Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 6 June 2018 – 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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Pearson

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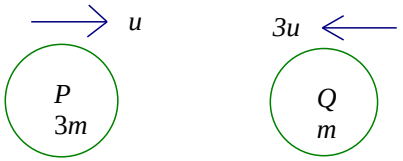
1. Particle P has mass $3m$ and particle Q has mass m. The particles are moving towards each other in opposite directions along the same straight line on a smooth horizontal plane. The particles collide directly. Immediately before the collision the speed of P is u and the speed of Q is $3u$. In the collision, the magnitude of the impulse exerted by Q on P is $5mu$.

(i) Find the speed of P immediately after the collision.

(ii) Find the speed of Q immediately after the collision.

(6)

Mechanics 1 - WME01 June 2018
Mark Scheme

Question Number	Scheme	Marks	Notes
			Mark parts (i) and (ii) together For marking:1st equation in one unknown M1A1 2nd equation in one unknown M1A1 1st value A1, 2nd value A1
1i.	Impulse - momentum equation for P	M1	Must be trying to subtract. Terms dimensionally consistent.
	$5mu = 3m(v_P - -u)$	A1	Correct unsimplified equation
	$v_P = \frac{2u}{3}$	A1	Final answer positive Condone unexplained sign change
1ii.	Impulse momentum equation for Q	M1	Must be trying to subtract Terms dimensionally consistent.
	$5mu = m(v_Q - -3u)$	A1	Correct unsimplified equation
	$v_Q = 2u$	A1	
1ii alt	Use of CLM	M1	Need all terms and dimensionally consistent. Condone sign errors.
	$3mu - 3mu = -3m\frac{2u}{3} + mv_Q$ or $3mu - 3mu = 3mv_P + 2mu$	A1	Correct unsimplified equation
	$v_Q = 2u$	A1	Final answer positive Condone unexplained sign change
		[6]	

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2.

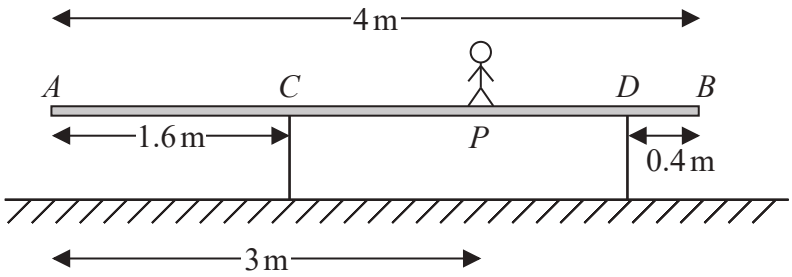

Figure 1

A uniform wooden beam AB, of mass 20 kg and length 4 m, rests in equilibrium in a horizontal position on two supports. One support is at C, where $AC = 1.6$ m, and the other support is at D, where $DB = 0.4$ m. A boy of mass 60 kg stands on the beam at the point P, where $AP = 3$ m, as shown in Figure 1. The beam remains in equilibrium in a horizontal position.

By modelling the boy as a particle and the beam as a uniform rod,

(a) (i) find, in terms of g, the magnitude of the force exerted on the beam by the support at C,

(ii) find, in terms of g, the magnitude of the force exerted on the beam by the support at D.

(6)

The boy now starts to walk slowly along the beam towards the end A.

(b) Find the greatest distance he can walk from P without the beam tilting.

(4)

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Question Number	Scheme	Marks	Notes
	Mark parts (i) and (ii) together		For marking:1st equation M1A1 2nd equation M1A1 1st value A1, 2nd value A1
2a i	Moments equation	M1	Use moments to form an equation in R_C and/or R_D All terms required. Dimensionally correct. Condone sign errors.
	$M(D)$: $(60g \text{ x } 0.6) + (20g \text{ x } 1.6) = R_C \text{ x } 2$ $M(C)$: $(60g \text{ x } 1.4) + (20g \text{ x } 0.4) = R_D \text{ x } 2$ *M(A)*: $2\times 20g + 3\times 60g = 1.6R_C + 3.6R_D$ *M(B)*: $0.4R_D + 2.4R_C = 60g\times 1 + 20g\times 2$	A1	Correct unsimplified equation
	$R_C = 34g$	A1	333 (333.2) is an accuracy error
ii	Resolve vertically	M1	Or form a moments equation in R_D
	$(\uparrow)\ R_C + R_D = 80g$	A1	Correct unsimplified equation
	$R_D = 46g$	A1	451 (450.8) is an accuracy error (penalise once only if *g* substituted in both answers and correct versions not seen)
		(6)	
2b	Set $R_D = 0$ and use moments to form equation in a relevant distance (One unknown only)	M1	Complete method for a relevant distance Dimensionally correct equation. Using their answers from (a) is M0
	$M(C)$, $(20g\times 0.4) = (60g\times x)$ where *x* = distance from C when beam tilts	A1	Correct unsimplified equation for a relevant distance
	$\left(x = \frac{2}{15}\right)$		
	Use their distance to find the distance walked	DM1	Dependent on the previous M1
	Distance $= 1.4 + \frac{2}{15} = \frac{23}{15} = 1.53$ m	A1	
		(4)	
		[10]	

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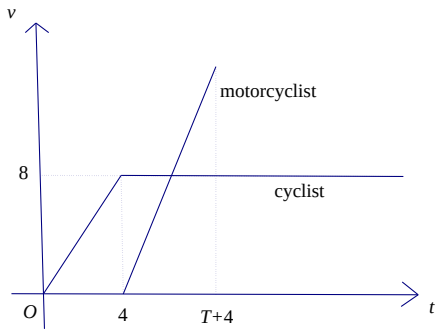
3. A cyclist starts from rest at the point O on a straight horizontal road. The cyclist moves along the road with constant acceleration $2\,\text{m s}^{-2}$ for 4 seconds and then continues to move along the road at constant speed. At the instant when the cyclist stops accelerating, a motorcyclist starts from rest at the point O and moves along the road with constant acceleration $4\,\text{m s}^{-2}$ in the same direction as the cyclist. The motorcyclist has been moving for T seconds when she overtakes the cyclist.

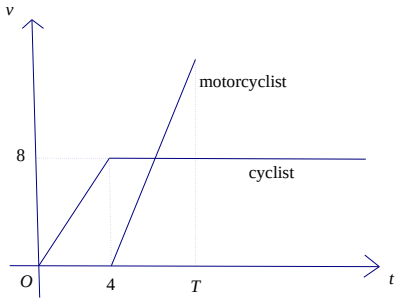
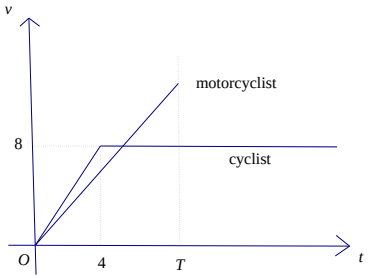
(a) Sketch, on the same axes, a speed-time graph for the motion of the cyclist and a speed-time graph for the motion of the motorcyclist, to the time when the motorcyclist overtakes the cyclist.

(4)

(b) Find, giving your answer to 1 decimal place, the value of T.

(6)

Question Number	Scheme	Marks	Notes
3a		B1 shape B1 figs B1 shape B1 figs (4)	Correct shape graph for cyclist 4 marked Motorcyclist graph in relatively correct position Must start at $t = 4$ and must continue beyond point of intersection of the graphs $T + 4$ marked Treat two separate graphs as two attempts and award the marks for the better attempt
3b	$\frac{1}{2}T.4T = \left(\frac{T+T+4}{2}\right)8$	M1	Equate distances to form equation in T
		A1	One distance correct
		A1	Both distances correct
	$T^2 - 4T - 8 = 0$	A1	Simplify to 3 term quadratic
	$T = 2 \pm \sqrt{12}$	M1	Solve a 3 term quadratic for T
	$T = 5.5$	A1	Q asks for answer to 1 dp. Must reject negative solution if seen.
		(6)	
		[10]	
			See over

Question Number	Scheme	Marks	Notes
SC1			B1B1 B1B0 $16+8(T-4)=\frac{1}{2}\times 4(T-4)^2$ M1A1A1 $T^2-12T+24=0$ (or equivalent) A1 $T=6+2\sqrt{3}=9.5$ M1A0 (marking the T as a misread)
SC2			B1B1 B0B0 $16+8(T-4)=\frac{1}{2}\times 4T^2$ M1A1A1 $2T^2-8T+16=0$ A0M0A0 (completely changed the question but some evidence of correct thinking)

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4. A rough plane is inclined at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. A particle of mass 2 kg is projected with speed $6\,\text{m s}^{-1}$ from a point O on the plane, up a line of greatest slope of the plane. The coefficient of friction between the particle and the plane is 0.25

(a) Find the magnitude of the frictional force acting on the particle as it moves up the plane.

(3)

The particle comes to instantaneous rest at the point A.

(b) Find the distance OA.

(5)

The particle now moves down the plane from A.

(c) Find the speed of P as it passes through O.

(5)

Question Number	Scheme	Marks	Notes
4a	Resolve perpendicular to the surface	M1	Condone sin/cos confusion
	$R = 2g\cos\alpha$ (15.68)	A1	Correct resolution
	$F = \frac{1}{4}R = \frac{2g}{5} = 3.9$ N or 3.92 N	A1	Max 3 sf for decimal answer
		(3)	
4b	$-2g\sin\alpha - F = 2a$	M1	Equation of motion parallel to the plane. Require all terms and dimensionally correct. Condone sign errors and sin/cos confusion
		A1ft	Correct unsimplified equation in F (or their F)
	$\frac{-4g}{5} = a$	A1	Or $-7.84\,(\text{m s}^{-2})$ Accept +/-
	$0^2 = 6^2 - \frac{8g}{5}s$	DM1	Complete method using *suvat* and $a \neq g$ to find s Dependent on the previous M1
	$s = \frac{45}{2g} = 2.3$ m or 2.30 m	A1	Max 3 sf
		(5)	
4c	$2g\sin\alpha - F = 2a'$	M1	Equation for motion down the plane to find new acceleration. Require all terms and dimensionally correct. Condone sign errors and sin/cos confusion
		A1ft	Correct unsimplified equation in F (or their F)
	$\frac{2g}{5} = a'$	A1	Or $3.92\,(\text{m s}^{-2})$
	$v^2 = \frac{4g}{5}\frac{45}{2g} = 18 \Rightarrow$	DM1	Complete method using *suvat* , $a' \neq g$ and $a' \neq a$, to find v Dependent on the previous M1
	$v = \sqrt{18} = 4.2$ m s^{-1}(or better)	A1	g cancels Condone 4.25 (from using rounded values).
		(5)	
		[13]	

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5. [*In this question* **i** *and* **j** *are perpendicular horizontal unit vectors and position vectors are given relative to a fixed origin O.*]

A particle P is moving in a straight line with constant velocity. At 9 am, the position vector of P is $(7\mathbf{i} + 5\mathbf{j})$ km and at 9.20 am, the position vector of P is $6\mathbf{i}$ km. At time t hours after 9 am, the position vector of P is $\mathbf{r}_P$ km.

(a) Find, in km h^{-1}, the speed of P.

(4)

(b) Show that $\mathbf{r}_P = (7 - 3t)\,\mathbf{i} + (5 - 15t)\,\mathbf{j}$.

(2)

(c) Find the value of t when $\mathbf{r}_P$ is parallel to $16\mathbf{i} + 5\mathbf{j}$.

(4)

The position vector of another particle Q, at time t hours after 9 am, is $\mathbf{r}_Q$ km, where $\mathbf{r}_Q = (5 + 2t)\,\mathbf{i} + (-3 + 5t)\,\mathbf{j}$

(d) Show that P and Q will collide and find the position vector of the point of collision.

(5)

Question Number	Scheme	Marks	Notes
5a	Correct equation for $\mathbf{v}_P$ or find displacement	M1	Use of $\mathbf{r}_P = \mathbf{r}_0 + \mathbf{v}_P t$ to find $\mathbf{v}$. Allow for $\lambda(-\mathbf{i}-5\mathbf{j})$
	$\mathbf{v}_P = 3(6\mathbf{i}-(7\mathbf{i}+5\mathbf{j})) = -3\mathbf{i}-15\mathbf{j}$	A1	
	$\sqrt{(-3)^2+(-15)^2}$	M1	Use of Pythagoras to find magnitude of their $\mathbf{v}$
	$= \sqrt{234} = 15.3 \left(\text{km h}^{-1}\right)$ (or better)	A1	CSO $\left(3\sqrt{26}\right)$ A0 if it comes from $3\mathbf{i}+15\mathbf{j}$
			NB Could score the M marks in reverse order - find displacement in 20 minutes and then multiply by 3
		(4)	
5b	Use of $\mathbf{r}_P = \mathbf{r}_0 + \mathbf{v}_P t$: $\mathbf{r}_P = 7\mathbf{i}+5\mathbf{j}+t(-3\mathbf{i}-15\mathbf{j})$	M1	For their $\mathbf{v}_P$
	$\Rightarrow \mathbf{r}_P = (7-3t)\mathbf{i}+(5-15t)\mathbf{j}$	A1	Obtain **given answer** from correct working
		(2)	
5c	$\dfrac{(7-3t)}{(5-15t)} = \dfrac{16}{5}$	M1	Use given answer and direction to form equation in t
		A1	Correct unsimplified equation
	$35-15t = 80-240t$	DM1	Solve for t. Dependent on the previous M1
	$t = 0.2$	A1	
		(4)	
5d	P and Q in the same place at the same time	M1	Equate **i** or **j** components of position vectors and solve for t
	$\Rightarrow\ 7-3t = 5+2t$ or $5-15t = -3+5t$	A1	Either
	$t = 0.4$	A1	
	Check that the same value of t gives equal values for the other component	DM1	Dependent on the previous M mark
	$\mathbf{r} = (5.8\mathbf{i}-\mathbf{j})$ km	A1	Must be a vector
		(5)	
		[15]	

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6. A car pulls a trailer along a straight horizontal road using a light inextensible towbar. The mass of the car is M kg, the mass of the trailer is 600 kg and the towbar is horizontal and parallel to the direction of motion. There is a resistance to motion of magnitude 200 N acting on the car and a resistance to motion of magnitude 100 N acting on the trailer. The driver of the car spots a hazard ahead. Instantly he reduces the force produced by the engine of the car to zero and applies the brakes of the car. The brakes produce a braking force on the car of magnitude 6500 N and the car and the trailer have a constant deceleration of magnitude $4\,\text{m}\,\text{s}^{-2}$

Given that the resistances to motion on the car and trailer are unchanged and that the car comes to rest after travelling 40.5 m from the point where the brakes were applied, find

(a) the thrust in the towbar while the car is braking,

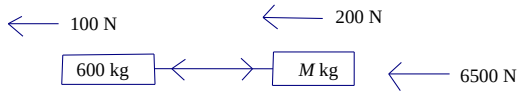
(3)

(b) the value of M,

(3)

(c) the time it takes for the car to stop after the brakes are applied.

(3)

Question Number	Scheme	Marks	Notes
			
6a	For the trailer:	M1	Complete method to form an equation in T. e.g. equation of motion for the trailer. Need all 3 terms. Condone sign errors.
	$-100-T=600\times(-4)$	A1	Correct unsimplified equation. Allow with $\pm T$
	$T=2300$ N	A1	Must be positive
		(3)	
6b	For the car and trailer:	M1	Complete method to solve for M. Equation of motion for the car + trailer. Need all terms. Condone sign errors.
	$6500+100+200=4(M+600)$	A1	Correct unsimplified equation
	$M=1100$	A1	
			Allow M1A1 if a correct equation is seen in (a) and used in (b)
6balt	For the car:	M1	Equation of motion for the car. Need all terms. Condone sign errors.
	$6500+200-T=4M$	A1	Correct unsimplified equation in T or their T
	$M=1100$	A1	
		(3)	
6c	$s=vt-\frac{1}{2}at^2$	M1	Complete method using s*uvat* to find t Clear use of $s=ut+\frac{1}{2}at^2$ with $u=0, a=4$ is M0. e.g. $40.5=-2t^2$ from no working is M0A0
	$40.5=\frac{1}{2}.4.t^2$	A1	Correct unsimplified equation
	$t=4.5$ s	A1	
		(3)	
		[9]	

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7.

Figure 2

A washing line $ABCD$ is fixed at the points A and D. There are two heavy items of clothing hanging on the washing line, one fixed at B and the other fixed at C. The washing line is modelled as a light inextensible string, the item at B is modelled as a particle of mass 3 kg and the item at C is modelled as a particle of mass M kg. The section AB makes an angle α with the horizontal, where $\tan\alpha = \frac{3}{4}$, the section BC is horizontal and the section CD makes an angle β with the horizontal, where $\tan\beta = \frac{12}{5}$, as shown in Figure 2. The system is in equilibrium.

(a) Find the tension in AB.

(4)

(b) Find the tension in BC.

(3)

(c) Find the value of M.

(5)

Question Number	Scheme	Marks	Notes
7a	$\sin\alpha = \frac{3}{5}$ or $\cos\alpha = \frac{4}{5}$	B1	Correct trig ratios for α seen or implied Watch out - it could be up beside the diagram
	At B, $(\uparrow)$	M1	Complete method to form equation in T_{AB}
	$\Rightarrow \quad T_{AB}\sin\alpha = 3g$	A1	Correct unsimplified equation
	$T_{AB} = 5g = 49$ N	A1	
		(4)	
7b	At B, $(\rightarrow)$	M1	Complete method to form equation in T_{BC}
	$\Rightarrow \quad T_{AB}\cos\alpha = T_{BC}$	A1	Correct unsimplified equation. Allow with their T_{AB}
	$T_{BC} = 4g = 39$ or 39.2 N	A1	
		(3)	
7c	Resolve at C:	M1	Resolve to form equation in T_{CD} There is a lot of confusion over the labelling of the tensions. Allow if a value is used correctly, whatever it is called.
	At C, $(\rightarrow)$ $T_{CD}\cos\beta = T_{BC}$	A1	One correct equation in T_{CD} Could be whole system equations e.g. $T_{AB}\cos\alpha = T_{CD}\cos\beta$ $T_{AB}\sin\alpha + T_{CD}\sin\beta = (3+M)g$
	At C, $(\uparrow)$ $T_{CD}\sin\beta = Mg$	A1	Two correct equations in T_{CD} (=101.92)
	$\tan\beta = \dfrac{Mg}{T_{BC}}$	DM1	Dependent on previous M1. Use $\tan\beta$ and solve for M
	$Mg = 4g \times \frac{12}{5} \Rightarrow M = 9.6$	A1	
		(5)	
		[12]	