ and $x$ or their defined unknown distance |
| **dM1** | Dependent on both M's, solve simultaneous equations for either $W$ or their unknown<br>Correct answer for $W$ |
| **A1** | Correct answer for $x$ This must be the distance stated in the question, from |
| **A1** | $C$ to the centre of mass.<br><br>**N.B.** If they include $g$ in a moments equation, they lose the A mark for that equation and both final A marks. |

**Scenario 1**




Equations with unknown distance, $x$, measured from $C$.

Complete method will involve one moments equation with $R_D = 0$ or two equations with $R_C$ eliminated and $R_D = 0$.

M0 if $R_D$ never equals zero

Vert $R_C + 150 = W$

M($A$) $(R_C \times 0.24) + (150 \times 1.5) = W(x + 0.24)$

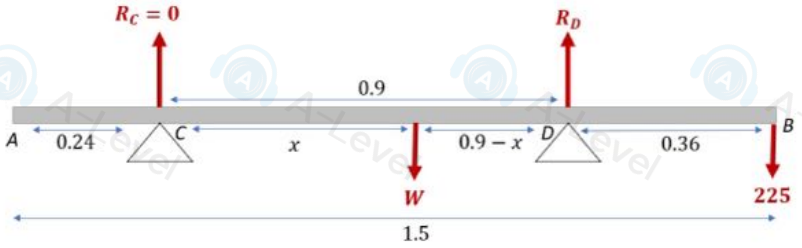
M($C$) $(150 \times 1.26) = Wx$

M($G$) $R_C x = 150(1.26 - x)$

M($D$) $(R_C \times 0.9) = (150 \times 0.36) + W(0.9 - x)$

M($B$) $(R_C \times 1.26) = W(1.26 - x)$

**Scenario 2**




Equations with unknown distance, $x$, measured from $C$

Complete method will involve one moments equation with $R_C = 0$ or two equations with $R_D$ eliminated and $R_C = 0$.

M0 if $R_C$ never equals zero

Vert $R_D = 225 + W$

M($A$) $(R_D \times 1.14) = (225 \times 1.5) + W(x + 0.24)$

M($C$) $(225 \times 1.26) + Wx = (R_D \times 0.9)$

M($G$) $R_D(0.9 - x) = 225(1.26 - x)$

M($D$) $(225 \times 0.36) = W(0.9 - x)$