EXPERT TUITION

Maths Questions By Topic:

Forces & Newton's Laws Mark Scheme

A-Level Edexcel

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Question	Scheme	Marks	AOs
	N.B. Use the mass in the '*ma*' term of an equation to determine which part of the system (cage and block, cage or block) it applies to.		
1(a)	Translate situation into the model and set up the **equation** of motion for the cage and the block to obtain an equation in T only.	M1	3.3
	$T-40g-10g=50\times0.2$	A1	1.1b
	500 (N) Must be positive	A1	1.1b
	Some examples: $T-50=50\times0.2$ and $T-40g-10g=50g\times0.2$ both score M1A0A0		
		(3)	
(b)	Use the model to set up the equation of motion for the block to obtain an equation in R only.	M1	3.4
	$R-10g=10\times0.2$ Allow - R instead of R	A1	1.1b
	100 (N) Must be positive.	A1	1.1b
	OR: Use the model to set up the equation of motion for the cage to obtain an equation in R only.	M1	3.4
	$T-40g-R=40\times0.2$ with their T substituted	A1	1.1b
	100 (N) Must be positive	A1	1.1b
		(3)	
			(6 marks)

Notes:
N.B. Only penalise the use of an incorrect value of *g* ONCE for the whole question, so max (a) M1A1A0 (b) M1A1A1

1a	M1	Correct number of terms, condone sign errors
	A1	Correct equation in T only
	A1	cao
1b	M1	Correct number of terms, condone sign errors
	A1	Correct equation in R only
	A1	cao

Question	Scheme	Marks	AOs
2(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)**	
2(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)	
2(c)	e.g. The distance that Q falls to the ground would not be exactly h oe	B1	3.5b
		(1)	
2(d)	e.g. The accelerations of the balls would not have equal magnitude (allow 'wouldn't be the same' oe) B0 if they say 'inextensible => acceleration same'	B1	3.5a
		(1)	
			(13 marks)

Notes:		
2a	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
2b	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 3.4*h* or better
2c	B1	B0 if any incorrect extras are given
2d	B1	B0 if any incorrect extras are given or for an incorrect statement e.g. tension is not constant so accelerations will be different

Question	Scheme	Marks	AOs
3(a)	Equation of motion for P with usual rules	M1	3.3
	$4mg - T = 4ma$	A1	1.1b
	Equation of motion for Q with usual rules	M1	3.3
	$T - 3mg = 3ma$	A1	1.1b
	Solve these equations for T (does not need to be in terms of mg)	M1	1.1b
	$T = \frac{24mg}{7}$ in any form (does not need to be a single term)	A1	1.1b
	Force on pulley = $2T$	M1	3.4
	$\frac{48mg}{7}$ Accept $6.9mg$ or better	A1	1.1b
		(8)	
3(b)	Weight of the rope or extensibility of rope Or: pulley may not be smooth	B1	3.5b
		(1)	
			(9 marks)

Notes:

(a)	M1	Translate situation into the model and set up the equation of motion for P M0 if they omit m's i.e. $4g - T = 4a$
	A1	Correct equation
	M1	Translate situation into the model and set up the equation of motion for Q M0 if they omit m's i.e. $T - 3g = 3a$
	A1	Correct equation
		N.B. Condone either of the above equations being replaced by the 'whole system equation': $4mg - 3mg = 7ma$ (N.B. $a = g/7$) **N.B.** a replaced by $-a$ consistently can score all the marks
	M1	Solve equations for T
	A1	$T = \frac{24mg}{7}$ oe
	M1	T does not need to be substituted.
	A1	$\frac{48mg}{7}$ oe <u>Must be in terms of m and g</u> and be a single term
(b)	B1	B0 if any incorrect extras are given

Question	Scheme	Marks	AOs
4(a)	$v = 3t - 2t^2 + 14$ and differentiate	M1	3.1a
	$a = \frac{dv}{dt} = 3 - 4t$ or $(7 - 2t) - 2(t + 2)$ using product rule	A1	1.1b
	$3 - 4t = 0$ and solve for t	M1	1.1b
	$t = \frac{3}{4}$ oe	A1	1.1b
		(4)	
4(b)	Solve problem using $v = 0$ to find a value of t $\left(t = \frac{7}{2}\right)$	M1	3.1a
	$v = 3t - 2t^2 + 14$ and integrate	M1	1.1b
	$s = \frac{3t^2}{2} - \frac{2t^3}{3} + 14t$	A1	1.1b
	Substitute $t = \frac{7}{2}$ into their s expression (M0 if using *suvat*)	M1	1.1b
	$s = \frac{931}{24} = 38\frac{19}{24} = 38.79166..(\text{m})$ Accept 39 or better	A1	1.1b
		(5)	
			(9 marks)

Notes:		
(a)	M1	Multiply out and attempt to differentiate, with at least one power decreasing
	A1	Correct expression
	M1	Equate their a to 0 and solve for t
	A1	cao
(b)	M1	Uses $v = 0$ to obtain a value of t
	M1	Attempt to integrate, with at least one power increasing
	A1	Correct expression
	M1	Substitute in their value of t ,which must have come from using $v = 0$, into their s (must have integrated)
	A1	39 or better

N.B. Omission or extra g in a resolution is an accuracy error not a method error

In 2(a), use the mass which appears in the '*ma*' term of an equation of motion, to identify which particle that equation of motion applies to.

Question	Scheme	Marks	AOs	Notes
5(a)	Equation of motion for Q	M1	3.3	Equation of motion for Q with correct no. of terms, condone sign errors.
	$0.6g - T = 0.6a$	A1	1.1b	A correct equation
	Equation of motion for P	M1	3.3	Equation of motion for Q with correct no. of terms, condone sign errors.
	$T = 0.8a$	A1	1.1b	A correct equation
	$a = 4.2$ (m s^{-2}) *	A1*	2.2a	Given acceleration obtained correctly. **You must see an equation in a only before reaching $a = 4.2$**
		(5)		**N.B.** if they just use the whole system equation: $0.6g = 1.4a$, can only score max M1A1M0A0A0 **N.B**. Use of $g = 9.81$ or 10 loses final A mark only. **N.B.** Complete verification, using both equations, can score full marks.
(b)	$0.4 = \frac{1}{2} \times 4.2 \times t_1^2$ or e.g. they may find v first and then use $v = 4.2t_1$	M1	2.1	Complete method (they may use more than one *suvat* equation) to find time for Q to hit the floor (M0 if 0.4 **not** used as distance moved and/or if 4.2 is **not** used as acceleration and this applies to finding v as well if they use v to find t_1)
	$t_1 = 0.436$ (4357…..) Allow 0.43, 0.44, 0.436, or better, or any surd form e.g. $\frac{2}{\sqrt{21}}$	A1	1.1b	See alternatives
	$v = 4.2 \times t_1$ or $v = \sqrt{2 \times 4.2 \times 0.4}$ or $0.4 = \frac{(0+v)}{2} \times t_1$ ($v = 1.8330\ldots$)	M1	3.4	Complete method to find speed of Q as it hits the floor (M0 if 0.4 **not** used as distance moved and/or if 4.2 is **not** used as acceleration and this applies to finding t_1 as well if they use t_1 to find v)
	$t_2 = \frac{1.5 - 0.4}{v}$	M1	1.1b	Uses distance/speed to find time for P to hit the pulley after Q has hit the floor. N.B. This is independent of previous M mark.
	Complete strategy to solve the problem by finding the sum of the two times $t_1 + t_2$	**DM**1	3.1b	Complete method to solve the problem by finding and adding the two required times, dependent on previous three M marks
	1.0 (s) or 1.04 (s)	A1	1.1b	
		(6)		
(c)	e.g. rope being light; rope being inextensible; pulley being smooth; pulley being small; balls being particles	B1	3.5b	Clear statement. Allow negatives of these i.e. the rope may not be light, the rope may not be inextensible etc Must be a limitation of the model stated in the question Penalise incorrect or irrelevant extras
		(1)		B0 for: Air resistance, table being smooth
		(12 marks)		

Question	Scheme	Marks	AOs
6(a)	Equation of motion for P	M1	3.3
	$2mg - T = 2m \times \frac{5g}{7}$	A1	1.1b
	$T = \frac{4mg}{7}$	A1	1.1b
		(3)	
(b)	Since the string is modelled as being inextensible	B1	3.4
		(1)	
(c)	Equation of motion for Q **OR** for whole system	M1	3.3
	$T - kmg = km \times \frac{5g}{7}$ **OR** $2mg - kmg = (km + 2m)\frac{5g}{7}$	A1	1.1b
	$\frac{4mg}{7} - kmg = km \times \frac{5g}{7}$ oe and solve for k	DM1	1.1b
	$k = \frac{1}{3}$ or 0.333 or better	A1	1.1b
		(4)	
(d)	e.g The model does not take account of the mass of the string (see notes below for alternatives)	B1	3.5b
		(1)	
			(9 marks)

Notes: Condone both equations of motion appearing in (a) if used in (c)

(a)

M1: Resolving vertically for P with usual rules, correct no. of terms but condone sign errors and a does not need to be substituted (N.B. inconsistent omission of m is M0). Allow ma on RHS for M1

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

A1: A correct answer of form cmg, where $c = \frac{4}{7}$ oe or 0.57 or better

(b)

B1: String is inextensible. N.B. B0 if any extras (wrong or irrelevant) given

(c)

M1: Resolving vertically for Q or for a whole system equation, with usual rules, correct no. of terms but condone sign errors and neither T nor a does need to be substituted

(N.B. inconsistent omission of m is M0 and M0 if k is omitted from LHS or RHS or both.)

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

DM1: Sub for T using their answer from (a), if necessary, and solve to give a numerical value of k (i.e. m's must cancel)

A1: $k = \frac{1}{3}$ or 0.333 or better.

(d)

B1: e.g. Pulley may not be smooth
Pulley may not be light
Particles may not be moving freely e.g. air resistance
Balls may not be particles
String may not be light
String may not be inextensible
(but allow converses in all cases e.g. 'pulley smooth')

N.B. B0 if any extra incorrect answer is given BUT ignore incorrect consequence of a correct answer.

Also note: B0 : Use of a more accurate value of g

Question	Scheme	Marks	AOs
7(a)(i)	Equation of motion for P with usual rules	M1	3.3
	$T-1.5=0.4\times2.5$	A1	1.1b
	$T=2.5$ (N)	A1	1.1b
(ii)	Equation of motion for Q with usual rules	M1	3.3
	$10M-T=2.5M$	A1	1.1b
	$M=0.33$	A1	1.1b
		(6)	
(b)	$2=\frac{1}{2}\times2.5t^2$	M1	3.4
	$t=1.3$ (s)	A1	1.1b
		(2)	
(c)	e.g. the mass of the rope	B1	3.5b
		(1)	
			(9 marks)

Notes:

(a) (i)
M1: Resolve horizontally for P
A1: Correct equation
A1: Correct answer. Ignore units

(a)(ii)
M1: Resolve vertically for Q
A1: Correct equation
A1: Correct answer

(b)
M1: Use $s=ut+\frac{1}{2}at^2$
A1: 1.3. Ignore units

(c)
B1: e.g. the pulley may not be smooth,
air resistance

Question	Scheme	Marks	AOs
8(a)(i)	Equation of motion for A	M1	3.3
	$T - 12.7 = 2.5a$	A1	1.1b
(ii)	Equation of motion for B	M1	3.3
	$1.5g - T = 1.5a$	A1	1.1b
		(4)	
(b)	Solving two equations for a	M1	1.1b
	$a = 0.5$	A1	1.1b
		(2)	
(c)	$1 = \frac{1}{2} \leftarrow 0.5\, t^2$	M1	3.4
	$t = 2$ seconds	A1ft	1.1b
		(2)	
(d)	Valid improvement, see below in notes	B1	3.5c
	Valid improvement, see below in notes	B1	3.5c
		(2)	
			(10 marks)

Continued question 8
Notes:
(a)(i) **M1:** For resolving horizontally for A **A1:** For a correct equation
(a)(ii) **M1:** For resolving vertically for B **A1:** For a correct equation
(b) **M1:** For complete correct strategy for solving the problem, setting up **two** equations in a, and then solving them for a **A1:** For $a = 0.5$
(c) **M1:** For a complete method (which could involve use of more than one *suvat* formula) to give an equation in t only **A1:** Ft from their a to get time in seconds
(d) **B1, B1** for any two of e.g. Include the dimensions of the ball in the model so that the distance it falls changes e.g. Include the dimensions of the pulley in the model so string not parallel to table e.g. Include a variable resistance in the model instead of taking it to be constant e.g. Include a more accurate value for g in the model

Question	Scheme	Marks	AOs
9(a)(i)	Resolve vertically	M1	3.1b
	F acting UP the plane: **OR** F acting DOWN the plane: $(\uparrow) F\sin\alpha + 68.6\cos\alpha = 5g$ $\quad -F\sin\alpha + 68.6\cos\alpha = 5g$ Other possible equations from which X would need to be eliminated to give an equation in F **only** to earn the M mark are shown below. The equation in F **only** must then be correct to earn the A mark. Possible equations: $(\nwarrow) 68.6 = X\sin\alpha + 5g\cos\alpha$ (leads to $X = 49$ with $g = 9.8$) F acting UP the plane: **OR** F acting DOWN the plane: $(\nearrow) F + X\cos\alpha = 5g\sin\alpha$ $\quad -F + X\cos\alpha = 5g\sin\alpha$ $(\rightarrow) F\cos\alpha + X = 68.6\sin\alpha$ $\quad -F\cos\alpha + X = 68.6\sin\alpha$	A1	1.1b
	9.8 (N) (49/5 is A0) **N.B.** If sin and cos are interchanged in all equations, this leads to an answer of 9.8 in the wrong direction and can only score (a) (i)M1A0A0 (ii) A0	A1	1.1b
		(3)	
9(a)(ii)	Down the plane (Allow down or downwards or an arrow ↙, but must appear as the answer to (a) (ii) not just on the diagram.)	A1	2.2a
		(1)	
9(b)	**N.B.** If they use $R = 68.6$ in this part, the maximum they can score is M1A1M0A0M0A0 If they use $F = 9.8$ or their F from (a) in this part, the maximum they can score is M1A1M0A0M0A0		
	Equation of motion down the plane	M1	2.1
	$5g\sin\alpha - F = 5a$ Allow $(-a)$ instead of a	A1	1.1b
	Resolve perpendicular to the plane	M1	3.1b
	$R = 5g\cos\alpha$	A1	1.1b
	$F = 0.5R$ seen	M1	3.4
	$a = 1.96$ or 2.0 or 2 (m s^{-2}) or $\frac{1}{5}g$	A1	1.1b
		(6)	
			(10 marks)

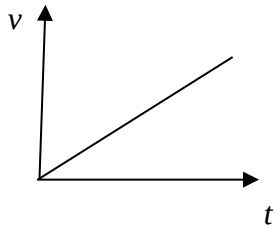
Notes:		
9a (i)	M1	Complete method to obtain an equation in F **only.** For **each** equation used, correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved.
	A1	Correct equation in F only, trig does **not** need to be substituted
	A1	cao (must be **positive**)
9a (ii)	A1	cao. Note that this mark is **dependen**t on an answer of 9.8 or -9.8 for (a)(i) from a fully correct solution unless they have used $g = 9.81$, in which case the answer will be 9.7 or – 9.7 (2sf) see **SC2** below. **N.B.** Allow this mark, if their answer to (a)(i) is fully correct apart from a small error due to use of inaccurate trig i.e using an angle 36.9^o
		SC 1: If they use μR at any point (with an unknown μ) for F in part (a), can score (a)(i) max M1A1A0 (a) (ii) A1, where they must have obtained $\mu R = 9.8$ or – 9.8, **from correct working**. **SC 2:** **If $g = 9.81$ is used consistently throughout 2(a)**, (leading to $X = 48.9\ldots$and $F = 9.7$ (2sf)) can score max (a)(i) M1A1A0 (a)(ii) A1
9b	M1	Correct no.of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved.
	A1	Correct equation **for their *F***.
	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved. (**N.B.** M0 if $R = 68.6$ (N) is used in this equation)
	A1	Correct equation
	M1	Could be seen on a diagram (**N.B**. M0 if $R = 68.6$ (N) is used)
	A1	Cao. **Must be positive**.

Question	Scheme	Marks	AOs
10(a)	$(4\mathbf{i}-\mathbf{j})+(\lambda\mathbf{i}+\mu\mathbf{j})=(4+\lambda)\mathbf{i}+(-1+\mu)\mathbf{j}$	M1	3.4
	Use **ratios** to obtain an equation in λ and μ *only*	M1	2.1
	$\dfrac{(4+\lambda)}{(-1+\mu)}=\dfrac{3}{1}$ or $\dfrac{\frac{1}{4}(4+\lambda)}{\frac{1}{4}(-1+\mu)}=\dfrac{3}{1}$	A1	1.1b
	$\lambda-3\mu+7=0$ * Allow $0=\lambda-3\mu+7$ but nothing else.	A1*	1.1b
		(4)	
(b)	$\lambda=2 \Rightarrow \mu=3$; Resultant force $=(6\mathbf{i}+2\mathbf{j})$ (N)	M1	3.1a
	$(6\mathbf{i}+2\mathbf{j})=4\mathbf{a}$ **OR** $\lvert(6\mathbf{i}+2\mathbf{j})\rvert=4a$	M1	1.1b
	Use of $\mathbf{r}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$ with $\mathbf{u}=\mathbf{0}$, their $\mathbf{a}$ and $t=4$: **Or** they may integrate their $\mathbf{a}$ twice with $\mathbf{u}=\mathbf{0}$ and put $t=4$: $\mathbf{r}=\frac{1}{2}\times\frac{(6\mathbf{i}+2\mathbf{j})}{4}4^2=(12\mathbf{i}+4\mathbf{j})$	DM1	2.1
	$\sqrt{12^2+4^2}$	M1	1.1b
	ALTERNATIVE 1 for last two M marks: Use of $s=ut+\frac{1}{2}at^2$, with $u=0$, their a and $t=4$: DM1 $s=\frac{1}{2}\times\sqrt{1.5^2+0.5^2}\times4^2$ Use of Pythagoras to find mag of $\mathbf{a}$: $a=\sqrt{1.5^2+0.5^2}$ M1		
	ALTERNATIVE 2 for last two M marks: Use of $s=ut+\frac{1}{2}at^2$, with $u=0$, their a and $t=4$: DM1 $s=\frac{1}{2}\times\left(\frac{\sqrt{6^2+2^2}}{4}\right)\times4^2$ Use of Pythagoras to find $\lvert(6\mathbf{i}+2\mathbf{j})\rvert$: $=\sqrt{6^2+2^2}$ M1		
	$\sqrt{160}$, $2\sqrt{40}$, $4\sqrt{10}$ oe or 13 or better (m)	A1	1.1b
		(5)	
			(9 marks)

Notes: Accept column vectors throughout

10a	M1	Adding the two forces, **i**'s and **j**'s must be collected (or must be a **single** column vector) seen or implied
	M1	Must be using ratios; Ignore an equation e.g. $(4+\lambda)\mathbf{i}+(-1+\mu)\mathbf{j}=3\mathbf{i}+\mathbf{j}$ if they go on to use ratios.

		However, if they write $4+\lambda=3$ and $-1+\mu=1$ then $3(-1+\mu)=3$ so $4+\lambda=3(-1+\mu)$ with no use of a constant, it's M0 They may use the acceleration, with a factor of $\frac{1}{4}$ top and bottom, see alternative **Allow one side of the equation to be inverted**
	A1	Correct equation
	A1*	Given answer correctly obtained. Must see at least one line of working, with the LH fraction 'removed'**.**
10b	M1	Adding $\mathbf{F}_1$ and $\mathbf{F}_2$ to find the resultant force, λ and μ must be substituted **N.B.** M0 if they use $\mu=2$ coming from $-1+\mu=1$ in part (a).
	M1	Use of $\mathbf{F}=4\mathbf{a}$ Or $\lvert\mathbf{F}\rvert=4a$, where **F** is <u>their</u> resultant. (including $3\mathbf{i}+\mathbf{j}$) This is an independent mark, so could be earned, for example, if they have subtracted the forces to find the 'resultant' **N.B.** M0 if only using $\mathbf{F}_1$ or $\mathbf{F}_2$
	DM 1	Dependent on previous M mark for **Either**: use of $\mathbf{r}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$ with **u** = **0**, their **a** and $t=4$ to produce a displacement vector **Or** : integrate twice, with **u** = **0**, their **a** and $t=4$ to produce a displacement Vector **Or**: use of $s=ut+\frac{1}{2}at^2$ with $u=0$, their a and $t=4$ to produce a length
	M1	Use of Pythagoras, with square root, to find the magnitude of their displacement vector, **a** or **F (**M0 if only using $\mathbf{F}_1$ or $\mathbf{F}_2$) depending on which method they have used.
	A1	cao

Question	Scheme	Marks	AOs
	Mark parts (a) and (b) together		
11(a)	Equation of motion for A	M1	3.3
	$3mg\sin\alpha - F - T = 3ma$	A1	1.1b
		(2)	
11(b)	Resolve perpendicular to the plane	M1	3.4
	$R = 3mg\cos\alpha$	A1	1.1b
	$F = \frac{1}{6}R$	B1	1.2
	Equation of motion for B **OR** for whole system	M1	3.3
	$T - mg = ma$ **OR** $3mg\sin\alpha - F - mg = 3ma + ma$	A1	1.1b
	Complete method to solve for a	DM1	3.1b
	$a = \frac{1}{10}g$ *	A1*	2.2a
		(7)	
11(c)		B1	1.1b
	e.g. acceleration (of B) is constant; dependent on first B1	DB1	2.4
		(2)	
11(d)	e.g. the tensions in the two equations of motion would be different. Tension on A would be different to tension on B	B1	3.5a
		(1)	
			(12 marks)

Notes: **N.B.** If m's are consistently missing treat as a MR, so max
(a) M1A0 (b) M1A0B0M1A1M1A1 (c) B1B1 (d) B1

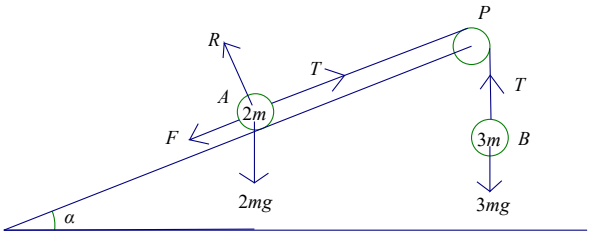
For (a) and (b), allow verification, but must see full equations of motion.

11a	M1	Equation in T and a with correct no. of terms, condone sign errors and sin/cos confusion (If one of the 3's is missing, allow M1) N.B. Treat sin(3/5) etc as an A error but allow recovery
	A1	Correct equation (allow $(-a)$ instead of a in <u>both</u> equations)

11b	M1	Correct no. of terms, condone sign errors and sin/cos confusion Allow if appears in (a)
	A1	Correct equation
	B1	Seen anywhere in (a) or (b), including on a diagram
	M1	Equation (for B) in T and a with correct no. of terms, condone sign errors and sin/cos confusion **OR Whole system equation** with correct no. of terms, condone sign errors and sin/cos confusion
	A1	Correct equation
	DM1	Complete method (trig may not be substituted), dependent on M1 in (a) and second M1 in (b) if they use two equations, or second M1 in (b) if they use one equation.
	A1*	Correct answer correctly obtained.
11c	B1	Straight line starting at the origin (could be reflected in the t-axis). B0 if continuous vertical line at the end.
	DB1	Dependent on first B1, for any equivalent statement
11d	B1	B0 if incorrect extras

Question	Scheme	Marks	AOs
12(a)	Resolve perpendicular to the plane	M1	3.4
	$R = mg\cos\alpha = \frac{4}{5}mg$	A1	1.1b
		(2)	
12(b)	Resolve parallel to the plane or horizontally or vertically	M1	3.4
	$F = mg\sin\alpha$ or $R\sin\alpha = F\cos\alpha$	A1	1.1b
	Use $F = \mu R$ and solve for μ	M1	2.1
	$\mu = \frac{3}{4}$*	A1*	2.2a
		(4)	
12(c)	The forces acting on *Q* will still balance as the *m*'s cancel oe Other possibilities: e.g. the friction will increase in the same proportion as the weight component or force down the plane. The force pulling the brick down the plane increases by the same amount as the friction oe This mark can be scored if they do the calculation.	B1	2.4
		(1)	
12(d)	Brick *Q* slides down the plane with **constant** speed.	B1	2.4
	No resultant force down the plane (so no acceleration) oe	B1	2.4
	These marks can be scored if they do the calculation.	**(2)**	
			(9 marks)

Notes:		
12a	M1	Correct no. of terms, condone sin/cos confusion
	A1	cao with no wrong working seen. *mg*cos36.86 is A0
12b	M1	Correct no. of terms, condone sin/cos confusion
	A1	Correct equation
	M1	Must use $F = \mu R$ (not merely state it) to obtain a numerical value for μ. This is an independent M mark.
	A1*	Given answer correctly obtained
12c	B1	Must have the 3 underlined phrases/word oe
12d	B1	Must say **constant** speed.
	B1	Any appropriate equivalent statement

Question	Scheme	Marks	AO
13(a)			
	$R = 2mg\cos\alpha$	B1	3.4
	$F = \frac{2}{3}R$	B1	1.2
	Equation of motion for A:	M1	3.3
	$T - F - 2mg\sin\alpha = 2ma$	A1	1.1b
	Equation of motion for B:	M1	3.3
	$3mg - T = 3ma$	A1	1.1b
	Complete strategy to find an equation in T, m and g only.	M1	3.1b
	$T = \frac{12mg}{5}$ *	A1*	2.2a
		(8)	
(b)	$(F_{\max} =)\frac{16mg}{13} > \frac{10mg}{13}$	M1	2.1
	…… so A will not move.	A1	2.2a
		(2)	
(c)	• Extensible string • Weight of string • Friction at pulley e.g. rough pulley • Allow for the dimensions of the blocks e.g. "Do not model blocks as particles"; "(include) air resistance";"include rotational effects of forces on blocks i.e. spin"	B1 B1	3.5c 3.5c
		(2)	
		(12)	

Marks		Notes
13a	B1	Normal reaction between A and the plane seen or implied, $\cos\alpha$ does not need to be substituted.
	B1	$F = \frac{2}{3}R$ seen or implied anywhere, including part (b)
	M1	Form an equation of motion for A. Must include all relevant terms. Must be the correct mass but condone consistent missing m's. Condone sign errors and sin/cos confusion
	A1	Correct unsimplified equation (F does not need to be substituted). Allow consistent use of $(-a)$ **N.B**. If $T - 2mg = 2ma$ is seen with no working, M0A0 unless both B1 marks have been scored.
	M1	Form an equation of motion for B. Must be the correct mass on RHS but condone consistent missing m's. Condone sign errors and sin/cos confusion.
	A1	Correct unsimplified equation (F does not need to be substituted). Allow consistent use of $(-a)$
		N.B. Allow the 'whole system' equation to replace the equation for A or B. $3mg - F - 2mg\sin\alpha = 5ma$ Must be the correct mass on RHS but condone consistent missing m's. Condone sign errors and sin/cos confusion.
	M1	Complete method to give an equation in T, m and g only. **N.B.** Allow θ in the equation if they have defined what θ is: e.g. $\theta = \tan^{-1}(\frac{5}{12})$ This is an <u>independent</u> mark but they must have two simultaneous equations in T and a unless one of the equations is the whole system equation in which case one equation will be in T and a and the other equation will be in a only.
	A1*	Obtain the **given answer** from correct working using EXACT trig ratios. (not available if using a decimal angle)
13b	M1	Comparison of their F_{max} ($\frac{2}{3}R$) and their component of weight down the slope, must be comparing numerical values. oe e.g. if they consider the difference **N.B.** Allow comparison of μ and $\tan\alpha$ with numerical values
	A1	Correctly justified conclusion and no errors seen **N.B.** If they equate their difference to an 'ma' term then A0
13c	B1 B1	Deduct 1 mark for each extra (more than 2) incorrect answer up to a maximum of 2 incorrect answers. Ignore extra correct answers. e.g. two correct, one incorrect B1 B0 one correct, one incorrect B1 B0 one correct, two incorrect B0 B0 Ignore incorrect reasons or consequences. Ignore any mention of wind or a general reference to friction.

Question	Scheme	Marks	AOs
14(a)	Resolve vertically	M1	3.1b
	$R + 40\sin\alpha = 20g$	A1	1.1b
	Resolve horizontally	M1	3.1b
	$40\cos\alpha - F = 20a$	A1	1.1b
	$F = 0.14R$	B1	1.2
	$a = 0.396$ or 0.40 (m s^{-2})	A1	2.2a
		(6)	
(b)	Pushing will increase R which will increase available F	B1	2.4
	Increasing F will decrease a * GIVEN ANSWER	B1*	2.4
		(2)	
			(8 marks)

Notes:

(a)

M1: Resolve vertically with usual rules applying

A1: Correct equation**.** Neither g nor $\sin a$ need to be substituted

M1: Apply $F = ma$ horizontally, with usual rules

A1: Neither F nor $\cos a$ need to be substituted

B1: $F = 0.14R$ seen (e.g. on a diagram)

A1: Either answer

(b)

B1: Pushing increases R which produces an increase in available (limiting) friction

B1: F increase produces an a decrease (need to see this)

N.B. It is possible to score B0 B1 but for the B1, some "explanation" is needed to say why friction is increased e.g. by pushing into the ground.

Question	Scheme	Marks	AOs
15	Differentiate wrt t	M1	1.1a
	$\mathbf{a} = (2t - 3)\,\mathbf{i} - 12\,\mathbf{j}$	A1	1.1b
	$(2t - 3)^2 + (-12)^2$	M1	1.1b
	$(2t - 3)^2 + (-12)^2 = (6.5 / 0.5)^2$ oe	M1	2.1
	$4t^2 - 12t - 16 = 0$	A1	1.1b
	$(t - 4)(t + 1) = 0$	M1	1.1b
	$t = 4$	A1	1.1b
		(7)	
			(7 marks)

Notes:

M1: At least one power going down
A1: A correct expression
M1: Sum of squares of components (with or without square root) of **a** or **F**
M1: Equating magnitude to 6.5/0.5 or 6.5 as appropriate and squaring both sides
A1: Correct quadratic = 0 in any form
M1: Attempt to solve a 3 term quadratic
A1: 4

Question	Scheme	Marks	AOs
16(a)	Resolve perp to the plane	M1	3.1b
	$R + 25\sin30^o = 3g\cos20^o$	A1	1.1b
	Equation of motion up the plane	M1	3.1b
	$25\cos30^o - 3g\sin20^o - F = 3a$	A1	1.1b
	$F = 0.3R$	B1	1.2
	Correct strategy: sub for F and solve for a	M1	3.1b
	$a = 2.4$ or 2.35 (m s^{-2})	A1	2.2a
		(7)	
(b)	e.g. Include air resistance	B1	3.5c
		(1)	
(c)	$R = 3g\cos20^o$ so $F\max = 0.9\, g\cos20^o$	B1	3.1b
	Consider $3g\sin20^o - 0.9g\cos20^o$	M1	2.1
	Since > 0 , box moves down plane. *	A1*	2.2a
		(3)	
			(11 marks)

Notes:

(a)
M1: Using an appropriate strategy to set up first of two equations, with usual rules applying
A1: g does not need to be substituted
M1: Using an appropriate strategy to set up second of two equations, with usual rules applying
A1: Neither g nor F need to be substituted (-1 each error)
B1: $F = 0.3R$ seen
M1: Correct overall strategy to solve problem by substituting for F and solving for a
A1: Only possible answers, since g = 9.8 used.

(b)
B1: e.g. include air resistance, allow for the weight of the rope

(c)
B1: Correct overall strategy (First equation could be implied)
M1: Must be difference or a comparison of the two values
A1*: Given answer

Question	Scheme	Marks	AOs
17(a)	$R = mg\cos\alpha$	B1	3.1b
	Resolve parallel to the plane	M1	3.1b
	$-F - mg\sin\alpha = -0.8mg$	A1	1.1b
	$F = \mu R$	M1	1.2
	Produce an equation in μ only and solve for μ	M1	2.2a
	$\mu = \frac{1}{4}$	A1	1.1b
		(6)	
(b)	Compare $\mu mg\cos\alpha$ with $mg\sin\alpha$	M1	3.1b
	Deduce an appropriate conclusion	A1 **ft**	2.2a
		(2)	
			(8 marks)

Notes:

(a)

B1: for $R = mg\cos\alpha$

1st M1: for resolving parallel to the plane

1st A1: for a correct equation

2nd M1: for use of $F = \mu R$

3rd M1: for eliminating F and R to give a value for μ

2nd A1: for $\mu = \frac{1}{4}$

(b)

M1: comparing size of limiting friction with weight component down the plane

A1ft: for an appropriate conclusion from their values

Question Number	Scheme	Marks
18.	(Parallel to plane): $P\cos 50 + F = 2g\cos 60$	M1 A2
	(Perp to plane): $R - P\sin 50 = 2g\cos 30$	M1 A2
	Other possible equations:	
	$(\rightarrow): R\cos 60 - F\cos 30 = P\cos 20$ M1 A2	
	$(\uparrow): R\cos 30 + F\cos 60 = P\cos 70 + 2g$ M1 A2	
	$F = \frac{1}{4}R$	B1
	Attempt to eliminate F and R to give an equation in P only	M1
	Solve for P	**DM**1
	P = 6.7 (2 SF) or 6.66 (3SF)	A1
		(10)
	Notes for Qu 18	
	First M1 for resolving parallel to the plane with usual rules. $2g$ term must be using 30° or 60° angle but allow sin/cos confusion. First and second A1's for a correct equation. A1A0 if one error. Second M1 for resolving perpendicular to the plane with usual rules. $2g$ term must be using 30° or 60° angle but allow sin/cos confusion. Third and fourth A1's for a correct equation. A1A0 if one error. B1 for F = ¼ R seen or implied Third M1, independent but must have two 3 (or 4) term equations, for attempt to eliminate F and R to give an equation in P only. Fourth DM1, dependent on third M1, for solving for P. Fifth A1 for 6.7 or 6.66 **Other possible equations**: First M1 for resolving horizontally with usual rules. R term must be using 30° or 60° angle and F term must be using 30° or 60° angle but allow sin/cos confusion. First and second A1's for a correct equation. A1A0 if one error. Second M1 for resolving vertically with usual rules. R term must be using 30° or 60° angle and F term must be using 30° or 60° angle but allow sin/cos confusion. Third and fourth A1's for a correct equation. A1A0 if one error.	

Question Number	Scheme	Marks
19(a)	$R - 60g = 60 \text{ x } 2$	M1A1
	$R = 708$ N or 710 N (must be positive)	A1 (3)
19(b)	$75n$	B1
	$10000 - Mg - 100 = M \times 3$	M1A2
	using $M = 250 + 75n \Rightarrow n = 6.9..$	**DM1**A1
	so 6 people	A1**ft** (7)
		(10)
	Notes for Qu 19	
	19(a) M1 for equation in R only, with usual rules First A1 for a correct equation Second A1 for 710 or 708 (N not needed)	
	19(b) B1 for $75n$ oe seen or implied First M1 for an equation in one unknown in the form $10000 - Mg - 100 = M \times a$ with usual rules (must be using 10000) where M can be any (relevant) number e.g. 250, 75, etc First A1 and second A1 for a correct equation with $a = 3$, A1A0 if one error (e.g. Use of $a = 2$ loses 1 A mark) Second **DM1**, dependent on first M1, for using $M = 250 + 75n$ and solving for n Third A1 for 6.9… (A0 for 7) Fourth A1**ft** for no. of people, ft on their n value (A0 for < 7) **N.B.** If no incorrect work seen, the third A mark can be implied by a correct answer ($n = 6$) **SC:** They may use Trial and Error to find the critical value of n, by writing down equations for the tension when n =1, 2, 3,…. until the tension exceeds 10000 oe This method can score the final DM1 A1 A1 if done fully correctly up to and including $n = 7$, with a correct answer given. It could also score some or all of the first 4 marks.	

Question Number	Scheme	Marks
20.(a)	$(4\mathbf{i}-6\mathbf{j})+(p\mathbf{i}+q\mathbf{j})=(4+p)\mathbf{i}+(q-6)\mathbf{j}$	M1
	$\frac{(4+p)}{(q-6)}=\frac{2}{1}$ or $-\frac{2}{1}$ **(or** $\frac{1}{2}$ or $-\frac{1}{2}$**)**	**DM**1 A1
	$2q-12=4+p$	
	$p-2q=-16$ GIVEN ANSWER	**DM**1 A1 (5)
(b)	$q=3 \Rightarrow p=-10$	B1
	EITHER $0.5\mathbf{a}=-6\mathbf{i}-3\mathbf{j}$ **OR** $\lvert\mathbf{R}\rvert=\sqrt{(-6)^2+(-3)^2}$	M1
	$\mathbf{a}=-12\mathbf{i}-6\mathbf{j}$ $=\sqrt{45}$ oe	A1
	$\lvert\mathbf{a}\rvert=\sqrt{(-12)^2+(-6)^2}$ $0.5a=\sqrt{45}$	M1
	$a=\sqrt{180}=13.4\text{ms}^{-2}$ $a=\sqrt{180}=13.4\text{ms}^{-2}$	A1 (5)
(c)	e.g. $\tan\theta=\frac{12}{6}\Rightarrow\theta=63.4^\circ$	M1A1
	Bearing $=180^\circ+63.4^\circ=243^\circ$ (nearest degree)	A1cao (3)
		(13)
	Notes for Qu 20	
	Allow column vectors throughout	
	20(a) First M1 for adding the two forces, with **i's** and **j**'s collected, seen or implied Second DM1, dependent on first M1, for an equation in p and q only. Allow $\frac{1}{2}$ or -$\frac{1}{2}$ or -$\frac{2}{1}$ instead of $\frac{2}{1}$ First A1 for a correct equation in any form Third DM1, dependent on the second M1, for (at least)one **correct** intermediate line of working Second A1 for correct **given answer**	
	20(b) B1 for $p=-10$ seen or implied **EITHER** First M1 for use of $\mathbf{F}=0.5\mathbf{a}$ with their <u>resultant force (must be a sum of the two forces)</u> First A1 for $\mathbf{a}=-12\mathbf{i}-6\mathbf{j}$ Second M1 (independent) for finding magnitude of their **a** Second A1 for $\sqrt{180}$ oe or 13.4 or better	

	OR First M1 for finding the magnitude of their resultant force **R** (must be a sum of the two forces) $R = \sqrt{(-6)^2 + (-3)^2}$ First A1 for $\sqrt{45}$ oe Second M1 for using $R = 0.5a$ to find a Second A1 for $a = 2\sqrt{45}$ oe 13.4 ms^{-2} or better	
	20(c) M1 for use of a relevant trig ratio from their **a** or their **R (may not be the sum of the two forces) or** $-2\mathbf{i} - \mathbf{j}$ First A1 for any relevant correct angle coming from a correct **a** or **R** or from $-2\mathbf{i} - \mathbf{j}$ Second A1 for 243	

Question Number	Scheme	Marks
21(a)	Inextensible string	B1 (1)
	MARK PARTS (b) and (c) together	
(b)	$4mg\sin\alpha - T - F = 4ma$	M1 A2
	$T - mg = ma$	M1 A1 (5)
(c)	$F = \frac{1}{4}R$	B1
	$R = 4mg\cos\alpha$	B1
	$\cos\alpha = \frac{4}{5}$ or $\sin\alpha = \frac{3}{5}$	B1
	Eliminating R, F and T	M1
	$a = \frac{3}{25}g = 1.2$ or $1.18\ (\text{m s}^{-2})$	A1 (5)
(d)	$v^2 = 2\times\frac{3}{25}gh = \frac{6}{25}gh$	M1
	$0^2 = \frac{6}{25}gh - 2gs$	
	$s = \frac{3}{25}h$	M1 A1
	$d > \frac{3}{25}h + h = \frac{28}{25}h$ GIVEN ANSWER	**DM**1 A1 (5)
		(16)
	Notes for Qu 21	
	21(a) B1 for inextensible (and taut) string; B0 if any extras given or if an incorrect consequence of the inextensiblity of the string is given.	
	MARK PARTS (b) and (c) together **21(b)** **N.B.** Omission of *m* is a Method error i.e. M0 for that equation First M1 for equation of motion for *P* with usual rules (omission of 4 on RHS is M0) First A1 and second A1 for a correct equation, A1A0 if one error Second M1 for equation of motion for *Q* with usual rules Third A1 for a correct equation Use of e.g cos(4/5) instead of $\cos\alpha$ is an A error unless they recover correctly. N.B. Allow consistent use of $-a$	
	21(c) First B1 for $F = \frac{1}{4}R$ seen or implied Second B1 for $R = 4mg\cos\alpha$ seen or implied Third B1 for $\cos\alpha = \frac{4}{5}$ or $\sin\alpha = \frac{3}{5}$ seen or implied or an appropriate correct angle is used to give a correct trig ratio First M1 for eliminating *R*, *F* and *T* and finding an *a* value First A1 $a = \frac{3}{25}g = 1.2$ or $1.18\ (\text{m s}^{-2})$ (must be positive)	

	21(d) First M1 for finding v or v^2 for P using their a (M0 if g is used) Second M1 for a complete method to find s, independent but must have found v or v^2 (M0 if g not used) First A1 for $s = \frac{3}{25}h$ oe Third DM1, dependent on previous two M's, for adding h onto their s oe Second A1 for GIVEN ANSWER	

Question Number	Scheme	Marks
22	$(15\mathbf{i}+\mathbf{j})+(5q\mathbf{i}-p\mathbf{j})+(-3p\mathbf{i}-q\mathbf{j})=\mathbf{0}$ $3p-5q=15$ $p+q=1$ $p=2.5 \quad q=-1.5$	M1 M1 A1 M1 A1 A1 **6**
	Notes	
	First M1 for equating the sum of the three forces to zero (can be implied by subsequent working) Second M1 for equating the sum of the **i** components to zero AND the sum of the **j** components to zero oe to produce TWO equations, each one being in p and q ONLY. First A1 for TWO correct equations (in any form) **N.B.** It is possible to obtain TWO equations by using $\lambda(3p-5q-15)=\mu(p+q-1)$ with TWO different pairs of values for λ and μ, with one pair not a multiple of the other e.g $\lambda=1$, $\mu=1$ AND $\lambda=1$, $\mu=2$. Third M1(independent) for attempt (either by substitution or elimination) to produce an equation in either p ONLY or q ONLY. Second A1 for $p = 2.5$ (any equivalent form, fractions do not need to be in lowest terms) Third A1 for $q = -1.5$ (any equivalent form, fractions do not need to be in lowest terms)	

Question Number	Scheme	Marks
23	$F = \mu R$ $(\nwarrow)$, $R = 10\sin\alpha + 5g\cos\alpha$ (45.2) $(\nearrow)$, $F = 5g\sin\alpha - 10\cos\alpha$ (21.4) $\mu = \dfrac{g\sin\alpha - 2\cos\alpha}{2\sin\alpha + g\cos\alpha} = 0.47$ or 0.473	B1 M1 A2 M1 A2 M1 A1 **9**
	Notes	
	B1 for $F = \mu R$ seen or implied First M1 for resolving perpendicular to the plane with usual rules First and second A1's for a correct equation. A1A0 if one error. Second M1 for resolving parallel to the plane with usual rules Third and fourth A1's for a correct equation. A1A0 if one error. If m is used instead of 5, penalise once in each equation. Third M1 <u>independent</u> for eliminating R to produce an equation in μ only. Does not need to be $\mu =$ …. Fifth A1 for 0.47 or 0.473.	

Question Number	Scheme	Marks
24	$T - 0.5g = 0.5a$ $15 - T - 0.75g = 0.75a$ (OR: $15 - 0.5g - 0.75g = 1.25a$) $(a = 2.2 \text{ m s}^{-2})$ $T = 6 \text{ N}$	M1 A1 M1 A1 M1 A1 **6**
	Notes	
	First M1 for an equation of motion for either *P* or *Q* with usual rules i.e. correct no. of terms, dimensionally correct but condone sign errors First A1 for a correct equation (allow *T* replaced by – *T* and/or *a* replaced by –*a*) Second M1 for another equation of motion (for either *P* or *Q* or whole system) with usual rules as above Second A1 for a correct equation (allow *T* consistently replaced by – *T* and/or *a* consistently replaced by –*a*) Third M1 for solving two THREE term equations of **motion** for *T* Third A1 for 6 (N). Must be positive but allow a change from – 6 to 6, if they have consistently used -*T* instead of *T*.	

Question Number	Scheme	Marks
25(a) **(i)** **(ii)**	For A : $T - F = 2ma$ For B : $mg - T = ma$	M1 A1 M1 A1 (4)
(b)	$R = 2mg$ $mg(1-2\mu) = 3ma$ $\frac{g}{3}(1-2\mu) = a$	B1 M1 A1 (3)
(c)	$v^2 = \frac{2gh}{3}(1-2\mu)$ $v = \sqrt{\frac{2gh}{3}(1-2\mu)}$	M1 A1 (2)
(d)	$-\mu R = 2ma$ ¢ $0^2 = \text{their } u^2 - 2a$ ¢s $0 = \frac{2gh}{3}(1-\frac{2}{3}) - 2(\frac{1}{3}g)s$ (or $s = (d-h)$) $s = \frac{1}{3}h$ $d = \frac{1}{3}h + h = \frac{4}{3}h$	M1 M1 A1 (A1) A1 A1 (5)
(e)	A (or B) would not move; **OR** A (or B) would remain in (limiting) equilibrium; **OR** the system would remain in (limiting) equilibrium	B1 (1) **15**

	Notes	
25(a)(i) **(ii)**	First M1 for equation of motion for A with usual rules First A1 for a correct equation (allow $-T$ instead of T) Second M1 for equation of motion for B with usual rules Second A1 for a correct equation (allow consistent $-T$ instead of T)	
25(b)	B1 for $R = 2mg$ M1 for using $F = \mu R$ and eliminating to give equation in a and μ only. A1 for PRINTED ANSWER (Must be identical to printed answer)	
25(c)	M1 for using $v^2 = u^2 + 2as$ or any other complete method to find the speed of A A1 for correct answer in any form	
25(d)	First M1 for equation of motion for A with $T = 0$ and $F = \mu R$ e.g. $\mu R = 2ma$ (must be $2m$) Second M1 for using $v^2 = u^2 + 2as$ with their u^2 from (c), $v = 0$ and a **new** a (does **not** need to be substituted) First A1 for a correct equation in s, g and h with $\mu = {}^1/_3$ Second A1 for $s = {}^1/_3\, h$ Third A1 for $d = {}^4/_3\, h$ **ALTERNATIVE** using work-energy principle: M2 for $\mu Rs = \frac{1}{2}2mu^2$ (their u^2 from (c)) (M1 if they use m) First A1 for $\frac{1}{3}2mgs = \frac{1}{2}2m\frac{2gh}{3}$ ($1 - \frac{2}{3}$) Second A1 for $s = {}^1/_3\, h$ Third A1 for $d = {}^4/_3\, h$	
25(e)	B1 for any one of the alternatives listed above.	

Question Number	Scheme	Marks
26(a)	$T - 0.5g - 1.5g = 2 \times 0.5$ $T = 20.6$ (N) or 21 (N)	M1 A1 A1 (3)
(b)	$R - 1.5g = 1.5 \times 0.5$ Force = 15.5 (N) or 15 (N) OR: $T - R - 0.5g = 0.5 \times 0.5$ Force = 15.5 (N) or 15 (N)	M1 A1 A1 (3) **OR** M1 A1 A1 (3) **6**
	Notes	
26(a)	**N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered M1 is for an equation for whole system in T only, with usual rules First A1 for a correct equation Second A1 for 20.6 or 21	
26(b)	First M1 is for an equation for the brick only (1^{st} alternative) or for the scale pan only (2^{nd} alternative) with usual rules. First A1 for a correct equation (in the second alternative T does not need to be substituted) Second A1 for 15.5 or 15	
	N.B. If R is replaced by $-R$ in either equation, can score M1A1. This would lead to R = -15.5 or -15. The second A1 can then only be scored if the candidate explains why the –ve sign is being ignored.	

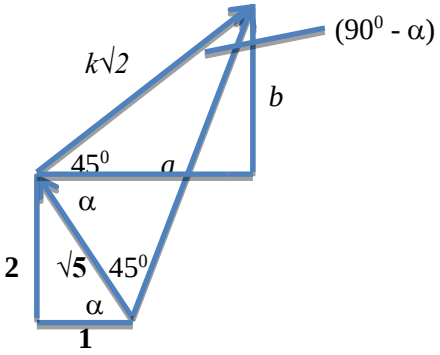
Question Number	Scheme	Marks
27.	mR $R = 2g\cos 20^\circ + 40\cos 60^\circ$ $F = 40\cos 30^\circ - 2g\cos 70^\circ$ $m = \dfrac{40\cos 30^\circ - 2g\cos 70^\circ}{2g\cos 20^\circ + 40\cos 60^\circ}$ $= 0.73$ or 0.727	B1 M1 A2 M1 A2 M1 M1 A1 **10**
	Notes	
27.	B1 for μR seen or implied.	
	First M1 for resolving perpendicular to the plane with usual rules (must be using $2(g)$ with 20^0 or 70^0 and 40 with 30^0 or 60^0)	
	First and second A1's for a correct equation. A1A0 if one error	
	Second M1 for resolving parallel to the plane with usual rules (must be using $2(g)$ with 20^0 or 70^0 and 40 with 30^0 or 60^0)	
	Third and fourth A1's for a correct equation. A1A0 if one error	
	Third M1 <u>independent</u> for eliminating R to produce an equation in μ only. Does not need to be $\mu =$ ….	
	Fourth M1 <u>independent</u> for solving for μ	
	Fifth A1 for 0.727 or 0.73	
	N.B. They may choose to resolve in 2 other directions e.g. horizontally and vertically.	
	N.B. If F is replaced by $-F$ in the second equ^n, treat this as an error unless they subsequently explain that they have their F acting in the wrong direction, in which case they could score full marks for the question.	

Question Number	Scheme	Marks
28(a)	$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ $(-1+a)\mathbf{i} + (2+b)\mathbf{j}$ $\frac{-1+a}{2+b} = \frac{1}{3}$ $a = b = k = 2.5;\ \mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$ **ALTERNATIVE:** $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ $(-1+a)\mathbf{i} + (2+b)\mathbf{j} = p(\mathbf{i} + 3\mathbf{j})$ $-1+a = p$ $2+b = 3p$ $a = b = k = 2.5;\ \mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$	B1 M1 **DM**1 A1 **DM**1 A1; A1 (7) B1 M1 for LHS **DM**1 A1 **DM**1 A1; A1 (7)
(b)	$\mathbf{v} = 3\mathbf{i} - 22\mathbf{j} + 3(3\mathbf{i} + 9\mathbf{j})$ $= 12\mathbf{i} + 5\mathbf{j}$ $\lvert\mathbf{v}\rvert = \sqrt{12^2 + 5^2} = 13\ \text{ms}^{-1}$	M1 A1 M1 A1 **cso** (4) **11**
	Notes	
28(a)	B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ $(k \neq 1)$ seen or implied in working, including for an incorrect final answer, with the wrong k value. First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with **i**'s and **j**'s collected (which can be implied by later working) but allow a slip. (M0 if a and b both assumed to be 1) Second M1, dependent on first M1, for ratio of their cpts = 1/3 or 3/1 (Must be correct way up for the M mark) First A1 for a correct equation which may involve two unknowns Third M1, dependent on first and second M1, for solving for k oe Second A1 for a correct k value Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$	

ALTERNATIVE: Using two simultaneous equations

B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ ($k \neq 1$) seen or implied in working.
First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with **i**'s and **j**'s collected (LHS of equation) (M0 if *a* and *b* both assumed to be 1) but allow a slip
Second M1, dependent on first M1, for equating coeffs to produce *two* equations in 2 or 3 unknowns. Must have *p* and 3*p* (M0 if *p* is assumed to be 1 or *k*)
First A1 for two correct equations
Third M1, dependent on first and second M1, for solving for *k* oe
Second A1 for a correct k value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

ALTERNATIVE: Using magnitudes and directions



$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$, seen or implied — B1
Correct vector triangle — M1

$\frac{k\sqrt{2}}{\sin 45^0} = \frac{\sqrt{5}}{\sin(90^0 - a)}$, a = arctan2 — **DM**1 A1

$2k = 5$

$k = 2.5$; $\mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$ — **DM**1 A1; A1 (7)

ALTERNATIVE: Using magnitudes and directions
B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ seen or implied in working.
First M1 for a correct vector triangle (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$). (M0 if *a* and *b* both assumed to be 1 and/or longest side is assumed to be √10)
Second M1, dependent on first M1, for using sine rule on vector triangle
First A1 for a correct equation. 45^0 may not appear exactly.
Third M1, dependent on first and second M1, for solving for *k* oe
Second A1 for a correct *k* value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

(b)	First M1 for use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ with $t = 3$ First A1 for $12\mathbf{i} + 5\mathbf{j}$ seen or implied. However, if a wrong **v** is seen A0 Second M1 for finding magnitude of their **v** Second A1 for 13	

Question Number	Scheme	Marks
29(a)	$F = \frac{1}{5}R$ $R = 1.5g$ $T - F = 1.5a$ $3g - T = 3a$ $T = 1.2g$ or 11.8 N or 12 N	M1 B1 M1 A1 M1 A1 **DM1** A1 (8)
(b)	$R = \sqrt{T^2 + T^2}$ or $2T\cos 45^0$ or $\frac{T}{\cos 45^0}$ $= 16.6$ (N) or 17(N) or $\frac{6g\sqrt{2}}{5}$ Direction is 45^o below the horizontal oe	M1 A1 A1 B1 (4) **12**
	Notes	
29(a)	First M1 for *use of* $F = \frac{1}{5}R$ in an equation. B1 for $R = 1.5g$ Second M1 for resolving horizontally with usual rules First A1 for a correct equation Third M1 for resolving vertically with usual rules Second A1 for a correct equation **N.B.** Either of the above could be replaced by a *whole system* equation: $3g - F = 4.5a$ **N.B.** All of the marks for the two equations can be scored if they consistently use $-a$ instead of a. Fourth M1 dependent on first, second and third M marks for solving their equations for T Third A1 for 1.2g, 11.8 (N) or 12 (N)	
(b)	First M1 for a complete method for finding the magnitude of the resultant (**N.B.** M0 if different tensions used), First A1 for $\sqrt{T^2 + T^2}$ or $2T\cos 45^o$ Second A1 for 16.6(N) or 17 (N) B1 for 45^o below the horizontal or a diagram with an arrow and a correct angle. Ignore subsequent wrong answers e.g. a bearing of 225^0, which scores B0, as does SW etc.	

Question Number	Scheme	Marks
30	$T_P \cos 55 = T_Q \cos 35$ $T_P \sin 55 + T_Q \sin 35 = 2g$ Eliminating T_P or T_Q $T_P = 16\text{N or } 16.1\text{N};\ T_Q = 11\text{N or } 11.2\text{N}$	M1 A1 M1 A1 M1 A1 A1 **7**
ALT 1	$\left(\text{Along } RP\right)\ T_P = 2g\cos 35° = 16\text{N or } 16.1\text{N}$ $\left(\text{Along } RQ\right)\ T_Q = 2g\cos 55° = 11\text{N or } 11.2\text{N}$	M1 M1 A1 A1 M1 A1 A1
	Notes	
	First M1 for resolving horizontally with correct no. of terms and both T_P and T_Q terms resolved. (M0 if they assume $T_P = T_Q$) First A1 for a correct equation. Second M1 for resolving vertically with correct no. of terms and both T_P and T_Q terms resolved. (M0 if they assume $T_P = T_Q$) Second A1 for a correct equation. Third M1 (independent) for eliminating either T_P or T_Q Third A1 for T_P = 16 (N) or 16.1 (N) Fourth A1 for T_Q = 11 (N) or 11.2 (N) N.B. If both are given to more than 3SF, deduct the third A1.	
ALT 1	**Alternative 1 (resolving along each string)** First M2 for resolving along one of the strings (e.g. $T_P = 2g\cos 35^o$) First A1 for a correct equation ($T_P = 2g\sin 35^o$ scores M2A0A0) Third A1 for T_P = 16 (N) or 16.1 (N) Third M1 for resolving along the other string (e.g. $T_Q = 2g\cos 55^o$) Second A1 for a correct equation ($T_Q = 2g\sin 55^o$ scores M1A0A0) Fourth A1 for T_Q = 11 (N) or 11.2 (N)	
ALT 2	**Alternative 2 (using a Triangle of Forces)** Both of the equations in Alternative 1 could come from using *sohcahtoa* or The Sine Rule on a triangle of forces, so mark in the same way. Note that, in either case, once they have found either T_P or T_Q , they could then use $T_P = T_Q \tan 55^o$ or $T_Q = T_P \tan 55^o$ to find the other one. (Note that both of these are equivalent to the horizontal resolution) or Pythagoras. e.g. $T_P = 2g\cos 35^o$ M2 First A1 = 16 (N) or 16.1 (N) Third A1 $T_Q = T_P \tan 35^o$ or $\sqrt{\{(2g)^2 - (T_P)^2\}}$ M1 Second A1 = 11 (N) or 11.2 (N) Fourth A1	

	N.B. If they are clearly using The Sine Rule but have say 35^o, 55^o and 80^o in their triangle, all 3 M marks would be available and at most 1 A mark e.g. $T_P = \frac{2g\sin 55}{\sin 80}$ M2 A0A0 $T_Q = \frac{T_P \sin 35}{\sin 55}$ M1 SecondA1 A0	

Question Number	Scheme	Marks
31(a)	For crate, $55g - 473 = 55a$ $a = 1.2\text{m s}^{-2}$	M1 A1 A1 (3)
(b)	For system, $55g + 200g \pm T - 150 = 255a$ Magnitude $= 2040$ N or 2000 N OR For lift, $200g + 473 - 150 \pm T = 200a$ Magnitude $= 2040$ N or 2000 N	M1 A2 A1 M1 A2 A1 (4) **7**
	Notes	
31(a)	M1 for an equation in a only, with usual rules. First A1 for a correct equation Second A1 for 1.2 (m s^{-2}). Allow – 1.2 (m s^{-2}) if appropriate	
31(b)	M1 for an equation, in T and a , for the system or the lift only, with usual rules. (a does not need to be a numerical value) A2 (-1 each error) for a correct equation (**Allow** $\pm T$). We do **not** need to see a numerical value for a. Third A1 for 2040 (N) or 2000 (N) **N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered.	

Question Number	Scheme	Marks
32(a)	$R = 4g\cos\alpha$ $T - 0.5g = 0.5a$ $4g\sin\alpha - T - F = 4a$ (OR: $4g\sin\alpha - F - 0.5g = 4.5a$) $F = \frac{1}{2}R$; $\sin\alpha = \frac{4}{5}$ or $\cos\alpha = \frac{3}{5}$ Eliminating a or finding a Solving for T (must have had an a) $T = \frac{2g}{3}$ N or 6.5N or 6.53N	M1 A1 M1 A1 M1 A1 B1; B1 M1 M1 A1 (11)
(b)	Magnitude $= 2T\cos\left(\frac{90-\alpha}{2}\right)$ $= 2 \text{ x } \frac{2g}{3} \text{ x } \frac{3}{\sqrt{10}}$ (0.94868..) $= 12N$ or $12.4N$ $\left(\frac{4g}{\sqrt{10}}\right)$	M1 A1 **A1 ft on *T*** A1 (4) **15**
	Notes	
32(a)	First M1 for resolving perp to plane, with usual criteria First A1 for a correct equation Second M1 for resolving vertically, with usual criteria Second A1 for a correct equation, in terms of a and T Third M1 for resolving parallel to the slope, with usual criteria. Third A1 for a correct equation , in terms of a, F and T N.B. Their a could be UP the slope in which case all 4 marks for the 2 equations are available with $-a$ replacing a, provided they are consistent. If they are inconsistent, then assume the vertical resolution is the correct one and mark accordingly. Either of the above two equations can be replaced by the 'whole system' equation **N.B. If they use a = 0, in any of the above 3 equations, and they use the equation to find T, they lose both marks for that equation, and they lose the two M marks for eliminating and solving.** First B1 for $F = \frac{1}{2}R$ seen or implied; Second B1 for $\sin\alpha = 0.8$ or $\cos\alpha = 0.6$ seen or implied. Allow close approximations if $\alpha = 53.1^{\circ}\ldots$ used. Fourth M1 independent for eliminating a or finding a. Fifth M1 for solving for T but must have had an a. Fourth A1 for 2g/3, 6.5 or 6.53.	

(b)	First M1 for a complete method for finding the magnitude of the resultant (**N.B.** M0 if same tensions used) $2T\cos\left(\frac{90^\circ-\alpha}{2}\right)$.Allow sin/cos confusion and allow $2T\cos\left(\frac{\alpha}{2}\right)$ **OR** $\sqrt{(T+T\sin\alpha)^2+(T\cos\alpha)^2}$. Allow sin/cos confusion and allow omission of √ sign, but only if R^2 = ……. is included **OR** $\sqrt{T^2+T^2-2T^2\cos(90^\circ+\alpha)}$**.** Allow $(90^\circ-\alpha)$ but must be cos and and allow omission of √ sign, but only if R^2 =…….is included **OR** $\frac{T\sin(90+\alpha)}{\sin\left(\frac{90^\circ-\alpha}{2}\right)}$**. (Sine Rule)** Allow sign errors in angles but must be sin First A1 for correct expression in terms of T and α Second A1, **ft** on their T, for a 'correct' **single numerical** answer Third A1 cao for 12 (N) or 12.4 (N)	

Question Number	Scheme	Marks
33a	Resolving horizontally: $T\cos 30° = 6\cos 50°$ $T = 4.45$ (N), 4.5 (N), or better	M1A1 A1 (3)
b	Resolving vertically: $W = 6\cos 40° + T\cos 60°$ = 6.82 (N), 6.8 (N), or better	M1A1 A1 (3)
		[6]

Notes for Question 33

Question 33(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 : $\frac{T_{AC}}{\sin 40^o} = \frac{6}{\sin 60^o}$ (same equation as → resolution) M1A1

Or

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

Question 33(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 : $\frac{6}{\sin 60^o} = \frac{W}{\sin 80^o}$ M1A1

Or Lami's Theorem: $\frac{6}{\sin 120^o} = \frac{W}{\sin 100^o}$ 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
34(a)	$R = mg\cos 40$	B1
	Use of $F = \mu R$	B1
	$mg\sin 40 - F = \pm ma$	M1A1
	$acc = 2.55$ (m s^{-2}) or 2.5 (m s^{-2})	A1 (5)
(b)	$v^2 = u^2 + 2as = 2 \times a \times 3$ Speed at B is 3.9 (m s^{-1}) or 3.91(m s^{-1})	M1A1 (2)
		[7]

Notes for Question 34

(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 34(a)

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

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

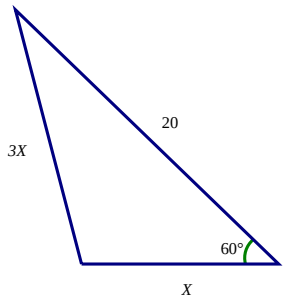
Second A1 for 2.5 (ms^{-2}) or 2.55 (ms^{-2}) Must be **positive.**

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

Question 34(b)

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

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

Question Number	Scheme	Marks
35a	 Resolve and use Pythagoras $(X - 20\cos 60)^2 + (20\cos 30)^2 = (3X)^2$ $8X^2 + 20X - 400 = 0$ $X = \frac{-5 \pm \sqrt{25+800}}{4} = 5.93$ **(3 SF)**	 M1 A1 A1 M1A1 (5)
35a alt	Cosine rule $(3X)^2 = 20^2 + X^2 - 2.20X\cos 60$ $8X^2 + 20X - 400 = 0$ $X = \frac{-5 \pm \sqrt{25+800}}{4} = 5.93$ (**3SF**)	M1A1 A1 M1A1 (5)
b	$\lvert\mathbf{P} - \mathbf{Q}\rvert^2 = 20^2 + X^2 - 2X \times 20 \times \cos 120$ $\lvert\mathbf{P} - \mathbf{Q}\rvert = 23.5$ (N) (**3SF**)	M1A1 **DM1** A1 (4)
35b alt	$\lvert\mathbf{P} - \mathbf{Q}\rvert^2 = (X + 20\cos 60)^2 + (20\cos 30)^2$ $\lvert\mathbf{P} - \mathbf{Q}\rvert = 23.5$ (N) (**3SF**)	M1A1 **DM1** A1 (4)
		[9]

Notes for Question 35

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 35(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 $(\pm(X - 20\cos 60^o))^2 + (\pm(20\cos 30^o))^2 = (3X)^2$
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 $\cos 60^o$ **(M0 if they use 120^o)**
First A1 for a correct equation unsimplified e.g, allow $\cos 60^o$ 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 $3X / \sin 60 = X / \sin a$ **AND**

Either: $X / \sin a = 20 / \sin (120^o - a)$
Or: $3X / \sin 60^o = 20 / \sin (120^o - a)$
(These could be in terms of *b* where $b = (120^o - a)$)

First A1 for two correct equations
Second A1 for $a = 16.778..^o$ (or $b = 103.221..^o$)
Second M1 for solving:
$X / \sin a = 20 / \sin (120^o - a)$ **or** $3X / \sin 60^o = 20 / \sin (120^o - a)$
with their *a* or *b*, to find *X*
Third A1 for 5.93

Question 35(b)

First M1 for use of cosine rule unsimplified with $\cos 120^o$ **(M0 if they use 60^o)**
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 $(\pm(X + 20\cos 60^o))^2 + (\pm(20\cos 30^o))^2$
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
36(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)	$v^2 = u^2 + 2as = 2 \times \frac{g}{7} \times 0.7 = 1.96$, $v = 1.4$ 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
	$s = \frac{2.5 \times 1.96^2}{g} = 0.5$ (m)	A1
	Total height = $0.7 + 0.5 = 1.2\,(\text{m})$	A1 **ft** (3)
		[16]

Notes for Question 36

Question 36(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 36(b)

M1 for an equation in v only (usually $v^2=u^2+2as$)
A1 for 1.4 (ms^{-1}) allow $\sqrt{(g/5)}$ oe.

Question 36(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 (ms^{-2}) (*allow a negative answer)*

Question 36(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 $s = 0.5$ (m) correctly obtained
Second A1 **ft** for their 0.5 + 0.7 =1.2 (m)

Alternative using conservation of energy

M1 for an equation in s only, with correct number of terms, using their v from (b):-
$(3mgs - 2mgs) = ½\ 3m\ (1.4)^2 + ½\ 2m\ (1.4)^2$
First A1 for $s = 0.5$ (m) correctly obtained
Second A1 **ft** for their 0.5 + 0.7 =1.2 (m)

Question Number	Scheme	Marks
37(a)	Resolving horizontally: $5 = T\cos 65°$ $T =$ 12, 11.8, or better (N)	M1A1 A1 (3)
(b)	Resolving vertically: $W = T\cos 25°$ $= 11.8\cos 25° =$ 11, 10.7 or better (N)	M1A1 A1 (3)
		[6]

Notes for Question 37

Question 37(a)

First M1 for resolving horizontally with correct no. of terms and T term resolved.
First A1 for a correct equation in T only.
Second A1 for 12 (N) or 11.8 (N) or better.
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 only* (i.e. W eliminated correctly)

Alternatives:

Lami's Theorem: $\frac{T}{\sin 90^o} = \frac{5}{\sin 155^o}$ (same equation as → resolution) M1A1

Question 37(b)

First M1 for resolving vertically with correct no. of terms and T (does not need to be substituted) term resolved.
First A1 for a correct equation in T only.
Second A1 for 11 (N), 10.7 (N) or better.

Alternatives:

Triangle of forces: $W = 5\tan 65^o$ M1A1

Lami's Theorem: $\frac{T}{\sin 90^o} = \frac{W}{\sin 115^o}$ M1A1

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

Question Number	Scheme	Marks
38(a)	$(4\mathbf{i} - 2\mathbf{j}) + (2\mathbf{i} + q\mathbf{j}) = (6\mathbf{i} + (q-2)\mathbf{j})$ $6 = 2(q-2)$ ratio 2:1 $q = 5$	M1A1 **DM**1 A1 (4)
(b)	$6\mathbf{i} + 3\mathbf{j} = 1.5\mathbf{a}$ $\mathbf{a} = (4\mathbf{i} + 2\mathbf{j})$ m s^{-2} $\mathbf{v} = \mathbf{u} + \mathbf{a}t = (-2\mathbf{i} + 4\mathbf{j}) + 2(4\mathbf{i} + 2\mathbf{j})$ $= 6\mathbf{i} + 8\mathbf{j}$ speed $= \sqrt{6^2 + 8^2}$ $= 10$ m s^{-1}	M1 A1 M1 A1**ft** **M**1 A1 (6) **[10]**

Notes for Question 38

Question 38(a)

First M1 for $(4\mathbf{i} - 2\mathbf{j}) + (2\mathbf{i} + q\mathbf{j})$

First A1 for $(6\mathbf{i} + (q-2)\mathbf{j})$ (seen or implied)

Second M1, **dependent on first M1**, for using 'parallel to $(2\mathbf{i} + \mathbf{j})$' to obtain an equation in *q only*.

Second A1 for $q = 5$

Question 38(b)

First M1 for their **resultant force** $= 1.5\mathbf{a}$

First A1 for $\mathbf{a} = 4\mathbf{i} + 2\mathbf{j}$

Second M1 for $(-2\mathbf{i} + 4\mathbf{j}) + 2$ x (their **a)** **(M0** if force is used instead of **a)**

Second A1 **ft** for their velocity at $t = 2$

Third M1for finding the magnitude of their velocity at $t = 2$

Third A1 for 10 (ms^{-1})

N.B. In (b), if they use scalars throughout, M0A0M0A0M0A0

Question Number	Scheme	Marks
39a	$3mg - T = 3ma$ $T - 2mg = 2ma$ $T = 2mg + 2\left(mg - \frac{T}{3}\right)$ $T = \frac{12}{5}mg$ ***Given Answer***	M1A1 M1A1 **DM**1 A1 (6)
b	$a = \frac{g}{5}$ At time of impact $v^2 = u^2 + 2as = 2 \times \frac{g}{5} \times 1.5 = 0.6g$ Vertical motion under gravity $0 = 0.6g - 2gs$ $s = 0.3(\text{m})$ Total distance $2 \times 0.3 = 0.6$ (m)	B1 M1A1 M1 **DM**1A1 (6)
c	Impulse = $3m(v-u) = -3mu$ Magnitude = $3m\sqrt{0.6g} = 3.6$ (Ns) (3.64)	M1 A1 (2) **[14]**

Notes for Question 39

Question 39(a)

First M1 for resolving vertically (up or down) for *B*, with correct no. of terms etc (allow if they omit *m* but have the 3)
First A1 for a correct equation.
Second M1 for resolving vertically (up or down) for *A*, with correct no. of terms etc (allow if they omit *m* but have the 2)
Second A1 for a correct equation
Third M1, **dependent on the first two M marks**, for eliminating *a*
Third A1 for $T = 12mg/5$ **given answer**

N.B. Either equation above can be replaced by the whole system equation
M1A1 for $3mg - 2mg = 5ma$; any error loses both marks.

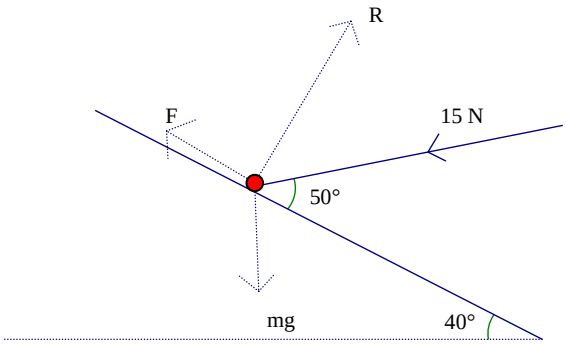
N.B. If *m* has been omitted in (a), which has led to a dimensionally incorrect value of *a*, can score max B0M1A0M1M1A0 in (b) and M1A0 in (c).

Question 39(b)

B1 for $a = g/5$ found (possibly in part (a)) and used here.
First M1 for using *suvat* with their *a* from part (a), to find the speed *v* (or v^2) of *B* at impact
First A1 for $\sqrt{(0.6g)}$ oe, 2.4 or better (may be implied) *found correctly.*
Second M1 for using *suvat* with $a = \pm g$, to obtain an equation in *s* only, using their *v* (or v^2) *with final velocity* = 0
Third M1, **dependent on second M1**, for doubling their *s* value
Second A1 for 0.6 (m)

Question 39(c)

M1 for $\pm 3m$ x (their *v*) or ± 1.5 x (their *v*) or
$\pm m$ x (their *v*) or ± 0.5 x (their *v*)
M0 if $3m$ missing or extra *g*
A1 for 3.6 or 3.64 (Ns)

Question Number	Scheme	Marks
40a	 Perpendicular to the slope: $R = 2.7g\cos 40 + 15\cos 40$ $= 31.8$ (N) or 32 (N)	M1A2 A1 (4)
40b	Parallel to the slope: $F = 2.7g\sin 40 - 15\cos 50$ $\left(F = 7.366..\right)$ Use of $F = \mu R$ $\mu = \dfrac{2.7g\sin 40 - 15\cos 50}{R} = 0.23$ or 0.232	M1A2 M1 A1 (5)
40c	Component of wt parallel to slope = $2.7g\sin 40°$ $(=17.0)$ $F_{\max} = 0.232 \times 2.7 \times g \times \cos 40° = 4.7...$ (N) $17.0 > 4.70$ so the particle moves	B1 M1A1 A1 (4)
		[13]

Notes for Question 40

N.B. Only penalise over- or under-accuracy after using $g = 9.8$, (or use of g = 9.81), once in whole question**.**

Question 40(a)

First M1 for resolving perpendicular to the slope, with correct no. of terms, and both the 2.7g and 15 terms resolved.
First A2 for a correct equation; -1 each error.
Third A1 for 32 (N) or 31.8 (N)

Question 40(b)

First M1 for resolving parallel to the slope, with correct no. of terms, and both the 2.7g and 15 terms resolved.
First A2 for a correct equation; -1 each error.
Second M1 for use of $F = \mu R$
Third A1 for 0.23 or 0.232

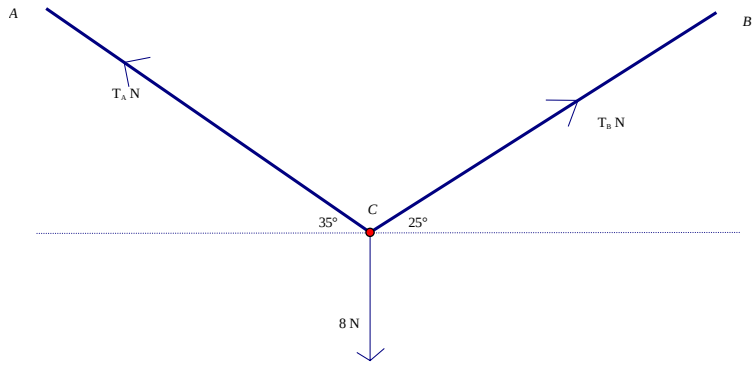
Question 40(c)

B1 for component of weight down the plane $2.7g\sin 40^{o}$ (17 or better)
M1 for using their **NEW *R*** and μ to find max friction (M0 if they use *R* from (a))
First A1 for 4.7(or better) (should be 4.701242531)
Second A1 for comparison and correct conclusion.
N.B. If first A mark is 0, the second A mark must also be 0.

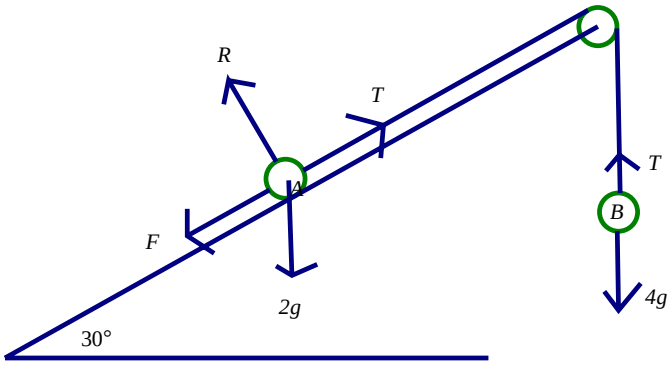
Question Number	Scheme	Marks
41.		
(a)	For system, $(\uparrow),\ T-950g-50g=1000\ \times -2$	M1 A1
	$T = 7800$ N	A1
		(3)
(b)	For woman, $(\uparrow),\quad R-50g=50\times -2$	M1 A1
	$R = 390$ N	A1
		(3)
		[6]
Notes for Question 41		
Q41(a)	(In both parts, use the *mass* to decide which part of the system is being considered and M marks can only be scored if an equation contains only forces acting on that part of the system) M1 is for a complete method for finding T i.e. for an equation in T *only*, dimensionally correct, with the correct number of terms. First A1 for a correct equation. Second A1 for 7800 (N).	
Q41(b)	M1 is for a complete method for finding R i.e. for an equation in R *only*, dimensionally correct, with the correct number of terms. First A1 for a correct equation. Second A1 for 390 (N). N.B. Equation for lift *only* is: $T - 950g - R = 950 \times (-2)$	

Question Number	Scheme	Marks
42.	$T\cos\alpha - F = 2g\cos 60^o$	M1 A1
	$T\sin\alpha + R = 2g\cos 30^o$	M1 A1
	$F = \frac{1}{3}R$	B1
	eliminating F and R	**DM**1
	$T = g(1+\frac{1}{\sqrt{3}})$, 1.6g (or better), 15.5, 15 (N)	**DM**1 A1
		(8)
		[8]
Notes for Question 42		
42	First M1 for resolving parallel to the plane with correct no. of terms and both T and $2g$ terms resolved. First A1 for a correct equation. (use of α instead of 30^o or 60^o or vice versa is an A error not M error; similarly if they use sin(3/5) or cos(4/5) when resolving, this can score M1A0) Second M1 for resolving perpendicular to the plane with correct no. of terms and both T and $2g$ terms resolved. Second A1 for a correct equation (use of α instead of 30^o or 60^o or vice versa is an A error not M error; similarly if they use sin(3/5) or cos(4/5) when resolving, this can score M1A0) B1 for F = 1/3 R seen or implied. Third M1, dependent on first two M marks and appropriate angles used when resolving in *both* equations, for eliminating *F and R.* Fourth M1 dependent on third M1, for solving for T Third A1 for 15(N) or 15.5 (N). N.B. The first two M marks can be for two resolutions in any directions. Use of tan α = 4/3 leads to an answer of 17.83…and can score max 7/8.	

Question Number	Scheme	Marks
43.		
(a)	For A, $T = 2ma$	B1
	For B, $3mg - T = 3ma$	M1 A1
	$3mg = 5ma$	**DM**1
	$\frac{3g}{5} = a$ (5.9 or 5.88 m s^{-2})	A1
		(5)
(b)	$T = 6mg/5$; $12m$; $11.8m$	B1
		(1)
(c)	$F = \sqrt{T^2 + T^2}$	M1 A1 **ft**
	$F = \frac{6mg\sqrt{2}}{5}$;$1.7mg$ (or better);$16.6m$;$17m$	A1
	Direction clearly marked on a diagram, with an arrow, and 45^o (oe) marked	B1
		(4)
		[10]
Notes for Question 43		
43(a)	B1 for $T = 2ma$ First M1 for resolving vertically (up or down) for B, with correct no. of terms. (allow omission of m, provided 3 is there) First A1 for a correct equation. Second M1, dependent on first M1, for eliminating T, to give an equation in a only. Second A1 for 0.6g, 5.88 or 5.9. N.B. 'Whole system' equation: $3mg = 5ma$ earns first 4 marks but any error loses all 4.	
43(b)	B1 for $\frac{6mg}{5}$, $11.8m$, $12m$	
43(c)	M1 $\sqrt{(T^2 + T^2)}$ or $\frac{T}{\sin 45^o}$ or $\frac{T}{\cos 45^o}$ or $2T\cos 45^o$ or $2T\sin 45^o$ (allow if m omitted) (M0 for $T \sin 45^o$) First A1 ft on their T. Second A1 cao for $\frac{6mg\sqrt{2}}{5}$ oe, $1.7mg$ (or better),$16.6m$,$17m$ B1 for the direction clearly shown on a diagram with an arrow and 45^o marked.	

Question Number	Scheme	Marks
44.		
	Resolve horizontally: $T_A \cos 35° = T_B \cos 25°$	M1A1
	Resolve vertically: $T_A \sin 35° + T_B \sin 25° = 8$	M1A1
	Equation in one unknown: $T_B \dfrac{\cos 25°}{\cos 35°} \sin 35° + T_B \sin 25° = 8$	**DM1**A1
	or $T_A \sin 35° + T_A \dfrac{\cos 35°}{\cos 25°} \sin 25° = 8$	
	T_A = 8.4, 8.37, 8.372 (N) or better	A1
	T_B = 7.6, 7.57, 7.567 (N) or better	A1 **(8)**
44alt	**OR**	
	Using Sine Rule on triangle of forces: $\dfrac{8}{\sin 60°} = \dfrac{T_A}{\sin 65°} = \dfrac{T_B}{\sin 55°}$	M1A1
	$\dfrac{8 \times \sin 65°}{\sin 60°} = T_A$, = 8.4, 8.37, 8.372 (N) or better	M1A1, A1
	$\dfrac{8 \times \sin 55°}{\sin 60°} = T_B$, = 7.6, 7.57, 7.567 (N) or better	M1A1, A1

Notes for Question 44		
44	First M1 for resolving horizontally with correct no. of terms and both T_A and T_B terms resolved. First A1 for a correct equation. Second M1 for resolving vertically with correct no. of terms and both T_A and T_B terms resolved. Second A1 for a correct equation. Third M1, dependent on first two M marks, for eliminating T_A or T_B Third A1 for a correct equation in one unknown Fourth A1 for T_A = 8.4 (N) or better. Fifth A1 for T_B = 7.6 (N) or better. N.B. The first two M marks can be for two resolutions in any two directions. N.B. If the two tensions are taken to be equal, can score max M1A0 for vertical resolution.	
44 alt 1	See **Alternative 1** using a Triangle of Forces and the Sine Rule.	
44 alt 2	**Alternative 2** is to resolve perpendicular to each string: The scheme is similar to Alt 1 and gives the same expressions for T_A and T_B M1A1 resolving perp to *both* strings as a complete method. M1A1A1 for finding T_A M1A1A1 for finding T_B	

Question Number	Scheme	Marks
45.		
	Equation of motion of B: $4g - T = 4a$	M1A1
	Equation of motion of A: $T - F - 2g\sin 30 = 2a$	M1A2
	OR: $4g - F - 2g\sin 30 = 6a$	
	Resolve perpendicular to the plane at A: $R = 2g\cos 30$	B1
	Use of $F = \mu R$: $F = \frac{1}{\sqrt{3}} \times 2g\cos 30 (= g)$	M1
	$T - g - g = T - 2g = 2a$	
	$2T - 4g = 4g - T$, $3T = 8g$, $T = \frac{8g}{3} (\approx 26)$ 26.1(N)	**DM1**A1
		(9) **[9]**
	Notes for Question 45	
45	First M1 for resolving vertically (up or down) for B, with correct no. of terms. First A1 for a correct equation. Second M1 for resolving parallel to the plane (up or down) for A, with correct no. of terms. A2 for a correct equation (-1 each error) **OR**: M2 A3 for the whole system equation - any method error loses all the marks. B1 for perpendicular resolution Third M1 for sub for R in $F = \mu R$ Fourth DM1, dependent on first and second M marks, for eliminating a. Fourth A1 for 8g/3, 26.1 or 26 (N). (392/15 oe is A0)	

Question Number	Scheme	Marks
46. **(a)**	$s = \frac{u+v}{2}t \qquad 10 = \frac{2+v}{2} \times 3.5$ $v = \frac{20}{3.5} - 2 = \frac{26}{7} = 3.71 \quad (\text{m s}^{-1})$	M1A1 A1 **(3)**
(b)	$a = \frac{v-u}{t} = \frac{\frac{26}{7} - 2}{3.5} = \frac{24}{49} = 0.490 \ (\text{m s}^{-2})$	M1A1 **(2)**
(c)	Normal reaction : $R = 0.6g\cos 25°$ Resolve parallel to the slope : $0.6g\sin 25° - \mu \times R = 0.6 \times a$ $\mu = 0.41$ or 0.411	B1 M1A2 A1 **(5)** **[10]**

Notes for Question 46

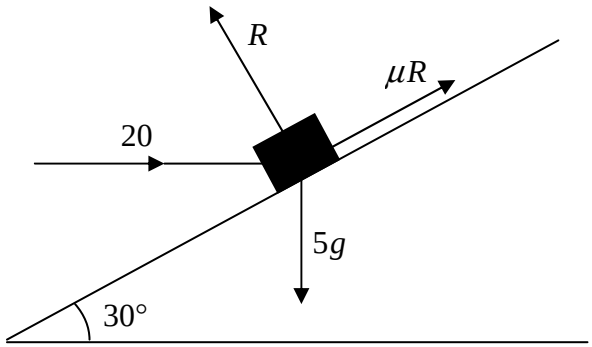
46(a)	First M1 for producing an equation in *v only*. First A1 for a correct equation Second A1 for 26/7 oe, 3.7 or better (ms^{-1})	
46(b)	M1 for producing an equation in *a only*. A1 for 24/49, 0.49 or better (ms^{-2})	
46(c)	B1 for $R = 0.6g\cos 25^{o}$ M1 for resolving along the plane, correct no. of terms etc. A2 (-1 each error) *R* and *a* do not need to be substituted Third A1 for 0.41 or 0.411	

Question Number	Scheme	Marks
47 **(a)**	Use of $v^2 = u^2 + 2as$ $14^2 = 20^2 - 2a \times 100$ Deceleration is 1.02(m s^{-2})	M1 A1 A1 **(3)**
(b)	Horizontal forces on the car: $\pm T\cos\theta - 300 = 750 \times -1.02 = -765$ T = - 1550/3 The force in the tow-bar is 1550/3, 520 (N) or better (allow –ve answer)	M1A2 **f.t.** A1 **(4)**
(c)	Horizontal forces on the truck: $\pm T\cos\theta - 500 - R = 1750 \times -1.02$ Braking force R = 1750 (N)	M1A2 **f.t.** A1 **(4)** **[11]**
	ALT: Whole system: $800 + R = 2500 \times 1.02$ R = 1750	M1A2 **f.t.** A1
	Notes for Question 47	
47(a)	M1 for a complete method to produce an equation in *a* only. First A1 for a correct equation. Second A1 for 1.02 (ms^{-2}) oe. must be POSITIVE.	
47(b)	M1 for considering *the car ONLY* horizontally to produce an equation in *T* only, with usual rules. i.e. correct no. of terms AND *T* resolved: $\pm T\cos\theta - 300 = 750$ x -1.02 A2 **ft** on their *a* for a correct equation (300 and *a* must have *same* sign); -1 each error (treat cos 0.9 as an A error) A1 for 1550/3 oe, 520 or better (N) N.B. Allow a negative answer.	
47(c)	M1 for considering *the truck ONLY* horizontally to produce an equation, with usual rules. i.e. correct no. of terms AND *T* resolved: $\pm T\cos\theta - 500 - R = 1750$ x -1.02 A2 **ft** on their *T* and *a* for a correct equation (500, *a* and *R* must have *same* sign); -1 each error (treat cos 0.9 as an A error) A1 for 1750 (N). **OR** M1 for considering *the whole system* to produce an equation in *R* only, with usual rules. i.e. correct no. of terms. A2 **ft** on their *a* for a correct equation (*a* and *R* must have *same* sign) -1 each error A1 for 1750 (N). N.B. If 300 and 500 are given separately, penalise any sign errors only ONCE.	

Question Number	Scheme	Marks
48.	$(\uparrow)$, $T\cos 30 + F\cos 60 = 2g$ $(\rightarrow)$, $T\cos 60 - F\cos 30 = 0$ $F = g = 9.8$ $T = \sqrt{3}g = 17$ or 17.0	M1 A1 M1 A1 M1 A1 M1 A1 **8**
OR:	$(\nearrow)$, $F = 2g\cos 60$ $(\nwarrow)$, $T = 2g\cos 30$ $F = g = 9.8$ $T = \sqrt{3}g = 17$ or 17.0	M1 A1 M1 A1 M1 A1 M1 A1 **8**

Question Number	Scheme	Marks
49.	$12.6^2 = 2a.50 \qquad (\Rightarrow a = 1.5876)$	M1 A1
	$800g\sin 15 - F = 800a$	M1 A1
	$R = 800g\cos 15$	M1 A1
	$F = \mu R$	B1
	$800g\sin 15 - \mu 800g\cos 15 = 800 \text{ x } 1.5876$	M1
	μ= 0.1, 0.10, 0.100	A1
		9

Question Number	Scheme	Marks
50.(a)	Inextensible string	B1 (1)
(b)	$4mg - T = 4ma$ $T - 2mg\sin\alpha - F = 2ma$	M1A1 M1A1 (4)
(c)	$F = 0.25R$ $R = 2mg\cos\alpha$ $\cos\alpha = 0.8$ or $\sin\alpha = 0.6$ Eliminating R, F and T $a = 0.4g = 3.92$	B1 B1 B1 M1 A1 (5)
(d)	$v^2 = 2 \text{ x } 0.4gh$ $-2mg\sin\alpha - F = 2ma'$ $a' = -0.8g$ $0^2 = 0.8gh - 2\text{x } 0.8g \text{ x } s$ $s = 0.5h$ $XY = 0.5h + h = 1.5h$	M1 M1 A1 M1 A1 A1 (6) **16**

Question Number	Scheme	Marks
51.		
	(a) ⊥ plane $R = 20\cos 60° + 5g\cos 30°$ $= 52.4\ (\text{N})$ or 52	M1 A2(1,0) A1 **(4)**
	(b) $F_r = \mu R$ P plane $F + 20\cos 30^\circ = 5g\cos 60^\circ$ Leading to $\mu = 0.137$ or 0.14	B1 M1 A2(1, 0) A1 **(5)** **[9]**

Question 51(a)

First M1 for resolving perpendicular to plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 52 or 52.4
N.B. In part (a), the M1 is for a complete method, so they must have sufficient equations to be able to solve for *R*. The A2 marks are then for *all* the equations.

Question 51(b)

B1 for use of $F=\mu R$ (could just be on diagram)
First M1 (allow if *F* is used rather than μR) for resolving parallel to the plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 0.14 or 0.137
N.B. If they resolve vertically AND horizontally, there are max 6 marks available (M1A2, M1A2) for the TWO equations, but if they only have one equation, there are no marks available for that equation.
The marks for the horizontal resolution should be entered first on ePen.

Question Number	Scheme	Marks
52.	(a) $v^2 = u^2 + 2as \Rightarrow 28^2 = u^2 + 2\times 9.8\times 17.5$ Leading to $u = 21$ ✱ cso	M1 A1 A1 **(3)**
	(b) $s = ut + \frac{1}{2}at^2 \Rightarrow 19 = 21t - 4.9t^2$ $4.9t^2 - 21t + 19 = 0$ $t = \frac{21 \pm \sqrt{21^2 - 4x4.9.x19}}{9.8}$ t = 2.99 or 3.0 t = 1.30 or 1.3	M1 A1 DM1 A1 A1 **(5)**
	(c) N2L $4g - 5000 = 4a$ $(a = -1240.2)$ $v^2 = u^2 + 2as \Rightarrow 0^2 = 28^2 - 2\times 1240.2\times s$ Leading to $s = 0.316$ (m) or 0.32	M1 A1 M1 A1 **(4)**
		[12]
	OR $\frac{1}{2}$ x 4 x $28^2 + 4gs = 5000s$ Work-Energy: $s = 0.316$ or 0.32	M1 A1 M1 A1

Question 52(a)

First M1 for a complete method for finding u e.g.

$28^2 = u^2 + 2g\text{x}17.5$

or $28^2 = u^2 + 2(-g)\text{x}(-17.5)$

or $28^2 = 2gs \Rightarrow s = 40$ then $0^2 = u^2 + 2(-g)\text{x}(22.5)$

condone sign errors

First A1 for a correct equation(s) with g = 9.8

Second A1 for "u = 21" PRINTED ANSWER

N.B. Allow a verification method, but they must state, as a conclusion, that "u = 21" , to score the final A1.

Question 52(b)

First M1 for a complete method for finding at least one t value i.e. for producing an equation in t only.
(condone sign errors but not missing terms)

First A1 for a correct quadratic equation in t only or TWO correct linear equations in t only.

Second DM1, dependent on first M1, for attempt to solve the quadratic or one of the linear equations.

Second A1 for 3.0 or 3 or 2.99

Third A1 for 1.3 or 1.30

Question 52(c)

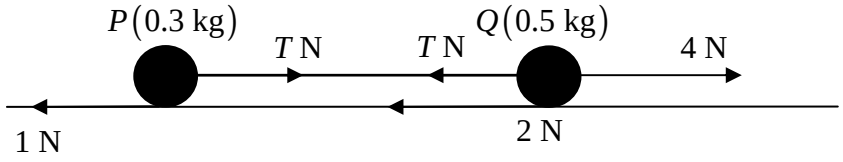
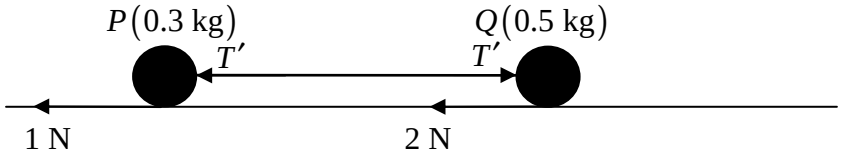
First M1 for resolving vertically with usual rules.

First A1 for a correct equation

Second M1 for use of $v^2 = u^2 + 2as$, with v = 0, u = 28 or u = 0 and v = 28 and their a, (or any other complete method which produces an equation in s,which could be negative)

M0 if they haven't *calculated* a value of a.

Second A1 for 0.32 or 0.316. (must be positive since it's a distance)

Question Number	Scheme	Marks
53.		
	(a) For system N2L $4-3=0.8a$ $a=1.25\ (\text{m s}^{-2})$, 1.3	M1 A1 A1 **(3)**
	(b) $v=u+at \Rightarrow v=0+1.25\times 6=7.5\ (\text{m s}^{-1})$	M1 A1 **(2)**
	(c) For P N2L $T-1=0.3\times 1.25$ ft their a $T=1.375\ (\text{N})$ 1.38, 1.4	M1 A1ft A1 **(3)**
	OR For Q N2L 4 - 2 – T = 0.5 x 1.25 	
	(d) For system N2L $-3=0.8a \Rightarrow a=-3.75$ $v^2=u^2+2as \Rightarrow 0^2=7.5^2-2\times 3.75s$ $s=7.5\ (\text{m})$	M1 A1 M1 A1 **(4)**
	(e) For P N2L $T'+1=0.3\times 3.75$ $T'=0.125\ (\text{N})$, 0.13	M1 A1 A1 **(3)** **[15]**
	Alternative for (e) For Q N2L $2-T'=0.5\times 3.75$ $T'=0.125\ (\text{N})$, 0.13	M1 A1 A1 **(3)**

Question 53(a) ***(In parts (a), (c), (d) and (e) use the value of the mass being used to guide you as to which part of the system is being considered, and mark equation(s) accordingly)***

M1 for resolving horizontally to produce an equation in *a* ONLY.
First A1 for a correct equation
Second A1 for 1.25

Question 53(b)

M1 for a complete method to find the speed
A1 cao 7.5

Question 53(c)

M1 for resolving horizontally, for either *P* or *Q*, to produce an equation in *T* only.
First A1ft for a correct equation,ft on their *a*
Second A1 cao for 1.38 (N) or 1.375 (N)

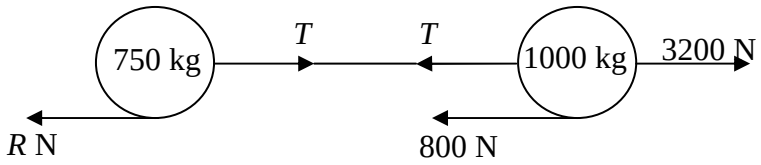
Question 53(d)

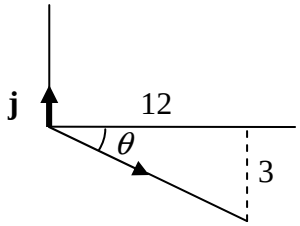
First M1 for resolving horizontally to produce an equation in *a* ONLY.
First A1cao for -3.75 (or 3.75)

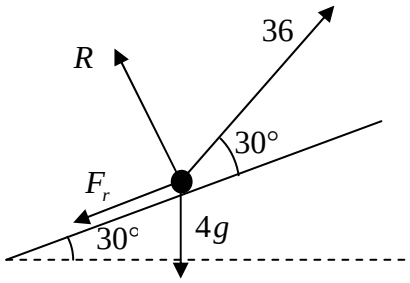
Second M1 for use of $v^2 = u^2 + 2as$, with $v = 0$, u= their (b) and their a, (or any other complete method which produces an equation in s only)
M0 if they haven't *calculated* a value of *a*.
Second A1 for 7.5 m

Question 53(e)

M1 for resolving horizontally, for either *P* or *Q*, to produce an equation in *T* only.
M0 if they haven't *calculated* a value of *a*
First A1cao for a correct equation
Second A1 cao for 0.125 or 0.13 (N) (must be positive)

Question Number	Scheme	Marks
54 (a)		
	For the whole system	
	$R(\rightarrow)$ $\quad 3200-800-R=1750\times0.88$	M1 A1
	Leading to $\quad R=860$ ✱	A1
		(3)
(b)	For the caravan	
	$R(\rightarrow)$ $\quad T-860=750\times0.88$	M1 A1
	Leading to $\quad T=1520\ (\text{N})$	A1
		(3)
		6
	Alternative for (b)	
	For the car	
	$R(\rightarrow)$ $\quad 3200-800-T=1000\times0.88$	M1 A1
	Leading to $\quad T=1520\ (\text{N})$	A1
		(3)

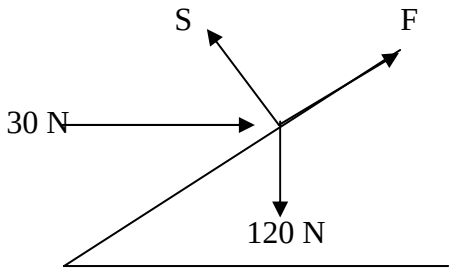
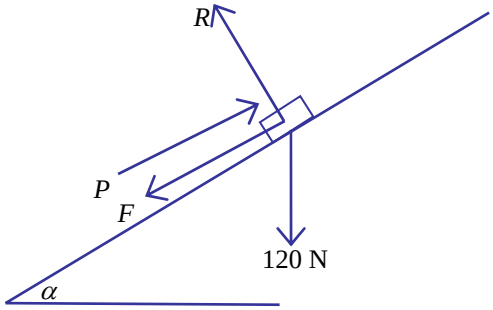
Question Number	Scheme	Marks
55 (a)	$7 + 5 + p = 0$ or $-9 + 6 + q = 0$ $p = -12$ $q = 3$	M1 A1 A1 (3)
(b)	$\mathbf{R} = 12\mathbf{i} - 3\mathbf{j}$ $\lvert\mathbf{R}\rvert = \sqrt{\left(12^2 + (-3)^2\right)} = \sqrt{153}$ or $3\sqrt{17}$ or 12.4 or better (N)	M1 A1 (2)
(c)	$\tan\theta = \frac{3}{12}$ $\theta = 14.03^0...$ Angle with **j** is $104°$, to the nearest degree cao 	M1 A1 A1 (3) **8**

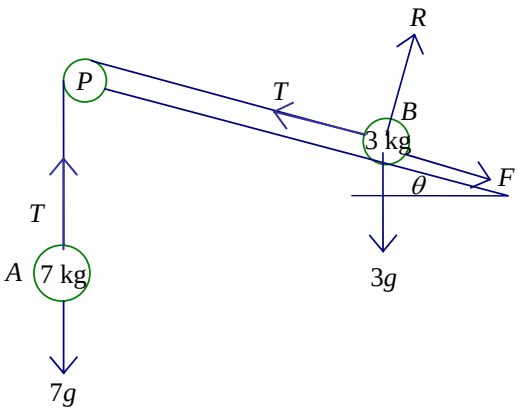
Question Number	Scheme	Marks
56(a)		
	$R + 36\sin 30° = 4g\cos 30°$	M1 A1
	$R \approx 15.9,\ 16$	M1 A1
		(4)
(b)	Use of $F_r = \mu R$	B1
	$36\cos 30° = F + 4g\sin 30°$	M1 A1
	$\mu = \dfrac{36\cos 30° - 4g\sin 30°}{R} \approx 0.726$	M1 A1
	0.73	
		(5)
(c)	After force is removed	
	$R = 4g\cos 30°$	B1
	$-\mu 4g\cos 30° - 4g\sin 30° = 4a$	M1 A1
	$a = (-)11.06\ ...$	
	$v^2 = u^2 + 2as \Rightarrow 0^2 = 16^2 - 2\times 11.06\ ... \times s$	M1
	$s = \dfrac{16^2}{2\times 11.06\ ...} \approx 11.6 \quad (\text{m})$	A1
	12	
		(5)
		14

Question Number	Scheme	Marks
57.	$\nearrow$ $4\cos\alpha + F = W\sin\alpha$	M1 A1
	$\nwarrow$ $R = 4\sin\alpha + W\cos\alpha$	M1 A1
	$F = 0.5R$	B1
	$\cos\alpha = 0.8$ or $\sin\alpha = 0.6$	B1
	$R = 20N$ ** GIVEN ANSWER	M1 A1
	$W = 22N$	A1
		(9)
OR	$\rightarrow$ $R\sin\alpha = 4 + F\cos\alpha$	M1 A1
	$\uparrow$ $R\cos\alpha + F\sin\alpha = W$	M1 A1
	$F = 0.5R$	B1
	$\cos\alpha = 0.8$ or $\sin\alpha = 0.6$	B1
	$R = 20N$ ** GIVEN ANSWER	M1 A1
	$W = 22N$	A1
		(9)
		9

Question Number	Scheme	Marks
58. **(a)**	$R = 0.3g\cos\alpha$ $= 0.24g = 2.35$ (3sf)=2.4 (2sf)	M1 A1 (2)
(b)	$mg - T = 1.4m$ $T - 0.3g\sin\alpha - F = 0.3$ x 1.4 $F = 0.5R$ Eliminating R and T $m = 0.4$	M1 A1 M1 A2 M1 **DM**1 A1 (8)
(c)	$v = 1.4$ x 0.5 $-0.3g\sin\alpha - F = 0.3a$ $a = -9.8$ $0 = 0.7 - 9.8t$ $t = 0.071$ s or 0.0714 s (1/14 A0)	B1 M1 A1 A1 M1 A1 (6) **16**

Question Number	Scheme	Marks
59. **(a)**	speed $= \sqrt{2^2 + (-5)^2}$ $= \sqrt{29} = 5.4$ or better	M1 A1 (2)
(b)	$\left((7\mathrm{i} + 10\mathrm{j}) - (2\mathrm{i} - 5\mathrm{j})\right)/5$ $= (5\mathbf{i} + 15\mathbf{j})/5 = \mathbf{i} + 3\mathbf{j}$ $\mathbf{F} = m\mathbf{a} = 2(\mathbf{i} + 3\mathbf{j}) = 2\mathbf{i} + 6\mathbf{j}$	M1 A1 A1 DM1 A1ft (5)
(c)	$\mathbf{v} = \mathbf{u} + \mathbf{a}t = (2\mathbf{i} - 5\mathbf{j}) + (\mathbf{i} + 3\mathbf{j})t$ $(-5 + 3t)\mathrm{j}$ Parallel to $\mathrm{i} \Rightarrow -5 + 3\mathrm{t} = 0$ $t = 5/3$	M1 A1 M1 A1 (4) **[11]**

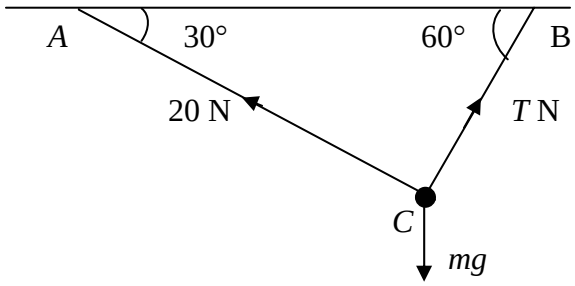
Question Number	Scheme	Marks
60. **(a)**	 Resolving perpendicular to the plane: $S = 120\cos\alpha + 30\sin\alpha$ $= 114$ *	 M1 A1 A1 A1 (4)
(b)	 Resolving perpendicular to the plane: $R = 120\cos\alpha$ $= 96$ $F_{max} = \frac{1}{2}R$ Resolving parallel to the plane: In equilibrium: $P_{max} = F_{max} + 120\sin\alpha$ $= 48 + 72 = 120$	 M1 A1 A1 M1 M1 A(2,1,0) A1 (8)
(c)	$30 + F = 120\sin\alpha$ **OR** $30 - F = 120\sin\alpha$ So $F = 42$N acting up the plane.	M1 A1 A1 (3) **[15]**

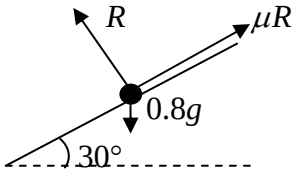
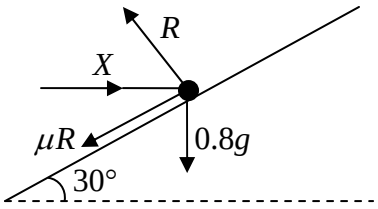
Question Number	Scheme	Marks
61. **(a)**	 $\tan\theta = \frac{5}{12}$ $\sin\theta = \frac{5}{13}$ $\cos\theta = \frac{12}{13}$	
	For A: $7g - T = 7a$	M1 A1
	For B: parallel to plane $T - F - 3g\sin\theta = 3a$	M1 A1
	perpendicular to plane $R = 3g\cos\theta$	M1 A1
	$F = \mu R = 3g\cos\theta = 2g\cos\theta$	M1
	Eliminating T, $7g - F - 3g\sin\theta = 10a$	DM1
	Equation in g and a: $7g - 2g\times\frac{12}{13} - 3g\frac{5}{13} = 7g - \frac{39}{13}g = 4g = 10a$	DM1
	$a = \frac{2g}{5}$ *oe* or 3.9 or 3.92	A1
		(10)
(b)	After 1 m,	
	$v^2 = u^2 + 2as$, $v^2 = 0 + 2\times\frac{2g}{5}\times 1$	M1
	$v = 2.8$	A1
		(2)
(c)	$-(F + 3g\ \sin\theta) = 3a$	M1
	$\frac{2}{3}\times 3g\times\frac{12}{13} + 3g\times\frac{5}{13} = 3g = -3a,\ a = -g$	A1
	$v = u + at,\ 0 = 2.8 - 9.8t,$	DM1
	$t = \frac{2}{7}$ oe, 0.29. 0.286	A1
		(4) **[16]**

Question Number	Scheme	Marks
62	$(\rightarrow)\ 100\cos 30 = F$ $F = 0.5R$ *seen* $(\downarrow)\ mg + 100\cos 60 = R$ $m = 13$ kg or 12.6 kg	M1 A1 A1 **(B1)** M1 A1 **DM**1 A1 **[7]**

Question Number	Scheme	Marks
63 (a)	$F = \frac{1}{3}R$	B1
	$(\uparrow)\ R\cos\alpha - F\sin\alpha = 0.4g$	M1 A1
	$R = \frac{2}{3}g = 6.53$ or 6.5	M1 A1 (5)
(b)	$(\rightarrow) P - F\cos\alpha - R\sin\alpha = 0$	M1 A2
	$P = \frac{26}{45}g = 5.66$ or 5.7	M1 A1 (5)
		[10]

Question Number	Scheme	Marks
64 (a)	$(\downarrow) 0.4g - T = 0.4a$	M1 A1
Mark	$(\uparrow) T - 0.3g = 0.3a$	M1 A1
together	solving for T	**DM1**
	$T = 3.36$ or 3.4 or 12g/35 (N)	A1 (6)
(b)	$0.4g - 0.3g = 0.7a$	**DM1**
	$a = 1.4$ m s^{-2}, $g/7$	A1 (2)
(c)	$(\uparrow) v = u + at$	
	$v = 0.5$ x 1.4	M1
	$= 0.7$	A1 ft on *a*
	$(\uparrow) s = ut + \frac{1}{2}at^2$	
	$s = 0.5$ x 1.4 x 0.5^2	M1
	$= 0.175$	A1 ft on *a*
	$(\downarrow) s = ut + \frac{1}{2}at^2$	
	$1.175 = -0.7t + 4.9t^2$	**DM1** A1 ft
	$4.9t^2 - 0.7t - 1.175 = 0$	
	$t = \frac{0.7 \pm \sqrt{0.7^2 + 19.6 \text{ x } 1.175}}{9.8}$	**DM1** A1 cao
	$= 0.5663..$or $-...$	
	Ans 0.57 or 0.566 s	A1 cao (9)
		[17]

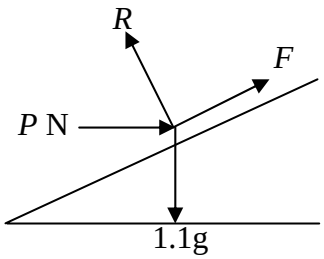
Question Number	Scheme	Marks
65.		
	(a) R($\rightarrow$) $20\cos 30° = T\cos 60°$ $T = 20\sqrt{3}$, 34.6, 34.64,…	M1 A2 (1,0) A1 (4)
	(b) R($\uparrow$) $mg = 20\sin 30° + T\sin 60°$ $m = \frac{40}{g} (\approx 4.1)$,4.08	M1 A2 (1,0) A1 (4)
		[8]

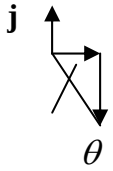
Question Number	Scheme	Marks
66.	(a) $s = ut + \frac{1}{2}at^2 \quad \Rightarrow \quad 2.7 = \frac{1}{2}a \times 9$	M1 A1
	$a = 0.6 \left(\text{m s}^{-2}\right)$	A1 (3)
	(b)	
		
	↖ $R = 0.8g\cos 30° \left(\approx 6.79\right)$	B1
	Use of $F = \mu R$	B1
	↙ $0.8g\sin 30° - \mu R = 0.8 \times a$	M1 A1
	$\left(0.8g\sin 30° - \mu 0.8g\cos 30° = 0.8 \times 0.6\right)$	
	$\mu \approx 0.51$ accept 0.507	A1 (5)
	(c)	
		
	↑ $R\cos 30° = \mu R\cos 60° + 0.8g$	M1 A2 (1,0)
	$\left(R \approx 12.8\right)$	
	→ $X = R\sin 30° + \mu R\sin 60°$	M1 A1
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1 (7)
		[15]
	Alternative to (c)	
	↖ $R = X\sin 30° + 0.8 \times 9.8\sin 60°$	M1 A2 (1,0)
	↙ $\mu R + 0.8g\cos 60° = X\cos 30°$	M1 A1
	$X = \frac{\mu 0.8g\sin 60° + 0.8g\cos 60°}{\cos 30° - \mu\sin 30°}$	
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1 (7)

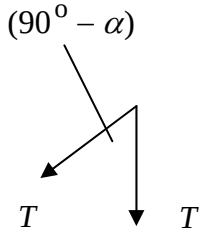
Question Number	Scheme	Marks
67.	(a) N2L A: $5mg - T = 5m \times \frac{1}{4}g$	M1 A1
	$T = \frac{15}{4}mg$ ✱ cso	A1 (3)
	(b) N2L B: $T - kmg = km \times \frac{1}{4}g$	M1 A1
	$k = 3$	A1 (3)
	(c) The tensions in the two parts of the string are the same	B1 (1)
	(d) Distance of A above ground $s_1 = \frac{1}{2} \times \frac{1}{4}g \times 1.2^2 = 0.18g \left(\approx 1.764\right)$	M1 A1
	Speed on reaching ground $v = \frac{1}{4}g \times 1.2 = 0.3g \left(\approx 2.94\right)$	M1 A1
	For B under gravity $\left(0.3g\right)^2 = 2gs_2 \Rightarrow s_2 = \frac{\left(0.3\right)^2}{2}g \left(\approx 0.441\right)$	M1 A1
	$S = 2s_1 + s_2 = 3.969 \approx 4.0$ (m)	A1 (7)
		[14]

Question Number	Scheme	Marks
68 (a)	$\tan\theta = \frac{p}{2p} \Rightarrow \theta = 26.6°$	M1 A1 (2)
(b)	$\mathbf{R} = (\mathbf{i} - 3\mathbf{j}) + (p\mathbf{i} + 2p\mathbf{j}) = (1 + p)\mathbf{i} + (-3 + 2p)\mathbf{j}$	M1 A1
	$\mathbf{R}$ is parallel to $\mathbf{i} \Rightarrow (-3 + 2p) = 0$	DM1
	$\Rightarrow p = \frac{3}{2}$	A1 (4) **[6]**

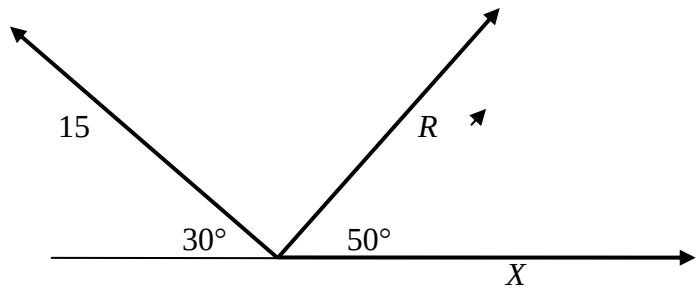
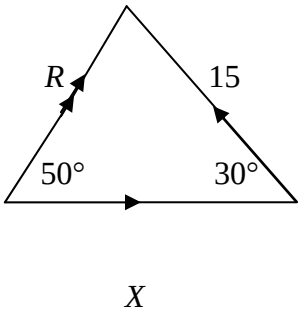
Question Number	Scheme	Marks
69	$0.5g\sin\theta - F = 0.5a$	M1 A1 A1
	$F = \frac{1}{3}R$ seen	B1
	$R = 0.5g\cos\theta$	M1 A1
	Use of $\sin\theta = \frac{4}{5}$ or $\cos\theta = \frac{3}{5}$ or decimal equiv or decimal angle e.g 53.1^o or 53^o	B1
	$a = \frac{3g}{5}$ or $5.88\ \text{m s}^{-2}$ or $5.9\ \text{m s}^{-2}$	DM1 A1 **[9]**
70	$F = P\cos 50^o$	M1 A1
	$F = 0.2R$ seen or implied.	B1
	$P\sin 50^o + R = 15g$	M1 A1 A1
	Eliminating R; Solving for P ; P = 37 (2 SF)	DM1;D M1; A1 **[9]**
71 (a)	For whole system: $1200 - 400 - 200 = 1000a$	M1 A1
	$a = 0.6\ \text{m s}^{-2}$	A1 (3)
(b)	For trailer: $T - 200 = 200$ x 0.6	M1 A1 **ft**
	$T = 320$ N	A1
	OR:	
	OR: For car: $1200 - 400 - T = 800$ x 0.6	M1 A1 **ft**
	$T = 320$ N	A1 (3)
(c)	For trailer: $200 + 100 = 200f$ or $-200f$	M1 A1
	$f = 1.5\ \text{m s}^{-2}$ (-1.5)	A1
	For car: $400 + F - 100 = 800f$ or $-800f$	M1 A2
	$F = 900$	A1 (7)
	(N.B. For both: $400 + 200 + F = 1000f$)	**[13]**

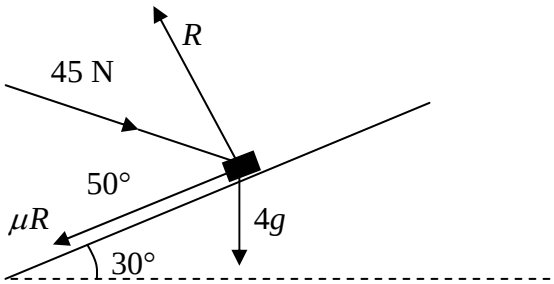
Question Number	Scheme	Marks
72 (a)		B2 -1 e.e.o.o. (labels not needed) (2)
(b)	$F = \frac{1}{2}R$ $(\uparrow),\ R\cos\alpha + F\sin\alpha = mg$ $R = \dfrac{1.1g}{(\cos\alpha + \frac{1}{2}\sin\alpha)} = 9.8$ N $(\rightarrow),\ P + \frac{1}{2}R\cos\alpha = R\sin\alpha$ $P = R(\sin\alpha - \frac{1}{2}\cos\alpha)$ $= 1.96$	B1 M1 A2 M1 A1 (6) M1 A2 M1 A1 (5) **[13]**

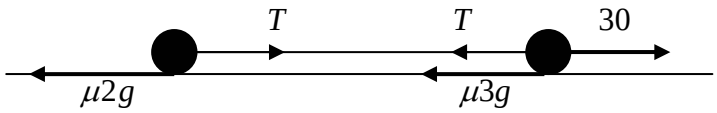
Question Number	Scheme	Marks
73 (a)	 $\tan\theta = \frac{2}{1} \Rightarrow \theta = 63.4^{o}$ angle is 153.4^{o}	M1 A1 A1 (3)
(b)	$(4+p)\mathbf{i} + (q-5)\mathbf{j}$ $(q-5) = -2(4+p)$ $2p + q + 3 = 0$ *	B1 M1 A1 A1 (4)
(c)	$q = 1 \Rightarrow p = -2$ $\Rightarrow \mathbf{R} = 2\mathbf{i} - 4\mathbf{j}$ $\Rightarrow \lvert\mathbf{R}\rvert = \sqrt{2^2 + (-4)^2} = \sqrt{20}$ $\sqrt{20} = m8\sqrt{5}$ $\Rightarrow m = \frac{1}{4}$	B1 M1 M1 A1 f.t. M1 A1 f.t. A1 cao (7) **[14]**

Question Number	Scheme	Marks
74 (a)	$T - 5g\sin\alpha = 5a$ $15g - T = 15a$ solving for a $a = 0.6g$ solving for T $T = 6g$	M1 A1 M1 A1 M1 A1 M1 A1 (8)
(b)	For Q : $5g - N = 5a$ $N = 2g$	M1 A1 A1 f.t. (3)
(c)	 $F = 2T\cos(\frac{90^o - \alpha}{2})$ $= 12g\cos 26.56..^o$ $= 105$ N	M1 A2 A1 f.t. A1 (5) **[16]**

Question Number	Scheme	Marks
75.	(a) $\tan\theta = \frac{8}{6}$ $\theta \approx 53°$	M1 A1 **(2)**
	(b) $\mathbf{F} = 0.4(6\mathbf{i} + 8\mathbf{j})$ $(= 2.4\mathbf{i} + 3.2\mathbf{j})$ $\lvert\mathbf{F}\rvert = \sqrt{(2.4^2 + 3.2^2)} = 4$ *The method marks can be gained in either order.*	M1 M1 A1 **(3)**
	(c) $\mathbf{v} = 9\mathbf{i} - 10\mathbf{j} + 5(6\mathbf{i} + 8\mathbf{j})$ $= 39\mathbf{i} + 30\mathbf{j}$ (ms^{-1})	M1 A1 A1 **(3)** **[8]**

Question Number	Scheme	Marks
76.	(a) 	
	$(\uparrow)\quad 15\sin 30° = R\sin 50°$	M1 A1
	$R \approx 9.79\ (\text{N})$	DM1 A1 **(4)**
	(b) $(\rightarrow)\ X - 15\cos 30° = R\cos 50°$ ft their R	M1 A2 ft
	$X \approx 19.3\ (\text{N})$	DM1 A1 **(5)** **[9]**
	Alternatives using sine rule in (a) or (b); cosine rule in (b)	
	 (a) $\frac{R}{\sin 30°} = \frac{15}{\sin 50°}$	M1 A1
	$R \approx 9.79\ (\text{N})$	DM1 A1 (4)
	(b) $\frac{X}{\sin 100°} = \frac{15}{\sin 50°} = \frac{R}{\sin 30°}$	M1 A2 ft on R
	$X \approx 19.3\ (\text{N})$	DM1 A1 (5)
	OR: cosine rule; any of $X^2 = R^2 + 15^2 - 2 \text{ x } 15 \text{ x } R\cos 100^o$ $R^2 = X^2 + 15^2 - 2 \text{ x } 15 \text{ x } X\cos 30^o$ $15^2 = R^2 + X^2 - 2 \text{ x } X \text{ x } R\cos 50^o$	M1 A2 ft on R
	$X \approx 19.3\ (\text{N})$	DM1 A1 (5)

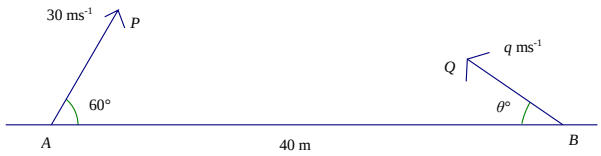
Question Number	Scheme	Marks
77.	(a) 	
	$R = 45\cos 40° + 4g\cos 30°$	M1 A2 (1, 0)
	$R \approx 68$ accept 68.4	DM1 A1 (5)
	(b) Use of $F = \mu R$	M1
	$F + 4g\sin 30 = 45\cos 50°$	M1 A2 (1, 0)
	Leading to $\mu \approx 0.14$ accept 0.136	DM1 A1 (6) **[11]**

Question Number	Scheme	Marks
78.	(a) 	
	$s = ut + \frac{1}{2}at^2 \quad \Rightarrow \quad 6 = \frac{1}{2}a \times 9$	M1
	$a = 1\frac{1}{3} \ \left(\text{ms}^{-2}\right)$	A1 **(2)**
	(b) N2L for system $30 - \mu 5g = 5a$ ft their a, accept symbol	M1 A1ft
	$\mu = \frac{14}{3g} = \frac{10}{21}$ or awrt 0.48	DM1 A1 **(4)**
	(c) N2L for P $T - \mu 2g = 2a$ ft their μ, their a, accept symbols	M1 A1 ft
	$T - \frac{14}{3g} \times 2g = 2 \times \frac{4}{3}$	
	Leading to $T = 12 \ \left(\text{N}\right)$ awrt 12	DM1 A1 **(4)**
	Alternatively N2L for Q	
	$30 - T - \mu 3g = 3a$	M1 A1
	Leading to $T = 12 \ \left(\text{N}\right)$ awrt 12	DM1 A1
	(d) The acceleration of P and Q (or the whole of the system) is the same.	B1 **(1)**
	(e) $v = u + at \quad \Rightarrow \quad v = \frac{4}{3} \times 3 = 4$	B1 ft on a
	N2L (for system or either particle)	
	$-5\mu g = 5a$ or equivalent	M1
	$a = -\mu g$	
	$v = u + at \quad \Rightarrow \quad 0 = 4 - \mu gt$	DM1
	Leading to $t = \frac{6}{7} \ \left(\text{s}\right)$ accept 0.86, 0.857	A1 **(4)**
		[15]

Question Number	Scheme	Marks
79.(a)	R (// plane): $49 \cos \theta = 6g \sin 30$	M1 A1
	$\Rightarrow \cos \theta = 3/5$ *	A1 (3)
(b)	R (perp to plane): $R = 6g \cos 30 + 49 \sin \theta$	M1 A1
	$R \approx$ 90.1 or 90 N	DM1 A1 (4)
(c)	R (// to plane): $49 \cos 30 - 6g \sin 30 = 6a$	M1 A2,1,0
	$\Rightarrow a \approx 2.17$ or 2.2 m s^{-2}	A1 (4)
		11

Question Number	Scheme	Marks
80.(a)	B: $2mg - T = 2m \times 4g/9$	M1 A1
	$\Rightarrow T = \underline{10mg/9}$	A1 (3)
(b)	A: $T - \mu \underline{mg} = m \times 4g/9$	M1 B1 A1
	Sub for T and solve: $\mu = 2/3$ *****	DM1 A1 (5)
(c)	When B hits: $v^2 = 2 \times 4g/9 \times h$	M1 A1
	Deceleration of A after B hits: $ma = \mu mg \Rightarrow a = 2g/3$	M1 A1 f.t.
	Speed of A at P: $V^2 = 8gh/9 - 2 \times 2g/3 \times h/3$	DM1
	$\Rightarrow V = \frac{2}{3}\sqrt{(gh)}$	A1 (6)
(d)	Same tension on A and B	B1 (1)
		15

Q	Scheme	Marks	Notes
81a	Differentiate **v**: $\mathbf{a}=(4-6t)\mathbf{i}+(-8+2t)\mathbf{j}$	M1A1	Anywhere in (a)
	Use of $\mathbf{F}=m\mathbf{a}$ and substitute $t=3$: $\mathbf{F}=0.5\left((4-6\times3)\mathbf{i}+(-8+2\times3)\mathbf{j}\right)=-7\mathbf{i}-\mathbf{j}$	DM1	Dependent on the first M1
	Use of Pythagoras' theorem:	DM1	Dependent on the first M1
			NB Could use Pythagoras and then use $\mathbf{F}=m\mathbf{a}$. 1st M1 – 1st step. 2nd M1 - 2nd step
	$\lvert\mathbf{F}\rvert=\sqrt{49+1}=\sqrt{50}\left(=5\sqrt{2}=7.07...\right)$	A1	7.1 or better
	For **v**, **i** component= **j** component: $\left(4t-3t^2\right)=\left(-40-8t+t^2\right)$	M1	With no incorrect equations in t seen
	Solve for t: $4t^2-12t-40=0,\ \Rightarrow\ t^2-3t-10=0$ $(t-5)(t+2)=0\ ,\ t=5$	DM1 A1	Dependent on the previous M, Must see method if solving an incorrect quadratic Only - could be implied by later rejection of -2
	$\mathbf{a}=(4-30)\mathbf{i}+(-8+10)\mathbf{j}=-26\mathbf{i}+2\mathbf{j}$ (ms^{-2})	A1	Only
		(9)	
81b	Integrate **v**: $\mathbf{r}=\left(2t^2-t^3(+p)\right)\mathbf{i}+\left(-40t-4t^2+\frac{1}{3}t^3(+q)\right)\mathbf{j}$	M1 A2	-1 ee
	$\mathbf{r}_1=\mathbf{i}-43\frac{2}{3}\mathbf{j}$, $\mathbf{r}_2=-93\frac{1}{3}\mathbf{j}$ $\quad\overrightarrow{AB}=\mathbf{r}_2-\mathbf{r}_1$	DM1	$\left(\frac{131}{3},\ \frac{280}{3}\right)$ Use limits in a definite integral or to evaluate a constant of integration Dependent on the previous M1
	$\overrightarrow{AB}=-\mathbf{i}-49\frac{2}{3}\mathbf{j}\left(=-\mathbf{i}-\frac{149}{3}\mathbf{j}\right)$	A1	49.7 or better
		(5)	
		[14]	

Q.	Scheme	Marks	Notes
82a			
	$30\cos 60\times 2+q\cos\theta\times 2=40$	M1	Equation for horizontal distance Need to be using the 40 m
		A1	Correct unsimplified
	$30\sin 60\times 2-4.9\times 4=q\sin\theta\times 2-4.9\times 4$ $30\sin 60=q\sin\theta$	M1	Equal vertical distance or initial vertical components of velocity
		A1	Correct unsimplified (no error seen)
	$q\cos\theta=\pm 5$ $q\sin\theta=15\sqrt{3}$		
	$\tan\theta=3\sqrt{3}$ $(\tan\theta=6\sin 60)$	DM1	Solve for q or θ Dependent on both preceding M marks
	$\theta=79.1$ (79)		(1.38 radians) or better
	$q=26.45...=26.5$	A1	(26 or better) $(10\sqrt{7})$ Both correct and no error seen
		(6)	
82b	Vertical component of speed =	M1	Must be working towards speed of P (or v^2) (condone if working on Q - they equal vertical components of velocity)
	$30\sin 60-2g\,(=6.38...)$	A1	Correct unsimplified. Accept ±
	speed $=\sqrt{(30\cos 60)^2+6.38^2}$	DM1	Use Pythagoras. Dependent on previous M Follow their vertical component.
		A1ft	Correct unsimplified equation in v or v^2.
	$=\sqrt{15^2+6.38^2}=16.3\,(\text{m s}^{-1})$	A1	or 16 2 or 3 sf only
		(5)	
82b alt	Vertical distance =	M1	Must be working towards speed of P
	$30\sin 60\times 2-4.9\times 4=32.36$	A1	Correct unsimplified
	Conservation of energy:	DM1	Dependent on previous M. Follow their vertical distance.
	$\frac{1}{2}mv^2+mg\times 32.36=\frac{1}{2}m\times 900$	A1ft	Correct unsimplified equation in v or v^2.
	$v=16.3$ (m s^{-1}) (16)	A1	
		(5)	
		[11]	

Question Number	Scheme	Marks	Notes
83 **(a)**	$M(A), F.4\sin 40^o = 5g.2\cos 25^o$	M1	A complete method to find F , e.g. take moments about A. Condone sin/cos confusion. Requires correct ratio of lengths.
		A1	Correct terms with at most one slip
		A1	All correct
	$F = 35$	A1	35 or 34.5 (>3sf not acceptable due to use of 9.8, but only penalise once in a question)
		(4)	
(b)	$F\cos 75^o \pm Y = 5g$	M1	Resolve vertically. Need all three terms but condone sign errors. Must be attempting to work with their 75° or 15°.
		A1	Correct equation (their F)
	$Y = 40$;	A1	40 or 40.1
	UP	A1	Apply ISW if the candidate goes on to find R. cso (the Q does specifically ask for the direction, so this must be clearly stated)
		(4)	
		8	
(b)	OR1: $4m\cos 25 \times Y = 5g \times 2m\cos 25 + F\cos 15 \times 4m\sin 25$ etc.	M1 A1	Taking moments about the point vertically below B and on the same horizontal level as A.(Their F)
	OR2: $R\cos\alpha = F\cos 40 + 5g\cos 65$ $R\sin\alpha + F\sin 40 = 5g\cos 25$		Resolve parallel & perpendicular to the rod
	R=52.1, α=25.3°		Solve for R, α
	$Y = R\sin(25+\alpha)$ Etc.	M1A1	Need a complete strategy to find Y for M1.

Question Number	Scheme	Marks
84.	(a) N2L $(6t-5)\mathbf{i}+(t^2-2t)\mathbf{j}=0.5\mathbf{a}$	M1
	$\mathbf{a}=(12t-10)\mathbf{i}+(2t^2-4t)\mathbf{j}$	A1
	$\mathbf{v}=(6t^2-10t)\mathbf{i}+\left(\frac{2}{3}t^3-2t^2\right)\mathbf{j}\quad(+\mathbf{C})$ ft their **a**	M1 A1ft+A1ft
	$\mathbf{v}=(6t^2-10t+1)\mathbf{i}+\left(\frac{2}{3}t^3-2t^2-4\right)\mathbf{j}$	A1 **(6)**
	(b) When $t=3$, $\mathbf{v}_3=25\mathbf{i}-4\mathbf{j}$	M1
	$-5\mathbf{i}+12\mathbf{j}=0.5(\mathbf{v}-(25\mathbf{i}-4\mathbf{j}))$ ft their $\mathbf{v}_3$	M1 A1ft
	$\mathbf{v}=15\mathbf{i}+20\mathbf{j}$	A1
	$\lvert\mathbf{v}\rvert=\sqrt{(15^2+20^2)}=25\quad(\text{ms}^{-1})$ cso	M1 A1 **(6)**
		[12]