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Pearson Edexcel
International
Advanced Level

Centre Number

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Candidate Number

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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 ►

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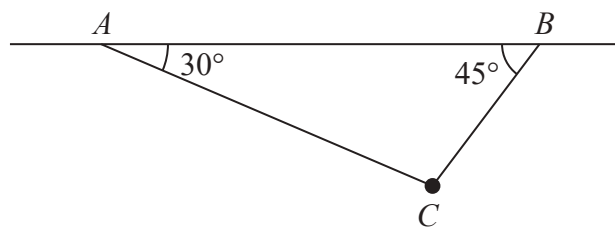


Figure 1

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)

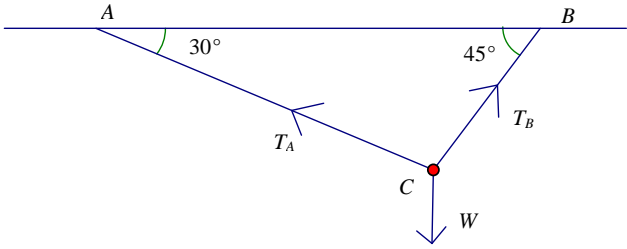
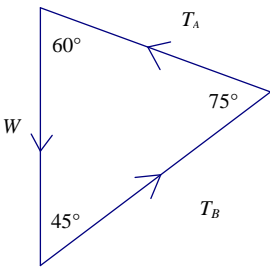
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January 2018
Mechanics 1 - WME01
Mark Scheme

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	DM1
	$T_A = \frac{2}{1 + \sqrt{3}} W (= 0.73W)$ (or better)	A1
	$T_B = \frac{\sqrt{6}}{1 + \sqrt{3}} W (= 0.90W)$ (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)	DM1A1
	$T_B = 0.90W$ (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 DM1 , 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 DM1 , 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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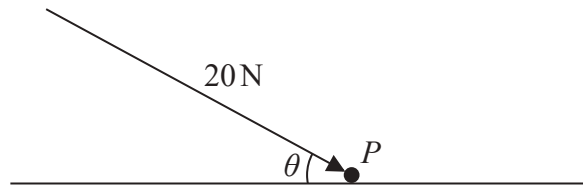


Figure 2

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

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

(6)

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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 $F \leq \mu R$: $20 \cos \theta \leq \mu(40 + 20 \sin \theta)$	DM1
	$\mu \geq \frac{20 \cos \theta}{40 + 20 \sin \theta} \Rightarrow \mu \geq \frac{\cos \theta}{2 + \sin \theta}$ 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 DM1 , dependent on both previous M marks, for use of $F \leq \mu R$ 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)

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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 $v > 0$: $kmv = 5mu - kmu > 0$	DM1
	$\Rightarrow k < 5$ 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 DM1A1	
		(4)
		[7]
	Notes for question 3	
3a	M1 for using impulse = change in momentum for A (M0 if <i>clearly</i> adding momenta or if g is included or if not using $2m$ in <i>both</i> 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 DM1 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 $A = \text{change in momentum for } B$ (M0 if <i>clearly</i> adding momenta or if g is included or if not using km in <i>both</i> terms) but condone sign errors.	
	First A1 for a correct equation (allow $-v$ in place of v)	
	Second DM1 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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- (a) Find the magnitude of the acceleration of the package. (6)

(b) Find the speed of the package as it passes through B . (2)

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[illegible]

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

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



Question Number	Scheme	Marks
5a		
	Basic shape 20, 4T and T placed correctly	B1 DB1
		(2)
5b	Use of $v = u + at$: constant speed $= 0.6 \times 20 = 12 \text{ (ms}^{-1}\text{)}$ (Speed at end $= 12 - 0.3T$)	M1A1
	Using $v-t$ graph: Distance: $705 = \frac{12}{2}(4T + (20 + 4T)) + \frac{T}{2}(12 + (12 - 0.3T))$	M1A2
	$= 48T + 120 + 12T - 0.15T^2 = 60T + 120 - 0.15T^2$	
	Form 3 term quadratic and solve for T: $\Rightarrow 3T^2 - 1200T + 11700 = 0 \quad (T^2 - 400T + 3900 = 0)$	M1
	$\Rightarrow (T - 10)(T - 390) = 0 \quad T = 10 \text{ only}$	A1
		(7)
	Alternative:	
	Use of $v = u + at$: constant speed $= 0.6 \times 20 = 12 \text{ (ms}^{-1}\text{)}$	M1A1
	Using $s = ut + \frac{1}{2}at^2$: $705 = (0.3 \times 400) + (4T \times 12) + (12T - 0.15T^2)$	M1A2
	$\Rightarrow 0.15T^2 - 60T + 585 = 0 \quad (T^2 - 400T + 3900 = 0)$	
	$\Rightarrow (T - 10)(T - 390) = 0 \quad T = 10 \text{ only}$	M1A1
	(7)	
5c	Extra time: $(2 \times 20) - \text{their } T$ OR $\frac{12 - 0.3 \times \text{their } T}{0.3}$	B1
	Total time: $20 + 5T + 40 - T$ (their T)	M1
	$= 100 \text{ (s)}$	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, <u>provided B clearly marked</u>	
	Second DB1 : may use, $20, 20 + 4T, 20 + 5T$	
5b	First M1 for attempt to find constant speed ($v = u + at$ or $a = \text{gradient}$) 20×0.6	
	First A1 for 12	
	Second (generous) M1 for clear attempt to use $705 = \text{total area}$ under the graph to give an equation in T only but must see $\frac{1}{2}$ 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 <i>evidence</i> 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 $705 = \frac{12}{2}(4T + (20 + 4T)) + T(12 - 0.3T) + \frac{1}{2}T \times 0.3T$ Triangle + Rectangle + Trapezium $705 = \frac{1}{2}.20.12 + (4T \times 12) + \frac{1}{2}T(12 + 12 - 0.3T)$ 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 <i>their</i> 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 \mathbf{i} and \mathbf{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)

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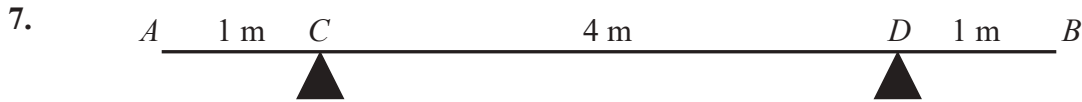


Figure 3

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)

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Question Number	Scheme	Marks
7a		
	<p>N.B. If R_C and R_D reversed, can score max: M1A1(if vert res is used)M1A0DM1A0</p> <p><u>Consistent omission of g in both parts of this question can score all of the marks.</u></p>	
	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	DM1A1
		(6)
	N.B. (Allow R_D instead of $2R_C$ in either equation for M mark)	
	<p>SC: M(G): $R(x-1) = 2R(5-x)$</p> <p>$x = \frac{11}{3}$ Given answer</p>	M2 A2 DM1 A1
		(6)
7b	<p>N.B. If they use a value for a reaction found in part (a) in their part (b), no marks for part (b) available.</p>	
	<p>N.B. $R_D = kR_F$</p>	
	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	DM1A1
		(6)
		[12]

Question Number	Scheme	Marks
	Notes for question 7	
7a	<p>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</p> <p>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.</p> <p>Third DM1, dependent on first two M marks, for solving for x Third A1 for “x (or AG) = $11/3$”</p> <p>GIVEN ANSWER (Must be EXACT)</p> $M(A), (R \times 1) + (2R \times 5) = 8gx$ <p>Possible equations: $M(B), (R \times 5) + (2R \times 1) = 8g(6 - x)$ $M(D), (R \times 4) = 8g(5 - x)$</p> <p>N.B. (Allow R_D instead of $2R_C$ in all cases for M mark)</p>	
7b	<p>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 DM1, dependent on first two M marks, for solving for k Third A1 for $k = 2/7$, any equivalent fraction or 0.29 or better</p> $M(A), 2R_F + 5kR_F = 8g \times \frac{11}{3}$ $M(B), 4R_F + (1 \times kR_F) = (8g \times \frac{7}{3}) + (3g \times 6)$ <p>Possible equations:</p> $M(D), 3R_F = 8g \times \frac{4}{3} + (3g \times 5)$ $M(G), \frac{5}{3}R_F - \frac{4}{3}kR_F = 3g \times \frac{11}{3}$ <p>N.B. (Allow R_D instead of kR_F in all cases for M mark)</p>	

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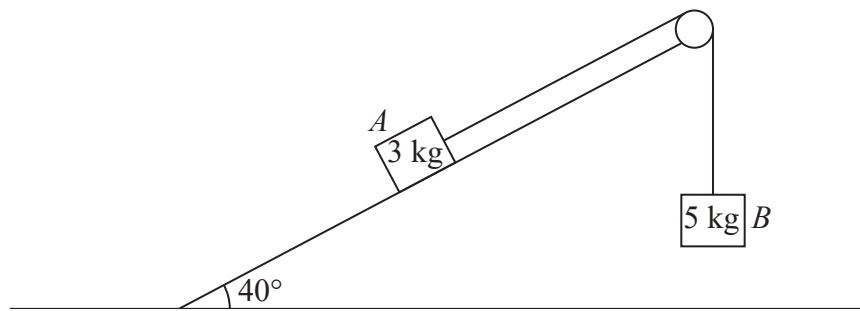


Figure 4

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)

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Question Number	Scheme	Marks
8a		
	Motion of A : $T - 3g \sin 40 = 3a$	M1A1
	Motion of B : $5g - T = 5a$	M1A1
	Solve for T	DM1
	30 (N) or 30.2 (N)	A1
		(6)
8b	$5g - T = 5a \Rightarrow a = \frac{1}{5}(5g - T) = \frac{g}{8}(5 - 3 \sin 40) (= 3.76) \text{ (ms}^{-2}\text{)}$	M1
	Use of <i>suvat</i> : $v = u + at = 3.76 \times 1.5 = 5.64 \text{ (ms}^{-1}\text{) or } 5.6 \text{ (ms}^{-1}\text{)}$	DM1A1
		(3)
8c	Distance in first 1.5 seconds: $s = \frac{1}{2}at^2 = 4.23 \text{ (m)}$ OR: $v^2 = u^2 + 2as$: $s = \frac{\text{their (b)}^2}{2 \times a} = 4.23 \text{ (m)}$	M1A1
	New $a = -g \sin 40$ (-ve sign not needed)	B1
	Distance up plane : $v^2 = u^2 + 2as$, $s = \frac{\text{their (b)}^2}{2 \times \text{new } a} \text{ (m)}$	DM1
	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 DM1, 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 DM1, 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	

[illegible]