

| Question Number | Scheme | Marks |
|-----------------|---|-------------------|
| 1a | Resolving horizontally: $T \cos 30^\circ = 6 \cos 50^\circ$ $T = 4.45 \text{ (N)}, 4.5 \text{ (N)}, \text{ or better}$ | M1A1 A1 (3) |
| b | Resolving vertically: $W = 6 \cos 40^\circ + T \cos 60^\circ$ $= 6.82 \text{ (N)}, 6.8 \text{ (N)}, \text{ or better}$ | M1A1 A1 (3) |
| | | [6] |

Notes for Question 1

Question 1(a)

First M1 for resolving horizontally with correct no. of terms and both T_{AC} and '6' terms resolved.

First A1 for a correct equation in T_{AC} only.

Second A1 for 4.5 (N), 4.45 (N) or better. (4.453363194)

N.B. The M1 is for a complete method to find the tension so where two resolution equations, neither horizontal, are used, the usual criteria for an M mark must be applied to *both* equations and the first A1 is for a correct equation in T_{AC} *only* (i.e. W eliminated correctly)

Alternatives:

Triangle of Forces : $\frac{T_{AC}}{\sin 40^\circ} = \frac{6}{\sin 60^\circ}$ (same equation as \rightarrow resolution) M1A1

Or

Lami's Theorem: $\frac{T_{AC}}{\sin 140^\circ} = \frac{6}{\sin 120^\circ}$ (same equation as \rightarrow resolution) M1A1

Question 1(b)

First M1 for resolving vertically with correct no. of terms and both T_{AC} (does not need to be substituted) and '6' terms resolved.

First A1 for a correct equation in T_{AC} and W .

Second A1 for 6.8 (N), 6.82 (N) or better. (6.822948256)

Alternatives:

Triangle of Forces : $\frac{6}{\sin 60^\circ} = \frac{W}{\sin 80^\circ}$ M1A1

Or Lami's Theorem: $\frac{6}{\sin 120^\circ} = \frac{W}{\sin 100^\circ}$ M1A1

Or Resolution in another direction e.g. along one of the strings M1 (usual criteria) A1 for a correct equation.

| Question Number | Scheme | Marks |
|-----------------|--|-------------|
| 2(a) | $R = mg \cos 40$ | B1 |
| | Use of $F = \mu R$ | B1 |
| | $mg \sin 40 - F = \pm ma$ | M1A1 |
| | $acc = 2.55 \text{ (m s}^{-2}\text{)} \text{ or } 2.5 \text{ (m s}^{-2}\text{)}$ | A1 (5) |
| | | |
| (b) | $v^2 = u^2 + 2as = 2 \times a \times 3$ Speed at B is $3.9 \text{ (m s}^{-1}\text{)} \text{ or } 3.91 \text{ (m s}^{-1}\text{)}$ | M1A1 (2) |
| | | [7] |

Notes for Question 2

(Deduct only 1 mark in **whole question** for not giving an answer to either 2 sf or 3 sf, following use of $g = 9.8$)

Question 2(a)

First B1 for $R = mg \cos 40^\circ$

Second B1 for $F = \mu R$ seen or implied (can be on diagram)

M1 for resolving parallel to plane, correct no. of terms, mg resolved (F does not need to be substituted)

First A1 for a correct equation

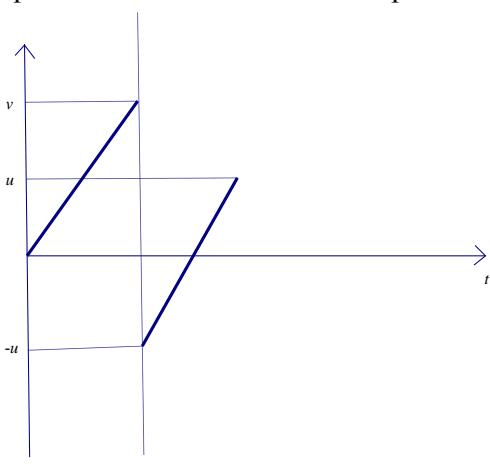
Second A1 for $2.5 \text{ (ms}^{-2}\text{)} \text{ or } 2.55 \text{ (ms}^{-2}\text{)}$ Must be **positive**.

S.C. If m is given a specific numerical value, can score max B1B1M1A0A0

Question 2(b)

M1 is for a complete method for finding speed (usually $v^2 = u^2 + 2as$)

A1 for $3.9 \text{ (ms}^{-1}\text{)} \text{ or } 3.91 \text{ (ms}^{-1}\text{)}$

| Question Number | Scheme | Marks |
|-----------------|--|--|
| 3a | Using $v^2 = u^2 + 2as$: $v^2 = 4g$, $v = \sqrt{4g}$ or 6.3 or 6.26 (m s ⁻¹) | M1,A1 (2) |
| b | Rebounds to 1.5 m, $0 = u^2 - 3g$, $u = \sqrt{3g}$, 5.4 or 5.42 (m s ⁻¹) | M1A1 (2) |
| c | Impulse = $0.3(6.3 + 5.4) = 3.5$ (Ns) | M1A1 (2) |
| d | If speed downwards is taken to be positive:  | First line B1 Second line B1 $-u, u,$ B1 (3) |
| e. | Use of suvat to find t_1 or t_2 , $\sqrt{4g} = gt_1 \quad t_1 = \sqrt{\frac{4}{g}} = 0.64 \text{ s}$ $\sqrt{3g} = gt_2 \quad t_2 = \sqrt{\frac{3}{g}} = 0.55 \text{ s}$ Total time = $t_1 + 2t_2 = 1.7 \text{ s}$ or 1.75 s | M1A1 (t_1 or t_2) DM1A1 (4) [13] |

Notes for Question 3

N.B. Deduct only 1 mark in **whole question** for not giving an answer to either 2 sf or 3 sf, following use of $g = 9.8$ or use of $g = 9.81$

Question 3(a)

M1 is for a complete method for finding speed (usually $v^2 = u^2 + 2as$)

A1 for $v = 6.3 \text{ (ms}^{-1}\text{)}$ or $6.26 \text{ (ms}^{-1}\text{)}$ or $\sqrt{4g} \text{ (ms}^{-1}\text{)}$ (must be positive)

Allow $0 = u^2 - 4g$ or $v^2 = 4g$ but not $0 = u^2 + 4g$ or $v^2 = -4g$

Question 3(b)

M1 is for a complete method for finding speed

Allow $0 = u^2 - 3g$ or $v^2 = 3g$ but not $0 = u^2 + 3g$ or $v^2 = -3g$

A1 for $5.4 \text{ (ms}^{-1}\text{)}$ or $5.42 \text{ (ms}^{-1}\text{)}$ or $\sqrt{3g} \text{ (ms}^{-1}\text{)}$ (must be positive)

Question 3(c)

M1 is for ± 0.3 (their (b) \pm their (a)) (unless they are definitely adding the momenta

i.e. using $I = m(v + u)$ which is M0). **N.B. Extra g is M0**

A1 for 3.5 (Ns) or 3.50 (Ns) (must be positive)

Question 3(d)

First B1 for a straight line from origin to their v which must be marked on the axis.

Second B1 for a parallel straight line correctly positioned (if continuous vertical lines are clearly included as part of the graph then B0)

Third B1 for their $-u$ and u correctly marked, provided their second line is correctly positioned

N.B. A reflection of the graph in the t -axis (upwards +ve) is also acceptable

Question 3(e)

First M1 for use of suvat or area under their v - t graph to find either t_1 or t_2 or $2t_2$

First A1 for correct value for either t_1 or t_2 (can be in terms of g at this stage or surds or unsimplified e.g. $6.3/9.8$)

Second M1 **dependent on the first M1** for their $t_1 + 2t_2$

Second A1 for 1.7 (s) or 1.75 (s).

| Question Number | Scheme | Marks |
|-----------------|---|---|
| 4a | Resolving vertically: $T + 2T (= 3T) = W$ Moments about A: $2W = 2T \times d$ Substitute and solve: $2W = 2 \frac{W}{3} d$ $d = 3$ | M1A1 M1A1 DM1 A1 (6) |
| b | Resolving vertically: $T + 4T = W + kW \quad (5T = W(1+k))$ Moments about A: $2W + 4kW = 3 \times 4T$ Substitute and solve: $2W + 4kW = \frac{12}{5}W(1+k)$ $2 + 4k = \frac{12}{5} + \frac{12}{5}k$ $\frac{8}{5}k = \frac{2}{5}, \quad k = \frac{1}{4}$ | M1A1 ft M1A1 ft DM1 A1 (6) |

Notes for Question 4

N.B. In moments equations, for the M mark, all terms must be force x distance but take care in the cases when the distance is 1.

Question 4(a)

N.B. If Wg is used, mark as a misread. *If T and 2T are reversed, mark as per scheme NOT as a misread.*

First M1 for an equation in W and T and possibly d (either resolve vertically or moments about any point other than the mid-pt), with usual rules.

First A1 for a correct equation.

Second M1 for an equation in W and T and possibly d (either resolve vertically or moments about any point other than the mid-pt), with usual rules.

Second A1 for a correct equation.

Third M1, dependent on first and second M marks, for solving for d

Third A1 for $d = 3$ cso

N.B. If a single equation is used (see below) by taking moments about the mid-point of the rod, $2T = 2T(d - 2)$, this scores M2A2 (-1 each error)

Third M1, dependent on first and second M marks, for solving for d

Third A1 for $d = 3$ cso

Question 4(b)

N.B. If Wg and kWg are used, mark as a misread.

If they use any results from (a), can score max M1A1 in (b) for one equation.

If T and 4T are reversed, mark as per scheme NOT as a misread.

First M1 for an equation in W and a tension T_1 and possibly their d or their d and k (either resolve vertically or moments about any point), with usual rules.

First A1 **ft** on their d , for a correct equation.

Second M1 for an equation in W and **the same tension** T_1 and possibly their d or their d and k (either resolve vertically or moments about any point), with usual rules.

Second A1 **ft** on their d , for a correct equation.

Third M1, dependent on first and second M marks, for solving to give a numerical value of k

Third A1 for $k = 1/4$ oe cso

| Question Number | Scheme | Marks |
|-----------------|--|-----------------------------|
| 5a | $\mathbf{F} = m\mathbf{a} : 3\mathbf{i} - 2\mathbf{j} = 0.5\mathbf{a}$ $\mathbf{a} = 6\mathbf{i} - 4\mathbf{j}$ $ \mathbf{a} = \sqrt{6^2 + (-4)^2} = 2\sqrt{13} (\mathbf{m s}^{-2}) **$ | M1 A1 M1A1 (4) |
| b | $\mathbf{v} = \mathbf{u} + \mathbf{at} : \mathbf{v} = (\mathbf{i} + 3\mathbf{j}) + 2(6\mathbf{i} - 4\mathbf{j})$ $= 13\mathbf{i} - 5\mathbf{j} \mathbf{m s}^{-1}$ | M1A1 ft A1 (3) |
| c | Distance = $2 \mathbf{v} = 2\sqrt{4+1} = 2\sqrt{5} = 4.47 (\mathbf{m})$ | M1A1 (2) |
| d | When $t = 3.5$, velocity of P is $(\mathbf{i} + 3\mathbf{j}) + 3.5(6\mathbf{i} - 4\mathbf{j}) = 22\mathbf{i} - 11\mathbf{j}$ Given conclusion reached correctly. E.g. $22\mathbf{i} - 11\mathbf{j} = 11(2\mathbf{i} - \mathbf{j})$ | M1A1 ft A1 (3) |
| | | [12] |

Notes for Question 5

Question 5(a)

Either:

First M1 for use of $\mathbf{F} = m \mathbf{a}$

First A1 for $\mathbf{a} = 6\mathbf{i} - 4\mathbf{j}$

Second M1 for $\mathbf{a} = \sqrt{(6^2 + (-4)^2)} \quad (\text{Allow } \sqrt{(6^2 + 4^2)})$

Second A1 for $\mathbf{a} = 2\sqrt{13} (\mathbf{ms}^{-2})$ **Given answer**

Or:

First M1 for $\mathbf{F} = \sqrt{(3^2 + (-2)^2)} \quad (\text{Allow } \sqrt{(3^2 + 2^2)})$

First A1 $\mathbf{F} = \sqrt{13}$

Second M1 for $\sqrt{13} = 0.5 \mathbf{a}$

Second A1 for $\mathbf{a} = 2\sqrt{13} (\mathbf{ms}^{-2})$ **Given answer**

Question 5(b)

M1 for $(\mathbf{i} + 3\mathbf{j}) + (2 \times \text{their } \mathbf{a})$

First A1 **ft** for a correct expression

Second A1 for $13\mathbf{i} - 5\mathbf{j}$; isw if they go on to find the speed

Question 5(c)

M1 for $2\sqrt{(2^2 + (-1)^2)} \text{ or } \sqrt{(4^2 + (-2)^2)}$

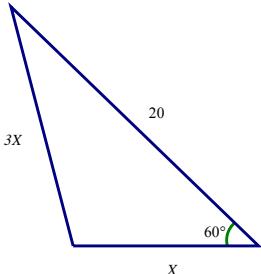
A1 for $2\sqrt{5}$ or $\sqrt{20}$ or 4.5 or 4.47 or better

Question 5(d)

M1 for $(\mathbf{i} + 3\mathbf{j}) + (3.5 \times \text{their } \mathbf{a})$, or possibly, their (b) + $(1.5 \times \text{their } \mathbf{a})$

First A1 **ft** for a correct expression of form $a\mathbf{i} + b\mathbf{j}$

Second A1 for given conclusion reached correctly e.g. $22\mathbf{i} - 11\mathbf{j} = 11(2\mathbf{i} - \mathbf{j})$ oe **Given answer**

| Question Number | Scheme | Marks |
|-----------------|--|-----------------------------|
| 6a |  <p>Resolve and use Pythagoras $(X - 20\cos 60)^2 + (20\cos 30)^2 = (3X)^2$</p> $8X^2 + 20X - 400 = 0$ $X = \frac{-5 \pm \sqrt{25 + 800}}{4} = 5.93 \text{ (3 SF)}$ | M1 A1 A1 M1A1 (5) |
| 6a alt | <p>Cosine rule $(3X)^2 = 20^2 + X^2 - 2 \cdot 20 \cdot X \cos 60$</p> $8X^2 + 20X - 400 = 0$ $X = \frac{-5 \pm \sqrt{25 + 800}}{4} = 5.93 \text{ (3SF)}$ | M1A1 A1 M1A1 (5) |
| b | $ \mathbf{P} - \mathbf{Q} ^2 = 20^2 + X^2 - 2 \cdot 20 \cdot X \cos 120$ $ \mathbf{P} - \mathbf{Q} = 23.5 \text{ (N) (3SF)}$ | M1A1 DM1 A1 (4) |
| 6b alt | $ \mathbf{P} - \mathbf{Q} ^2 = (X + 20\cos 60)^2 + (20\cos 30)^2$ $ \mathbf{P} - \mathbf{Q} = 23.5 \text{ (N) (3SF)}$ | M1A1 DM1 A1 (4) |
| | | [9] |

Notes for Question 6

In this question a misquoted Cosine Rule is M0.

The question asks for both answers to 3 SF but only penalise under or over accuracy once in this question.

Question 6(a)

First M1 for a complete method to give an **equation in X only** i.e. producing two components *and* usually squaring and adding and equating to $(3X)^2$ (condone sign errors and consistent incorrect trig. in the components for this M mark **BUT the x-component must be a difference**)

First A1 for a correct unsimplified equation in X *only*

e.g, allow $(\pm(X - 20\cos 60^\circ))^2 + (\pm(20\cos 30^\circ))^2 = (3X)^2$

Second A1 for any correct fully numerical 3 term quadratic = 0

Second M1(**independent**) for solving a 3 term quadratic

Third A1 for 5.93

Alternative using cosine rule:

First M1 for use of cosine rule with $\cos 60^\circ$ (**M0 if they use 120°**)

First A1 for a correct equation unsimplified e.g, allow $\cos 60^\circ$ and $(3X)^2$

Second A1 for any correct fully numerical 3 term quadratic = 0

Second M1(**independent**) for solving a 3 term quadratic

Third A1 for 5.93

Alternative using 2 applications of the sine rule:

First M1 for using $3X / \sin 60^\circ = X / \sin a$ **AND**

Either: $X / \sin a = 20 / \sin (120^\circ - a)$

Or: $3X / \sin 60^\circ = 20 / \sin (120^\circ - a)$

(These could be in terms of b where $b = (120^\circ - a)$)

First A1 for two correct equations

Second A1 for $a = 16.778..^\circ$ (or $b = 103.221..^\circ$)

Second M1 for solving:

$X / \sin a = 20 / \sin (120^\circ - a)$ **or** $3X / \sin 60^\circ = 20 / \sin (120^\circ - a)$
with their a or b, to find X

Third A1 for 5.93

Question 6(b)

First M1 for use of cosine rule unsimplified with $\cos 120^\circ$ (**M0 if they use 60°**)

First A1 for a correct expression for $|\mathbf{P} - \mathbf{Q}|$ in terms of X (does not need to be substituted)

Second M1, **dependent on first M1**, for substituting for their X and solving for $|\mathbf{P} - \mathbf{Q}|$

Second A1 for 23.5

Alternative using components:

First M1 for a complete method i.e. producing two components *and* squaring and adding (no square root needed) (condone sign errors and consistent incorrect trig. in the components for this M mark

BUT the x-component must be a sum)

First A1 for a correct expression for $|\mathbf{P} - \mathbf{Q}|$

(e.g, allow $(\pm(X + 20\cos 60^\circ))^2 + (\pm(20\cos 30^\circ))^2$

Second M1, **dependent on first M1**, for substituting for their X and solving for $|\mathbf{P} - \mathbf{Q}|$

Second A1 for 23.5

| Question Number | Scheme | Marks |
|-----------------|--|-------------------------|
| 7(a) | $4mg - T = 4ma$ | M1A1 |
| | $T - 3mg = 3ma$ | M1A1 |
| | Condone the use of $4mg - 3mg = 4ma + 3ma$ in place of one of these equations. | M1A1 |
| | Reach given answer $a = \frac{g}{7}$ correctly *** | A1 |
| | Form an equation in T : $T = 3mg + 3\left(mg - \frac{T}{4}\right)$, $T = 3mg + 3m\frac{g}{7}$, or $T = 4mg - 4m\frac{g}{7}$ | M1 |
| | $T = \frac{24}{7}mg$ or equivalent, $33.6m$, $34m$ | A1 (7) |
| (b) | $v^2 = u^2 + 2as = 2 \times \frac{g}{7} \times 0.7 = 1.96$, $v = 1.4 \text{ ms}^{-1}$ | M1A1 (2) |
| (c) | $3mg - T = 3ma$ $T - 2mg = 2ma$ $a = \frac{g}{5}$ | M1A1 A1 A1 (4) |
| (d) | $0 = 1.96 - 2 \times \frac{g}{5} \times s$ | M1 |
| | $s = \frac{5 \times 1.96}{2g} = 0.5 \text{ (m)}$ | A1 |
| | Total height = $0.7 + 0.5 = 1.2 \text{ (m)}$ | A1 ft (3) |
| Alt d | Using energy: $3mgs - 2mgs = \frac{1}{2}3m \times 1.4^2 + \frac{1}{2}2m \times 1.4^2$ | M1 |
| | $s = \frac{2.5 \times 1.96^2}{g} = 0.5 \text{ (m)}$ | A1 |
| | Total height = $0.7 + 0.5 = 1.2 \text{ (m)}$ | A1 ft (3) |
| | | [16] |

Notes for Question 7

Question 7(a)(i) and (ii)

First M1 for resolving vertically (up or down) for $B+C$, with correct no. of terms.

First A1 for a correct equation.

Second M1 for resolving vertically (up or down) for A , with correct no. of terms.

Second A1 for a correct equation.

Third A1 for $g/7$, obtained correctly. **Given answer (1.4 A0)**

Third M1 for an equation in T only

Fourth A1 for $24mg/7$ oe or $33.6m$ or $34m$

N.B. If they omit m throughout (which gives $a = g/7$), can score max M1A0M1A0A0M1A0 for part (a) BUT CAN SCORE ALL OF THE MARKS in parts (b), (c) and (d).

Question 7(b)

M1 for an equation in v only (usually $v^2=u^2+2as$)

A1 for $1.4 \text{ (ms}^{-1}\text{)}$ allow $\sqrt{g/5}$ oe.

Question 7(c)

First M1 for resolving vertically (up or down) for A or B , with correct no. of terms. (**N.B.** M0 if they use the tension from part (a))

First A1 for a correct equation for A .

Second A1 for a correct equation for B .

N.B. 'Whole system' equation: $3mg - 2mg = 5ma$ earns first 3 marks but any error loses all 3

Third A1 for $g/5$ oe or 1.96 or $2.0 \text{ (ms}^{-2}\text{)}$ (allow a negative answer)

Question 7(d)

M1 for an equation in s only using their v from (b) and a from (c).

either $0 = 1.4^2 - 2(g/5)s$ or $1.4^2 = 0 + 2(g/5)s$

First A1 for $s = 0.5 \text{ (m)}$ correctly obtained

Second A1 **ft** for their $0.5 + 0.7 = 1.2 \text{ (m)}$

Alternative using conservation of energy

M1 for an equation in s only, with correct number of terms, using their v from (b):-

$(3mgs - 2mgs) = \frac{1}{2} 3m (1.4)^2 + \frac{1}{2} 2m (1.4)^2$

First A1 for $s = 0.5 \text{ (m)}$ correctly obtained

Second A1 **ft** for their $0.5 + 0.7 = 1.2 \text{ (m)}$