Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 8 June 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WME01/01

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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1. A car is moving along a straight horizontal road with constant acceleration a m s^{-2} ($a > 0$). At time $t = 0$ the car passes the point P moving with speed u m s^{-1}. In the next 4 s, the car travels 76 m and then in the following 6 s it travels a further 219 m.

Find

(i) the value of u,

(ii) the value of a.

(7)

Question Number	Scheme	Marks	Notes
1.	$76 = 4u + \frac{1}{2}a.4^2$ or $76 = \frac{1}{2}\left(u + \overline{u+4a}\right)\times 4$	M1	Use of $s = ut + \frac{1}{2}at^2$ for $t = 4, s = 76$ and $u \neq 0$ (use of $u = 0$ is M0)
	$(38 = 2u + 4a)$	A1	Correctly substituted equation
	$295 = 10u + \frac{1}{2}a.10^2$ or $295 = \frac{1}{2}\left(u + \overline{u+10a}\right)\times 10$ or $295 = \left(u+10a\right)\times 10 - \frac{1}{2}a\times 100$	M1	Use of $s = ut + \frac{1}{2}at^2$ for $t = 10, s = 295$ or $s = u't + \frac{1}{2}at^2$ for $t = 6, s = 219, u' \neq u$
	$(59 = 2u + 10a)$ or $219 = \left(19+2a\right)\times 6 + \frac{1}{2}a\times 6^2$ or $219 = \left(38-u\right)\times 6 + \frac{1}{2}a\times 6^2$ or $219 = \left(u+4a\right)\times 6 + \frac{1}{2}a\times 6^2$ or $219 = \frac{1}{2}\left(\overline{u+4a} + \overline{u+10}\right)\times 6$ or $219 = (u+10a)\times 6 - \frac{1}{2}a\times 36$	A1	Correctly substituted equation
		DM1	Solve simultaneous for *u* or for *a* This marks is not available if they have assumed a value for *u* or *a* in the preceding work - it is dependent on the first 2 M marks
	$u = 12$	A1	
	$a = 3.5$	A1	
		[7]	
1 Alt	$t = 2,\ v_2 = \frac{76}{4} = 19 \quad t = 7,\ v_7 = \frac{219}{6} = 36.5$	M1 A1	Find the speed at $t = 2, t = 7$ Both values correct Averages with no links to times is M0
	$36.5 = 19 + 5a \Rightarrow a = 3.5$	M1 A1	Use of $v = u + 5a$ with their *u*,*v* Correct *a*
	$19 = u + 2a$	DM1 A1	Complete method for finding *u* Correct equation in *u*
	$u = 19 - 7 = 12$	A1	

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2. Two particles P and Q are moving in opposite directions along the same horizontal straight line. Particle P has mass m and particle Q has mass km. The particles collide directly. Immediately before the collision, the speed of P is u and the speed of Q is $2u$. As a result of the collision, the direction of motion of each particle is reversed and the speed of each particle is halved.

(a) Find the value of k.

(4)

(b) Find, in terms of m and u only, the magnitude of the impulse exerted on Q by P in the collision.

(2)

Question Number	Scheme	Marks	Notes
2.(a)	$mu - 2kmu = -\frac{1}{2}mu + kmu$ OR $m\left(\frac{1}{2}u + u\right) = -km\left(-u - 2u\right)$	M1	Use of CLM OR Equal and opposite impulses Need all 4 terms dimensionally correct. Masses and speeds must be paired correctly Condone sign errors Condone factor of g throughout.
		A1	Unsimplified equation with at most one error
		A1	Correct unsimplified equation
	$k = \frac{1}{2}$	A1	From correct working only
		(4)	
2.(b)	For $P: I = \pm m(\frac{1}{2}u \pm -u)$ For Q: $I = \pm km(u \pm -2u)$	M1	Impulse on *P* or impulse on *Q*. Mass must be used with the correct speeds e.g. $km \times \frac{1}{2}u$ is M0 If working on *Q*, allow equation using their *k*. Terms must be dimensionally correct. Use of g is M0
	$\frac{3mu}{2}$	A1	Only From correct working only
		(2)	
		[6]	

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3. A block A of mass 9 kg is released from rest from a point P which is a height h metres above horizontal soft ground. The block falls and strikes another block B of mass 1.5 kg which is on the ground vertically below P. The speed of A immediately before it strikes B is 7 m s^{-1}. The blocks are modelled as particles.

(a) Find the value of h.

(2)

Immediately after the impact the blocks move downwards together with the same speed and both come to rest after sinking a vertical distance of 12 cm into the ground. Assuming that the resistance offered by the ground has constant magnitude R newtons,

(b) find the value of R.

(8)

Question Number	Scheme	Marks	Notes
3.(a)	$7^2 = 2 \text{ x } 9.8h$	M1	Use of $v^2 = u^2 + 2as$ with $u = 0, v = 7$ or alternative complete method to find *h*.
	$h = 2.5$	A1	Condone $h = -2.5$ in the working but the final answer must be positive.
		(2)	
3.(b)	$9 \text{ x } 7 = 10.5\, u$	M1	Use CLM to find the speed of the blocks after the impact. Condone additional factor of g throughout.
	$u = 6$	A1	
	$0^2 = 6^2 - 2a \text{ x } 0.12$	M1	Use of $v^2 = u^2 + 2as$ with $u = 6, v = 0$ Allow for their *u* and $v = 0$ Allow for $u = 7, v = 0$ Accept alternative *suvat* method to form an equation in *a*. Condone use of 12 for 0.12
		A1	Correctly substituted equation in *a* with $u = 6, s = 0.12$ $(\text{implied by } a = 150)$
	$(\downarrow)\ 10.5g - R = 10.5 \text{ x } (-a)$	M1	Use of $F = ma$ with their $a \neq \pm g$. Must have all 3 terms and 10.5 Condone sign error(s)
	$(\downarrow)\ 10.5g - R = 10.5 \text{ x } (-150)$	A1	Unsimplified equation with *a* substituted and at most one error (their *a* with the wrong sign is 1 error)
		A1	Correct unsimplified equation with *a* substituted
	$R = 1680$ or 1700	A1	
		(8)	
	Alternative for the last 6 marks:		
	$\frac{1}{2} \times 10.5 \times 6^2 + 10.5 \times 9.8 \times 0.12 = R \times 0.12$	M2	Energy equation (needs all three terms)
		A3	-1 each error A1A1A0 for 1 error, A1A0A0 for 2 errors
	$R = 1680$ or 1700	A1	
		[10]	

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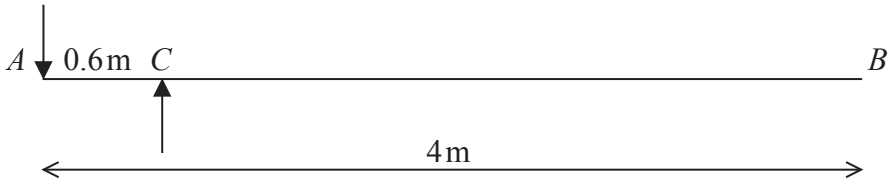


Figure 1

A diving board AB consists of a wooden plank of length 4 m and mass 30 kg. The plank is held at rest in a horizontal position by two supports at the points A and C, where $AC = 0.6$ m, as shown in Figure 1. The force on the plank at A acts vertically downwards and the force on the plank at C acts vertically upwards.

A diver of mass 50 kg is standing on the board at the end B. The diver is modelled as a particle and the plank is modelled as a uniform rod. The plank is in equilibrium.

(a) Find

(i) the magnitude of the force acting on the plank at A,

(ii) the magnitude of the force acting on the plank at C.

(6)

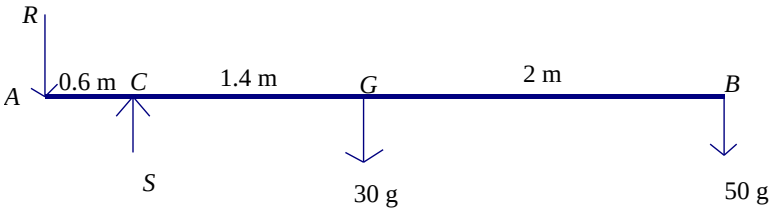
The support at A will break if subjected to a force whose magnitude is greater than 5000 N.

(b) Find, in kg, the greatest integer mass of a diver who can stand on the board at B without breaking the support at A.

(3)

(c) Explain how you have used the fact that the diver is modelled as a particle.

(1)

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

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5. Two forces, $\mathbf{F}_1$ and $\mathbf{F}_2$, act on a particle A.

$\mathbf{F}_1 = (2\mathbf{i} - 3\mathbf{j})$ N and $\mathbf{F}_2 = (p\mathbf{i} + q\mathbf{j})$ N, where p and q are constants.

Given that the resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ is parallel to $(\mathbf{i} + 2\mathbf{j})$,

(a) show that $2p - q + 7 = 0$

(5)

Given that $q = 11$ and that the mass of A is 2 kg, and that $\mathbf{F}_1$ and $\mathbf{F}_2$ are the only forces acting on A,

(b) find the magnitude of the acceleration of A.

(5)

Question Number	Scheme	Marks	Notes
5.(a)	$(2\mathbf{i}-3\mathbf{j})+(p\mathbf{i}+q\mathbf{j})=(p+2)\mathbf{i}+(q-3)\mathbf{j}$	M1	Resultant force = $\mathbf{F}_1+\mathbf{F}_2$ in the form $a\mathbf{i}+b\mathbf{j}$
	$\frac{p+2}{q-3}=\frac{1}{2}$ or $\left.\begin{matrix}p+2=n\\q-3=2n\end{matrix}\right\}$ for $n\neq 1$	M1	Use parallel vector to form a scalar equation in p and q.
		A1	Correct equation (accept any equivalent form)
	$4+2p=-3+q$	DM1	Dependent on no errors seen in comparing the vectors. Rearrange to obtain given answer. At least one stage of working between the fraction and the given answer
	$2p-q+7=0$	A1	**Given Answer**
		(5)	
5.(b)	$q=11\Rightarrow p=2$	B1	
	$\mathbf{R}=4\mathbf{i}+8\mathbf{j}$	M1	$(2+p)\mathbf{i}+8\mathbf{j}$ for their p
	$4\mathbf{i}+8\mathbf{j}=2\mathbf{a}$ $(\mathbf{a}=2\mathbf{i}+4\mathbf{j})$	M1	Use of $\mathbf{F}=m\mathbf{a}$
	$\lvert\mathbf{a}\rvert=\sqrt{2^2+4^2}$	DM1	Correct method for $\lvert\mathbf{a}\rvert$ Dependent on the preceding M1
	$=\sqrt{20}$ = 4.5 or 4.47 or better (m s^{-2})	A1	$2\sqrt{5}$
		(5)	
	Alternative for the last two M marks:		
	$\lvert\mathbf{F}\rvert=\sqrt{16+64}\left(=\sqrt{80}\right)$ M1		Correct method for $\lvert\mathbf{F}\rvert$
	$\sqrt{80}=2\times\lvert\mathbf{a}\rvert$ DM1		Use of $\lvert\mathbf{F}\rvert=m\lvert\mathbf{a}\rvert$ Dependent on the preceding M1
		[10]	

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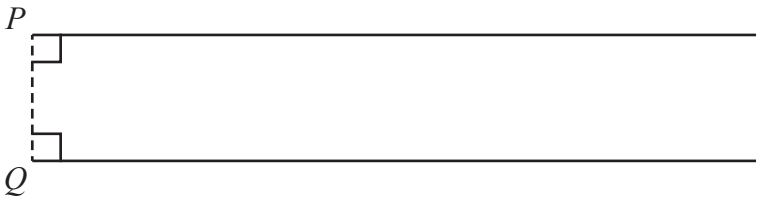


Figure 2

Two cars, A and B, move on parallel straight horizontal tracks. Initially A and B are both at rest with A at the point P and B at the point Q, as shown in Figure 2. At time $t = 0$ seconds, A starts to move with constant acceleration a m s^{-2} for 3.5 s, reaching a speed of 14 m s^{-1}. Car A then moves with constant speed 14 m s^{-1}.

(a) Find the value of a.

(2)

Car B also starts to move at time $t = 0$ seconds, in the same direction as car A. Car B moves with a constant acceleration of 3 m s^{-2}. At time $t = T$ seconds, B overtakes A. At this instant A is moving with constant speed.

(b) On a diagram, sketch, on the same axes, a speed-time graph for the motion of A for the interval $0 \leqslant t \leqslant T$ and a speed-time graph for the motion of B for the interval $0 \leqslant t \leqslant T$.

(3)

(c) Find the value of T.

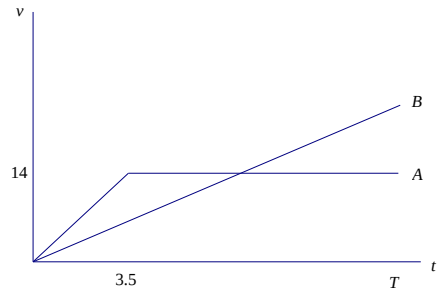
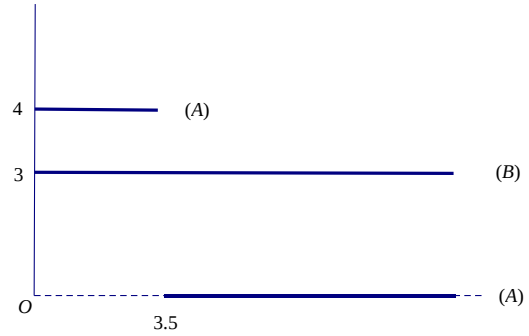
(8)

(d) Find the distance of car B from the point Q when B overtakes A.

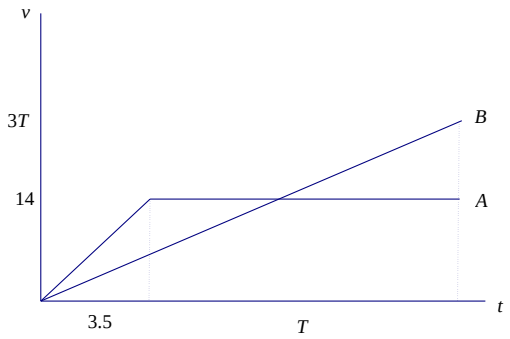
(1)

(e) On a new diagram, sketch, on the same axes, an acceleration-time graph for the motion of A for the interval $0 \leqslant t \leqslant T$ and an acceleration-time graph for the motion of B for the interval $0 \leqslant t \leqslant T$.

(3)

Question Number	Scheme	Marks	Notes
6.(a)	$v = u + at \Rightarrow 14 = 3.5a$	M1	Use of *suvat* to form an equation in a
	$a = 4$	A1(2)	
6.(b)		B1	Graph for A or B
		B1	Second graph correct and both graphs extending beyond the point of intersection
		B1	Values 3.5, 14, T shown on axes, with T not at the point of intersection. Accept labels with delineators.
		(3)	NB 2 separate diagrams scores max B1B0B1
6.(c)	$\frac{1}{2}T.3T$, $\frac{(T+T-3.5)}{2}.14$	M1	Find distance for A or B in terms of T only. Correct area formulae: must see $\frac{1}{2}$ in area formula and be adding in trapezium
		A1	One distance correct
		A1	Both distances correct
	$\frac{1}{2}T.3T = \frac{(T+T-3.5)}{2}.14$ $\frac{1}{2}T.3T = \frac{1}{2}\times 4\times 3.5^2 + 14(T-3.5)$	M1	Equate distances and simplify to a 3 term quadratic in T in the form $aT^2 + bT + c = 0$
	$3T^2 - 28T + 49 = 0$	A1	Correct quadratic
	$(3T-7)(T-7) = 0$	M1	Solve 3 term quadratic for T
	$T = \frac{7}{3}$ or 7	A1	Correct solution(s) - can be implied if only ever see $T = 7$ from correct work.
	but $T > 3.5$, $T = 7$	A1 (8)	
6.(d)	73.5 m	B1 (1)	From correct work only. B0 if extra answers.
6.(e)		B1	(*A*) Condone missing 4
		B1	(*B*) Condone graph going beyond $T = 7$ Must go beyond 3.5. Condone no 3.
		B1 (3)	(*A*) Condone graph going beyond $T = 7$ Must go beyond 3.5. B0 if see a solid vertical line. Sometimes very difficult to see. If you think it is there, give the mark.
		[17]	Condone separate diagrams.

See next page

	Alternative for (c) for candidates with a sketch like this: 	B1 B1 B0	Treat as a special case. B1B1B0 on the graph and then max 5/8 for (c) if they do not solve for the *T* in the question.
	$\frac{1}{2}\times 3\times (T+3.5)^2 = \frac{1}{2}\times 4\times 3.5^2 + 14T$	M1	Use diagram to find area
		A1	One distance correct
		A1	Both distances correct
	$12T^2 - 28T - 49 = 0$	M1	Simplify to a 3 term quadratic in *T*
		A1	Correct quadratic
	$(2T-7)(6T+7)=0$	M1	Complete method to solve for the *T* in the question
	$T = \frac{7}{2}$ or $\frac{-7}{6}$	A1	Correct solution(s) - can be implied if only ever see $\text{Total} = 7$
	$\text{Total time} = 7$	A1 (8)	

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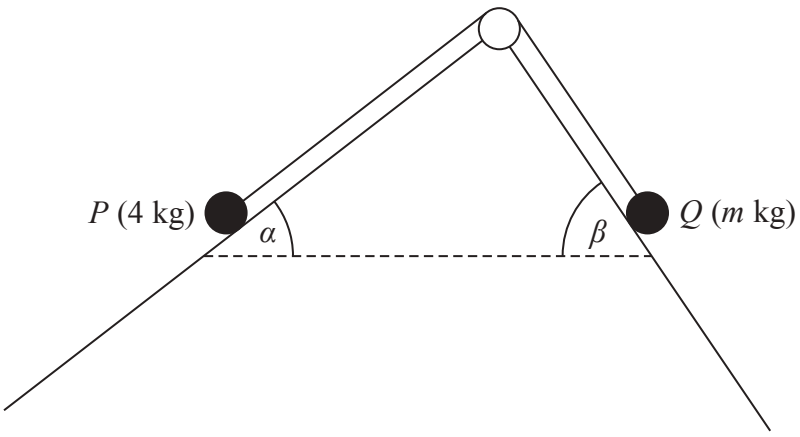

Figure 3

A particle P of mass 4 kg is attached to one end of a light inextensible string. A particle Q of mass m kg is attached to the other end of the string. The string passes over a small smooth pulley which is fixed at a point on the intersection of two fixed inclined planes. The string lies in a vertical plane that contains a line of greatest slope of each of the two inclined planes. The first plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$ and the second plane is inclined to the horizontal at an angle β, where $\tan\beta = \frac{4}{3}$. Particle P is on the first plane and particle Q is on the second plane with the string taut, as shown in Figure 3.

The first plane is rough and the coefficient of friction between P and the plane is $\frac{1}{4}$. The second plane is smooth. The system is in limiting equilibrium.

Given that P is on the point of slipping down the first plane,

(a) find the value of m,

(10)

(b) find the magnitude of the force exerted on the pulley by the string,

(4)

(c) find the direction of the force exerted on the pulley by the string.

(1)

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Question Number	Scheme	Marks	Notes
7.(a)	$F = 0.25R$	B1	
	$\sin\alpha = \frac{3}{5}$ or $\cos\alpha = \frac{4}{5}$ $\sin\beta = \frac{4}{5}$ or $\cos\beta = \frac{3}{5}$	B1	Use of correct trig ratios for α or β
	$R = 4g\cos\alpha$ (31.36)	M1	Normal reaction on *P* Condone trig confusion (using α)
		A1	Correct equation
	$T + F = 4g\sin\alpha$	M1	Equation of motion for *P*. Requires all 3 terms. Condone consistent trig confusion Condone an acceleration not equated to 0 : $T + F - 4g\sin\alpha = 4a$
	$(T + 7.84 = 23.52)$ $(T = 15.68)$	A1	Correct equation
	$T = mg\sin\beta$	M1	Equation of motion for *Q* Condone trig confusion Condone an acceleration not equated to 0: $T - mg\sin\beta = -ma$
	$(T = 7.84m)$	A1	Correct equation
	Solve for *m*	DM1	Dependent on the 3 preceding M marks Not available if their equations used $a \neq 0$
	$m = 2$	A1	
	NB Condone a whole system equation $4g\sin\alpha - F = mg\sin\beta$ followed by $m = 2$ for 6/6 M2 for an equation with all 3 terms. Condon trig confusion. Condone an acceleration $\neq 0$ A2 (-1 each error) for a correct equation:		
		(10)	
7.(b)	$F = \sqrt{T^2 + T^2}$ or $2T\cos 45°$ or $\frac{T}{\cos 45}$	M1	Complete method for finding *F* in terms of *T* Accept $\sqrt{(R_h)^2 + (R_v)^2}$
		A1	Correct expression in *T*
		DM1	Substitute their *T* into a correct expression Dependent on the previous M mark
	$F = \sqrt{2}\frac{8g}{5} = 22$ or 22.2 (N)	A1	Watch out - resolving vertically is not a correct method and gives 21.9 N.
		(4)	
7.(c)	Along the angle bisector at the pulley	B1 (1)	Or equivalent - accept angle + arrow shown on diagram. ($8.1°$ to downward vertical) Do not accept a bearing
		[15]	