Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number	Candidate Number

Mechanics M1

Advanced/Advanced Subsidiary

Monday 22 January 2018 – Afternoon
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 $g = 9.8 \text{ m s}^{-2}$, 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

Pearson

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1.

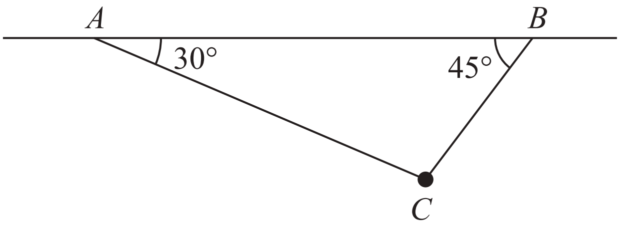


Figure 1

A particle of weight W is attached at C to two light inextensible strings AC and BC. The other ends of the strings are attached to fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with the strings in a vertical plane and with AC and BC inclined to the horizontal at 30° and 45° respectively, as shown in Figure 1.

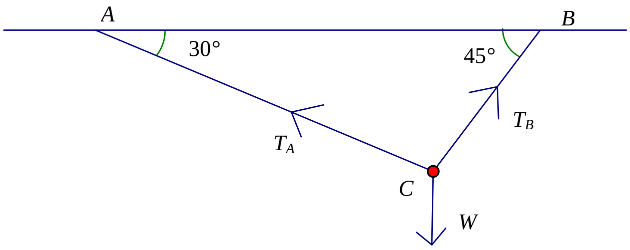
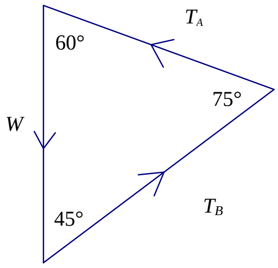
Find, in terms of W,

(i) the tension in AC,

(ii) the tension in BC.

(7)

January 2018
Mechanics 1 - WME01
Mark Scheme

Question Number	Scheme	Marks
1		
	N.B. If they assume that the tensions are the same, can score max:M0A0M1A0DM0A0A0. **If they use the same angles, can score max: M1A0M1A0DM0A0A0**	
	Resolve parallel to *AB*: $T_A \cos 30 = T_B \cos 45$	M1A1
	Resolve perpendicular to *AB*: $W = T_A \sin 30 + T_B \sin 45$	M1A1
	Solve for T_A or T_B	**DM**1
	$T_A = \frac{2}{1+\sqrt{3}}W\left(=0.73W\right)$ (or better)	A1
	$T_B = \frac{\sqrt{6}}{1+\sqrt{3}}W\left(=0.90W\right)$ (or better)	A1
		(7)
	Alternative (triangle of forces):	
		
	Sine rule for T_A: $\frac{T_A}{\sin 45} = \frac{W}{\sin 75}$ M1A1	
	Sine rule for T_B: $\frac{T_B}{\sin 60} = \frac{W}{\sin 75}$ M1A1	
	Solve for T_A or T_B: $T_A = 0.73W$ (or better) **DM**1A1	
	$T_B = 0.90W$ (or better) A1	
	(7)	
		[7]

Question Number	Scheme	Marks
	Notes for question 1	
1	First M1 for resolving horizontally with usual rules	
	First A1 for a correct equation	
	Second M1 for resolving vertically with usual rules	
	Second A1 for a correct equation	
	Third **DM**1, dependent on both previous M marks, for solving for either T_A or T_B	
	Third A1 for $T_A = 0.73W$ or better or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal. Allow 'invisible brackets'	
	Fourth A1 for $T_B = 0.90W$ or better ($0.9W$ is A0) or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal.	
	Alternative using sine rule or Lami's Theorem	
	First M1A1 for $\frac{T_A}{\sin 45} = \frac{W}{\sin 75}$ oe (e.g. allow sin 105 or reciprocals)	
	Second M1 for $\frac{T_B}{\sin 60} = \frac{W}{\sin 75}$ (allow sin 30 and/or sin 105)	
	Second A1 for $\frac{T_B}{\sin 60} = \frac{W}{\sin 75}$	
	Third **DM**1, dependent on either previous M mark, for solving for either T_A or T_B	
	Third A1 for $T_A = 0.73W$ or better or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal.	
	Fourth A1 for $T_B = 0.90W$ or better or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal.	

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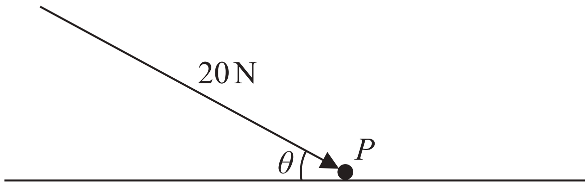


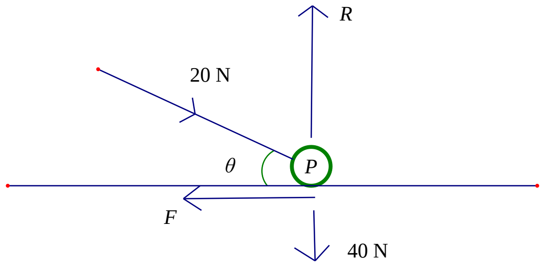
Figure 2

A particle P of weight 40 N lies at rest in equilibrium on a fixed rough horizontal surface. A force of magnitude 20 N is applied to P. The force acts at angle θ to the horizontal, as shown in Figure 2. The coefficient of friction between P and the surface is μ.

Given that the particle remains at rest, show that

$$\mu \geqslant \frac{\cos\theta}{2 + \sin\theta}$$

(6)

Question Number	Scheme	Marks
2.		
	Resolve horizontally: $F = 20\cos\theta$ **Their** F e.g. allow μR	M1A1
	Resolve vertically: $R = 40 + 20\sin\theta$	M1A1
	Use of $F \le \mu R$: $20\cos\theta \le \mu(40 + 20\sin\theta)$	**DM**1
	$\mu \ge \dfrac{20\cos\theta}{40 + 20\sin\theta} \Rightarrow \mu \ge \dfrac{\cos\theta}{2 + \sin\theta}$ **Given Answer**	A1
		[6]
	Notes for question 2	
2	First M1 for resolving horizontally with usual rules	
	First A1 for a correct **equation**	
	Second M1 for resolving vertically with usual rules	
	Second A1 for a correct **equation**	
	Third **DM**1, dependent on both previous M marks, for use of $F \le \mu R$ to give **inequality** in θ only. (N.B. If they use $F = \mu R$ in the horizontal resolution, this mark is not available)	
	Third A1 for given answer	

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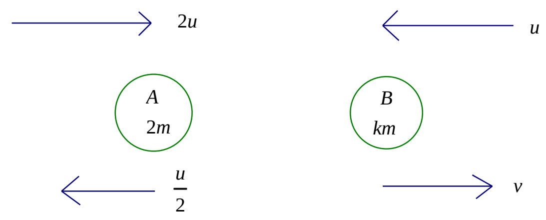
3. Two particles A and B have mass $2m$ and km respectively. The particles are moving in opposite directions along the same straight smooth horizontal line so that the particles collide directly. Immediately before the collision A has speed $2u$ and B has speed u. The direction of motion of each particle is reversed by the collision. Immediately after the collision the speed of A is $\frac{u}{2}$.

(a) Find, in terms of m and u, the magnitude of the impulse exerted by B on A in the collision.

(3)

(b) Show that $k < 5$

(4)

Question Number	Scheme	Marks
3a		
	Impulse on A $= 2m\left(\frac{u}{2} - (-2u)\right)$	M1A1
	Magnitude of impulse $= 5mu$	A1
		(3)
3b	CLM: $2m \times 2u - km \times u = 2m \times \left(-\frac{u}{2}\right) + kmv$	M1A1
	Use of $v > 0$: $kmv = 5mu - kmu > 0$	**DM**1
	$\Rightarrow k < 5$ **Given Answer**	A1
		(4)
3b alt	**Alternative**: Impulse on B: $5mu = km(v - (-u))$ M1A1	
	$v = \frac{5u}{k} - u$ **OR** $k = \frac{5u}{u+v}$	
	Use of $v > 0$: $\frac{5u}{k} - u > 0 \Rightarrow k < 5$ **OR** if $v >$ 0, then $k < 5$ **Given Answer** **DM**1A1	
	(4)	
		[7]
	Notes for question 3	
3a	M1 for using impulse = change in momentum for A (M0 if *clearly* adding momenta or if g is included or if not using $2m$ in *both* terms) but condone sign errors.	
	First A1 for $2m\left(\frac{u}{2} - (-2u)\right)$ or $-2m\left(\frac{u}{2} - (-2u)\right)$	
	Second A1 for $5mu$ (must be positive since magnitude) terms collected	
3a alt	**Alternative**: Use CLM to find $v = \frac{5u}{k} - u$ then use Impulse on B: $= km\ ((5u/k\ - u) + u)$ M1A1 for the <u>complete</u> method $= 5mu$ A1	
3b	First M1 for CLM with correct no. of terms, all dimensionally correct. Condone consistent g's or cancelled m's and sign errors.	
	First A1 for a correct equation (allow $-v$ in place of v)	
	Second **DM**1 for use of $v > 0$ or $v < 0$ as appropriate	
	Second A1 for given answer correctly obtained.	

Question Number	Scheme	Marks
3balt	First M1 for using their impulse on *A* = change in momentum for *B* (M0 if *clearly* adding momenta or if *g* is included or if not using *km* in *both* terms) but condone sign errors.	
	First A1 for a correct equation (allow $-v$ in place of v)	
	Second **DM**1 for use of $v > 0$ or $v < 0$, as appropriate, but must be from a correct v or k, to deduce given answer.	
	Second A1 for given answer correctly obtained.	

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4. A package of mass 6 kg is held at rest at a fixed point A on a rough plane. The plane is inclined at 30° to the horizontal. The package is released from rest and slides down a line of greatest slope of the plane. The coefficient of friction between the package and the plane is $\frac{1}{4}$. The package is modelled as a particle.

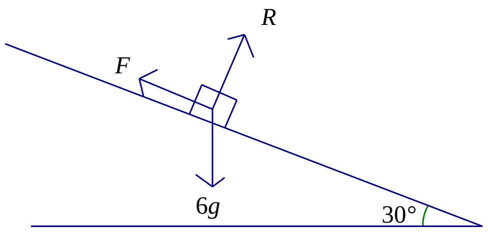
(a) Find the magnitude of the acceleration of the package.

(6)

As it slides down the slope the package passes through the point B, where $AB = 10$ m.

(b) Find the speed of the package as it passes through B.

(2)

Question Number	Scheme	Marks
4a		
	Perpendicular to plane: $R = 6g\cos 30$	B1
	Parallel to plane: $6g\sin 30 - F = 6a$ **N.B.** Could be their F	M1A1
	$F = \frac{1}{4}R$ seen. **N.B.** Could be their R	B1
	Solve for a : $a = 2.78$ (2.8) (ms^{-2})	M1A1
		(6)
4b	Use of *suvat*: $v^2 = u^2 + 2as = 2 \times 2.78 \times 10$	M1
	$v = 7.45417... = 7.45$ (7.5) (ms^{-1})	A1
		(2)
		[8]
	Notes for question 4	
4a	First B1 for R = 6gcos 30 seen	
	First M1 for resolving parallel to the plane with usual rules	
	First A1 for a correct equation **N.B.** F does not need to be substituted for this A mark	
	Second B1 for $F = \frac{1}{4}R$ seen **N.B.** could be their R	
	Second M1 for solving for a	
	Second A1 for 2.78 or 2.8	
4b	M1 for a complete method for finding v, using their a	
	A1 for 7.45 or 7.5	

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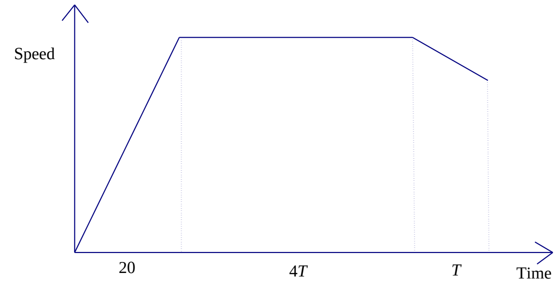
5. A cyclist is travelling along a straight horizontal road. The cyclist starts from rest at point A on the road and accelerates uniformly at 0.6 m s^{-2} for 20 seconds. He then moves at constant speed for $4T$ seconds, where $T < 20$. He then decelerates uniformly at 0.3 m s^{-2} and after T seconds passes through point B on the road. The distance from A to B is 705 m.

(a) Sketch a speed-time graph for the motion of the cyclist between points A and B.
(2)

(b) Find the value of T.
(7)

The cyclist continues his journey, still decelerating uniformly at 0.3 m s^{-2}, until he comes to rest at point C on the road.

(c) Find the total time taken by the cyclist to travel from A to C.
(3)

Question Number	Scheme	Marks
5a		
	Basic shape 20, 4*T* and *T* placed correctly	B1 **DB**1
		(2)
5b	Use of $v = u + at$: constant speed $= 0.6 \times 20 = 12$ (ms^{-1})	M1A1
	(Speed at end $= 12 - 0.3T$)	
	Using *v*-*t* graph: Distance: $705 = \frac{12}{2}\left(4T + \left(20 + 4T\right)\right) + \frac{T}{2}\left(12 + \left(12 - 0.3T\right)\right)$	M1A2
	$= 48T + 120 + 12T - 0.15T^2 = 60T + 120 - 0.15T^2$	
	Form 3 term quadratic and solve for *T*: $\Rightarrow 3T^2 - 1200T + 11700 = 0 \quad \left(T^2 - 400T + 3900 = 0\right)$	M1
	$\Rightarrow \left(T - 10\right)\left(T - 390\right) = 0 \qquad T = 10$ only	A1
		(7)
	Alternative:	
	Use of $v = u + at$: constant speed $= 0.6 \times 20 = 12$ (ms^{-1}) M1A1	
	Using $s = ut + \frac{1}{2}at^2$: $705 = \left(0.3 \times 400\right) + \left(4T \times 12\right) + \left(12T - 0.15T^2\right)$ M1A2	
	$\Rightarrow 0.15T^2 - 60T + 585 = 0 \ \left(T^2 - 400T + 3900 = 0\right)$	
	$\Rightarrow \left(T - 10\right)\left(T - 390\right) = 0 \qquad T = 10$ only M1A1	
	(7)	
5c	Extra time: $(2 \times 20) - \textit{their } T$ **OR** $\frac{12 - 0.3 \times \textit{their}T}{0.3}$	B1
	Total time: $20 + 5T + 40 - T$ (*their T*)	M1
	$= 100$ (s)	A1
		(3)
	Alternative: Total time to decelerate to rest = 12/0.3 = 40 B1	
	Total time *A* to *C* $= 20 + 4T + 40 = 100$ M1A1	
		[12]

Question Number	Scheme	Marks
	Notes for question 5	
5a	First B1 for basic shape. Allow if 'extra triangle' on end included, provided B clearly marked	
	Second **DB**1 : may use, 20, 20 + 4T, 20 + 5T	
5b	First M1 for attempt to find constant speed ($v = u + at$ or a = gradient) 20 x 0.6	
	First A1 for 12	
	Second (generous) M1 for clear attempt to use 705 = *total* area under the graph to give an equation in T only but must see ½ used somewhere **N.B.** M0 if just a trapezium oe is used	
	Second A1 and Third A1: for any correct equation, -1 e.e.o.o.	
	Third M1 for forming and attempt to solve a 3 term quadratic (need *evidence* of solving e.g. formula or factorising, if T values are incorrect) otherwise this M mark can be implied if they state that T = 10 with no working. (T = 390 NOT needed)	
	Fourth A1 for T = 10.	
	N.B. For total area, could see: Trapezium + Rectangle + Triangle $705 = \frac{12}{2}\left(4T + \left(20+4T\right)\right) + T(12-0.3T) + \frac{1}{2}T \times 0.3T$ Triangle + Rectangle + Trapezium $705 = \frac{1}{2}.20.12 + (4T \times 12) + \frac{1}{2}T\left(12+12-0.3T\right)$ Triangle + Rectangle + Rectangle + Triangle $705 = \frac{1}{2}.20.12 + (4T \times 12) + T(12-0.3T) + \frac{1}{2}T \times 0.3T$ Triangle + Rectangle + Trapezium (at top) $705 = \frac{1}{2}.20.12 + 5T(12-0.3T) + \frac{1}{2}0.3T(5T+4T)$ Rectangle – triangle– triangle $705 = 12(20+5T) - \frac{1}{2}.20.12 - \frac{1}{2}T \times 0.3T$	
5c	B1 for either additional time is $\frac{12}{0.3} - T$ **or** time to decelerate is $\frac{12}{0.3}$	
	M1 for a correct method to find the total time, using *their T* $= 20 + 4T + T + \frac{12}{0.3} - T$ **or** $20 + 4T + \frac{12}{0.3}$	
	A1 for 100 cao	

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6. [*In this question* **i** *and* **j** *are perpendicular horizontal unit vectors.*]

A particle P of mass 2 kg moves under the action of two forces, $(2\mathbf{i} + 3\mathbf{j})$ N and $(4\mathbf{i} - 5\mathbf{j})$ N.

(a) Find the magnitude of the acceleration of P.

(4)

At time $t = 0$, P has velocity $(-u\mathbf{i} + u\mathbf{j})$ m s^{-1}, where u is a positive constant.

At time $t = T$ seconds, P has velocity $(10\mathbf{i} + 2\mathbf{j})$ m s^{-1}.

(b) Find

(i) the value of T,

(ii) the value of u.

(5)

Question Number	Scheme	Marks
6a	Resultant force $=(2\mathbf{i}+3\mathbf{j})+(4\mathbf{i}-5\mathbf{j})=6\mathbf{i}-2\mathbf{j}$ (N)	M1
	Use of $\mathbf{F}=m\mathbf{a}$: $6\mathbf{i}-2\mathbf{j}=2\mathbf{a}$, $\mathbf{a}=3\mathbf{i}-\mathbf{j}$	M1
	Magnitude: $\lvert a\rvert=\sqrt{3^2+1^2}=\sqrt{10}\,(=3.2\text{ or better})$ (ms^{-2})	M1A1
		(4)
6b	$(10\mathbf{i}+2\mathbf{j})=(-u\mathbf{i}+u\mathbf{j})+T(3\mathbf{i}-\mathbf{j})$	M1
	$10=-u+3T$ and $2=u-T$	**DM**1A1**ft**
	$T = 6$	A1
	(i) $u = 8$	A1
	(ii)	(5)
		[9]
	Notes for question 6	
6a	First M1 for adding forces – must collect **i**'s and **j**'s	
	Second M1 for use of $\mathbf{F}=m\mathbf{a}$ or $F = ma$	
	Third M1 for finding a magnitude	
	A1 for $\sqrt{10}\,(=3.2\text{ or better})$	
6b	First M1 for use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ with their **a** (M0 if clearly using **F** instead of **a**)	
	Second **DM**1, dependent on previous M, for equating cpts of **i** and **j**	
	First A1**ft** for two correct equations following their **a**	
	Second A1 for $T = 6$	
	Third A1 for $u = 8$	

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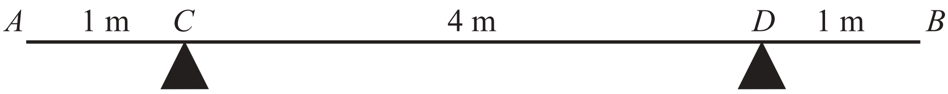


Figure 3

A non-uniform rod *AB* has length 6 m and mass 8 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at *C* and at *D*, where *AC* = 1 m and *DB* = 1 m, as shown in Figure 3. The magnitude of the reaction between the rod and the support at *D* is twice the magnitude of the reaction between the rod and the support at *C*. The centre of mass of the rod is at *G*, where *AG* = *x* m.

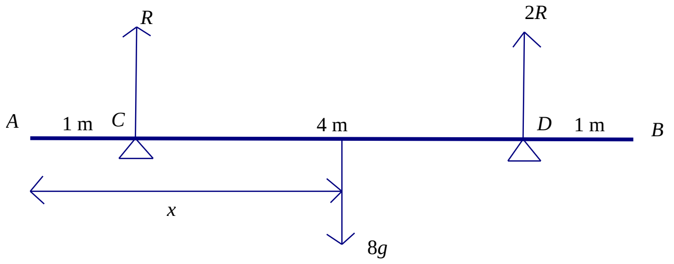
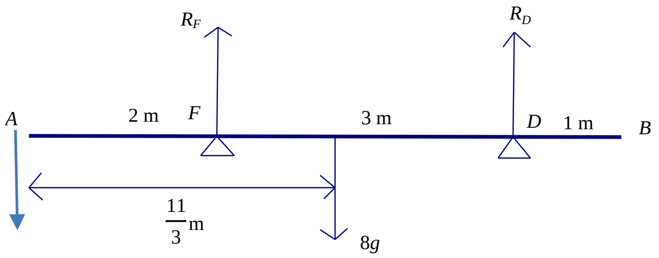
(a) Show that $x = \frac{11}{3}$.

(6)

The support at *C* is moved to the point *F* on the rod, where *AF* = 2 m. A particle of mass 3 kg is placed on the rod at *A*. The rod remains horizontal and in equilibrium. The magnitude of the reaction between the rod and the support at *D* is *k* times the magnitude of the reaction between the rod and the support at *F*.

(b) Find the value of *k*.

(6)

Question Number	Scheme	Marks
7a		
	N.B. If R_C and R_D reversed, can score max: M1A1(if vert res is used)M1A0DM1A0 <u>Consistent omission of *g* in both parts of this question can score all of the marks</u>.	
	Resolve vertically: $3R = 8g$	M1A1
	M(C) : $8g(x-1) = 4\times 2R$	M1A1
	$8gx = 8g + \frac{64g}{3} = \frac{88g}{3}$, $x = \frac{11}{3}$ **Given Answer**	**DM**1A1
		(6)
	N.B. (Allow R_D instead of $2R_C$ in either equation for M mark)	
	SC: M(G): $R(x-1) = 2R(5-x)$ $x = \frac{11}{3}$ **Given answer**	M2 A2 **DM**1 A1
		(6)
7b	**N.B.** If they use a value for a reaction found in part (a) in their part (b), no marks for part (b) available.	
	3g N.B. $R_D = kR_F$	
	Resolve vert : $R_F + kR_F = 11g$ (Allow R_D instead of kR_F for M mark))	M1A1
	M(F) : $(kR_F \times 3) + (3g \times 2) = 8g \times \frac{5}{3}$ (Allow R_D instead of kR_F for M mark)	M1A1
	$k = \frac{2}{7}$ oe , 0.29 or better	**DM**1A1
		(6)
		[12]

Question Number	Scheme	Marks
	Notes for question 7	
7a	First M1 for either resolving vertically or taking moments with usual rules First A1 for a correct equation Second M1 for taking moments with usual rules Second A1 for a correct equation **N.B**. Their moments equation(s) may not be in *x*, if they've clearly defined a different distance and can score the A1 in each case. Third **DM**1, dependent on first two M marks, for solving for *x* Third A1 for " *x* (or *AG*) = 11/3" **GIVEN ANSWER (Must be EXACT)** Possible equations: M(*A*), $(R\times1)+(2R\times5)=8gx$ M(*B*), $(R\times5)+(2R\times1)=8g(6-x)$ M(*D*), $(R\times4)=8g(5-x)$ **N.B.** (Allow R_D instead of $2R_C$ in all cases for M mark)	
7b	First M1 for either resolving vertically or taking moments with usual rules First A1 for a correct equation Second M1 for taking moments with usual rules Second A1 for a correct equation Third **DM**1, dependent on first two M marks, for solving for *k* Third A1 for *k* = 2/7, any equivalent fraction or 0.29 or better Possible equations: M(*A*), $2R_F+5kR_F=8g\times\frac{11}{3}$ M(*B*), $4R_F+(1\times kR_F)=(8g\times\frac{7}{3})+(3g\times6)$ M(*D*), $3R_F=8g\times\frac{4}{3}+(3g\times5)$ M(*G*), $\frac{5}{3}R_F-\frac{4}{3}kR_F=3g\times\frac{11}{3}$ **N.B.** (Allow R_D instead of kR_F in all cases for M mark)	

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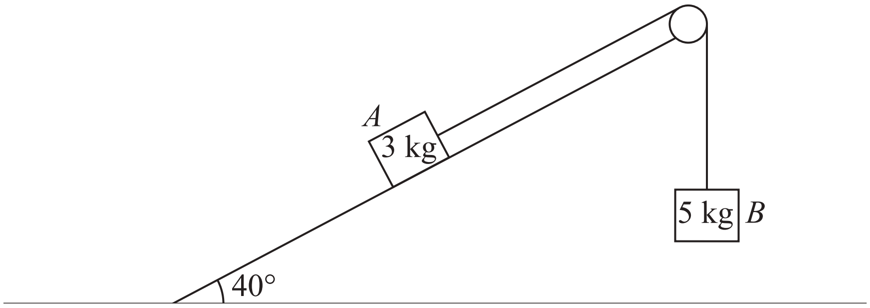


Figure 4

One end of a light inextensible string is attached to a block *A* of mass 3 kg. Block *A* is held at rest on a smooth fixed plane. The plane is inclined at 40° to the horizontal ground. The string lies along a line of greatest slope of the plane and passes over a small smooth pulley which is fixed at the top of the plane. The other end of the string is attached to a block *B* of mass 5 kg. Block *B* hangs freely at rest below the pulley, as shown in Figure 4. The system is released from rest with the string taut.

By modelling the two blocks as particles,

(a) find the tension in the string as *B* descends.

(6)

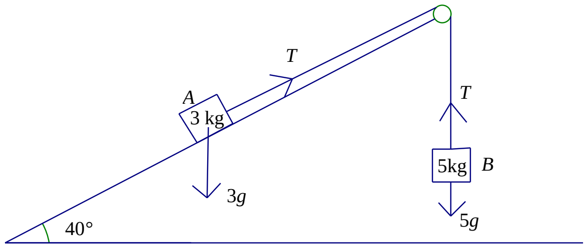
After falling for 1.5 s, block *B* hits the ground and is immediately brought to rest. In its subsequent motion, *A* does not reach the pulley.

(b) Find the speed of *B* at the instant it hits the ground.

(3)

(c) Find the total distance moved up the plane by *A* before it comes to instantaneous rest.

(5)

Question Number	Scheme	Marks
8a		
	Motion of A: $T - 3g\sin 40 = 3a$	M1A1
	Motion of B: $5g - T = 5a$	M1A1
	Solve for T	**DM**1
	30 (N) or 30.2 (N)	A1
		(6)
8b	$5g - T = 5a \Rightarrow a = \frac{1}{5}(5g - T) = \frac{g}{8}(5 - 3\sin 40)(= 3.76)$ (ms^{-2})	M1
	Use of *suvat* : $v = u + at = 3.76 \times 1.5 = 5.64$ (ms^{-1}) or 5.6 (ms^{-1})	**DM**1A1
		(3)
8c	Distance in first 1.5 seconds: $s = \frac{1}{2}a1.5^2 = 4.23$ (m) **OR**: $v^2 = u^2 + 2as$: $s = \frac{\textit{their}\ (b)^2}{2 \times a} = 4.23$ (m)	M1A1
	New $a = -g\sin 40$ (-ve sign not needed)	B1
	Distance up plane : $v^2 = u^2 + 2as$, $s = \frac{\textit{their}\ (b)^2}{2 \times \text{ new } a}$ (m)	**DM**1
	Total distance: 6.76 (m) (6.8)	A1
		(5)
		[14]
	Notes for question 8	
8a	First M1 for equation of motion for *A*, with usual rules	
	First A1 for a correct equation	
	Second M1 for equation of motion for *B*, with usual rules	
	Second A1 for a correct equation	
	N.B. Either of these can be replaced by the whole system equation:	
	$5g - 3g\sin 40 = 8a$	
	Third **DM**1, dependent on previous two M marks, for solving for *T*	
	Third A1 for 30 or 30.2 (N)	
8b	First M1 for finding a value for *a* (possibly incorrect) This mark could be earned in part (a) BUT MUST BE USED IN (b).	
	Second **DM**1,dependent on previous M, for a complete method to find the speed of *B* as it hits the ground	
	A1 for 5.6 or 5.64 (m s^{-1})	
8c	First M1 for a complete method to find distance fallen by *B* First A1 for 4.23 or better	

Question Number	Scheme	Marks
	B1 for new $a = -g\sin 40$ (- sign not needed) (seen or implied)	
	Second **DM**1, dependent on having found a *new a*, for a complete method to find extra distance moved by *A* up the plane BUT M0 if new *a* is *g*.	
	Second A1 for 6.8 or 6.76 (m).	