Write your name here

Surname	Other names

Pearson Edexcel International Advanced Level

Centre Number | Candidate Number

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 3 June 2015 – 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

P44836A

5/1/1/1/1/

P 4 4 8 3 6 A 0 1 2 8

PEARSON

Leave blank

1. Three forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ act on a particle P.

$\mathbf{F}_1 = (2\mathbf{i} + 3a\mathbf{j})$ N; $\mathbf{F}_2 = (2a\mathbf{i} + b\mathbf{j})$ N; $\mathbf{F}_3 = (b\mathbf{i} + 4\mathbf{j})$ N.

The particle P is in equilibrium under the action of these forces.

Find the value of a and the value of b.

(6)

Question Number	Scheme	Marks	Notes
1.	$(2\mathbf{i}+3a\mathbf{j})+(2a\mathbf{i}+b\mathbf{j})+(b\mathbf{i}+4\mathbf{j})=\mathbf{0}$	M1	Use of resultant force = 0 (Seen or implied)
	$2a+b+2=0;\ 3a+b+4=0$	M1	In an equation involving all three forces once and once only, compare **i** or **j** components to form an equation in *a* and *b*. Allow with **i** or **j**. $\lambda\mathbf{i}=\mu\mathbf{j}$ is M0
		A1	Two correct scalar equations. No i/j
	$a=-2; b=2$	DM1	Solve simultaneous equations to find *a* or *b*. Dependent on the previous M1
		A1	*a* correct
		A1	*b* correct
		6	
2(a)	$2mu-km3u=-2m\frac{1}{2}u+kmv$	M1	Conservation of momentum. Must have all four terms but condone sign errors and consistent omission of *m* or *g* included in all terms
	$(3u=kv+3ku)$	A2,1,0	-1 for each error. All correct A1A1, one error A1A0, two or more errors A0A0
	$v=(1-k)\dfrac{3u}{k}$ or $k=\dfrac{3u}{v+3u}$	A1	Correct expression for *v* or for *kv* or for *k*
	$v>0$ =>	M1	Correct inequality for their *v*
	=> $k<1$ *	A1	Reach **given answer** correctly
		(6)	
(b)	$I=2m(\frac{1}{2}u--u)$	M1	Impulse = <u>change</u> in momentum for *A* or for *B*. Condone sign errors.
		A1	Correct unsimplified expression in terms of *m* and *u*. Allow +/-
	$=3mu$	A1	Correct answer only.
		(3)	
		9	

Leave blank

2. Particle A of mass $2m$ and particle B of mass km, where k is a positive constant, 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 A is u and the speed of B is $3u$. The direction of motion of each particle is reversed by the collision. Immediately after the collision the speed of A is $\frac{1}{2}u$.

(a) Show that $k < 1$

(6)

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

(3)

Question Number	Scheme	Marks	Notes
1.	$(2\mathbf{i}+3a\mathbf{j})+(2a\mathbf{i}+b\mathbf{j})+(b\mathbf{i}+4\mathbf{j})=\mathbf{0}$	M1	Use of resultant force = 0 (Seen or implied)
	$2a+b+2=0;\ 3a+b+4=0$	M1	In an equation involving all three forces once and once only, compare **i** or **j** components to form an equation in *a* and *b*. Allow with **i** or **j**. $\lambda\mathbf{i}=\mu\mathbf{j}$ is M0
		A1	Two correct scalar equations. No i/j
	$a=-2; b=2$	DM1	Solve simultaneous equations to find *a* or *b*. Dependent on the previous M1
		A1	*a* correct
		A1	*b* correct
		6	
2(a)	$2mu-km3u=-2m\tfrac{1}{2}u+kmv$	M1	Conservation of momentum. Must have all four terms but condone sign errors and consistent omission of *m* or *g* included in all terms
	$(3u=kv+3ku)$	A2,1,0	-1 for each error. All correct A1A1, one error A1A0, two or more errors A0A0
	$v=(1-k)\dfrac{3u}{k}$ or $k=\dfrac{3u}{v+3u}$	A1	Correct expression for *v* or for *kv* or for *k*
	$v>0 \Rightarrow$	M1	Correct inequality for their *v*
	$\Rightarrow k<1$ *	A1	Reach **given answer** correctly
		(6)	
(b)	$I=2m(\tfrac{1}{2}u--u)$	M1	Impulse = <u>change</u> in momentum for *A* or for *B*. Condone sign errors.
		A1	Correct unsimplified expression in terms of *m* and *u*. Allow +/-
	$=3mu$	A1	Correct answer only.
		(3)	
		9	

Leave blank

3.

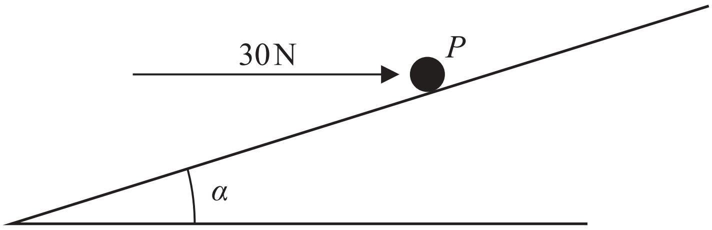


Figure 1

A particle P of mass 2 kg is pushed by a constant horizontal force of magnitude 30 N up a line of greatest slope of a rough plane. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$, as shown in Figure 1. The line of action of the force lies in the vertical plane containing P and the line of greatest slope of the plane. The particle P starts from rest. The coefficient of friction between P and the plane is μ. After 2 seconds, P has travelled a distance of 5.5 m up the plane.

(a) Find the acceleration of P up the plane.
(2)

(b) Find the value of μ.
(8)

3(a)	$5.5 = \frac{1}{2}a.2^2$	M1	Complete method using *suvat* equations to form an equation in *a* only
	$\Rightarrow a = 2.75$	A1	
		(2)	
(b)	$R = 30\sin\alpha + 2g\cos\alpha$	M1	Resolve perpendicular to the plane to find an expression for *R*. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error. All correct A1A1, one error A1A0, two or more errors A0A0 ($R = 33.68$)
	$-F + 30\cos\alpha - 2g\sin\alpha = 2\ a$	M1	Equation of motion parallel to the plane with *a* or their *a*. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error ($F = 6.74$)
	$\mu = \dfrac{30\cos\alpha - 2g\sin\alpha - 5.5}{30\sin\alpha + 2g\cos\alpha}$	DM1	Use $F = \mu R$ Dependent on the 2 previous M marks
	$= 0.200$ or 0.20	A1	Do not accept 0.2
		(8)	
		10	
4.		M1	Use $s = ut + \frac{1}{2}at^2$ or a complete *suvat* route to find h in terms of t
	$h = \frac{1}{2}gt^2$	A1	Or $h = \frac{1}{2}g\left(t+1\right)^2$. The expression for time used in the first equation defines the expression expected in the second equation.
	$h = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	A1	Or $h = 19.6(t) + \frac{1}{2}g(t)^2$ or $h = 4.9 + \left(9.8t + \frac{1}{2}gt^2\right)$
	$\frac{1}{2}gt^2 = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	M1	Equate the two expressions for *h*.
		DM1	Solve for *t*. Dependent on the previous M1.
	$t = 1.5$	A1	Using the "Or" approach gives $t = 0.5$
	$h = 11$ m or 11.0 m	A1	Accept 2 or 3 s.f. only
		7	

Leave blank

4. A small stone is released from rest from a point A which is at height h metres above horizontal ground. Exactly one second later another small stone is projected with speed 19.6 m s^{-1} vertically downwards from a point B, which is also at height h metres above the horizontal ground. The motion of each stone is modelled as that of a particle moving freely under gravity. The two stones hit the ground at the same time.

Find the value of h.

(7)

3(a)	$5.5 = \frac{1}{2}a.2^2$	M1	Complete method using *suvat* equations to form an equation in a only
	$\Rightarrow a = 2.75$	A1	
		(2)	
(b)	$R = 30\sin\alpha + 2g\cos\alpha$	M1	Resolve perpendicular to the plane to find an expression for R. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error. All correct A1A1, one error A1A0, two or more errors A0A0 ($R = 33.68$)
	$-F + 30\cos\alpha - 2g\sin\alpha = 2\ a$	M1	Equation of motion parallel to the plane with a or their a. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error ($F = 6.74$)
	$\mu = \dfrac{30\cos\alpha - 2g\sin\alpha - 5.5}{30\sin\alpha + 2g\cos\alpha}$	DM1	Use $F = \mu R$ Dependent on the 2 previous M marks
	$= 0.200$ or 0.20	A1	Do not accept 0.2
		(8)	
		10	
4.		M1	Use $s = ut + \dfrac{1}{2}at^2$ or a complete *suvat* route to find h in terms of t
	$h = \frac{1}{2}gt^2$	A1	Or $h = \frac{1}{2}g\left(t+1\right)^2$. The expression for time used in the first equation defines the expression expected in the second equation.
	$h = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	A1	Or $h = 19.6(t) + \frac{1}{2}g(t)^2$ or $h = 4.9 + \left(9.8t + \dfrac{1}{2}gt^2\right)$
	$\frac{1}{2}gt^2 = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	M1	Equate the two expressions for h.
		DM1	Solve for t. Dependent on the previous M1.
	$t = 1.5$	A1	Using the "Or" approach gives $t = 0.5$
	$h = 11$ m or 11.0 m	A1	Accept 2 or 3 s.f. only
		7	

Leave blank

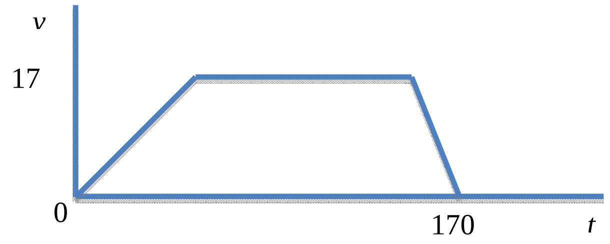
5. A car travelling along a straight horizontal road takes 170 s to travel between two sets of traffic lights at *A* and *B* which are 2125 m apart. The car starts from rest at *A* and moves with constant acceleration until it reaches a speed of 17 m s^{-1}. The car then maintains this speed before moving with constant deceleration, coming to rest at *B*. The magnitude of the deceleration is twice the magnitude of the acceleration.

(a) Sketch, in the space below, a speed-time graph for the motion of the car between *A* and *B*.

(3)

(b) Find the deceleration of the car.

(7)

5(a)		B1	shape
		B1	rel grad - RHS steeper than LHS
		B1 (3)	17 and 170 shown
(b)	$T;2T$	B1	Correct ratios of times for acceleration and deceleration seen or implied.
	$\frac{170+(170-3T)}{2}17=2125$ Or $\frac{1}{2}\times T_1\times 17+17(170-(T_1+T_2))+\frac{1}{2}\times 17\times T_2=2125$ Or $2125=\frac{17}{2}(170+T')$	M1	Form an equation for total distance with their times
		A2	-1 each error
	$T=30$ Or $T_1+T_2=90$	A1	Use their equation and the correct ratio to find the value for time decelerating or the total of time accelerating and decelerating
		M1	Use of $v=u+at$ or equivalent
	decel $=\frac{17}{30}$ oe	A1	$(0.5\dot{6})$ 3sf or better. Must be positive.
		(7)	
		10	

Leave blank

6.

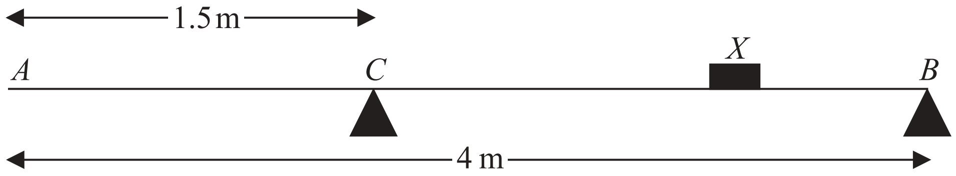


Figure 2

A plank AB has length 4 m and mass 6 kg. The plank rests in a horizontal position on two supports, one at B and one at C, where AC = 1.5 m. A load of mass 15 kg is placed on the plank at the point X, as shown in Figure 2, and the plank remains horizontal and in equilibrium. The plank is modelled as a uniform rod and the load is modelled as a particle. The magnitude of the reaction on the plank at C is twice the magnitude of the reaction on the plank at B.

(a) Find the magnitude of the reaction on the plank at C.
(3)

(b) Find the distance AX.
(5)

The load is now moved along the plank to a point Y, between A and C. Given that the plank is on the point of tipping about C,

(c) find the distance AY.
(4)

Question Number	Scheme	Marks	Notes
6(a)		M1	Resolve vertically to form an equation in R_c or R_D . All terms required. Condone sign errors.
	$2T+T=6g+15g$	A1	Correct unsimplified equation ($R+\frac{1}{2}R=6g+15g$)
	$2T=14g=137$ N or 140 N	A1	
		(3)	
(b)		M1	Take moments - all terms must be present and of the correct structure. Form an equation with one unknown length.
	$M(A)$ 15g AX + 6g x 2 = (2T x 1.5) + 4$T=7T$ $M(B)$ $15gd+6g\times 2=2T\times 2.5$ $M(\text{c of m})$ $2T\times 0.5+15gd=2\times T$ $M(C)$ $6g\times 0.5+15g(x-1.5)=T\times 2.5$	A2	-1 each error. Follow their T NB: Use of the correct reactions the wrong way round is one error. $(15g\approx 147,\ \ 6g\approx 58.8,\ \ 12g\approx 117.6)$
		M1	Substitute for T and solve for AX
	$AX=\frac{37}{15}$ m = 2.5 m (or better)	A1	$2.4\dot{6}$
		(5)	
	NB: If you see parts (a) and (b) merged, award the 8 marks as bM1 for the first moments equation bA2 for the equation correct aM1 for a second moments equation and an attempt to solve for R_C aA1 for the second equation correct aA1 for the reaction correct bM1 and bA1 as above		
(c)	$M(C)$, 15g YC = 6g x 0.5	M1	Requires both terms present and of the correct structure. No additional terms (Using $R_C=21g, R_B=0$)
		A1	Correct unsimplified equation
	YC = 0.2 m	A1	
	$AY=1.3$ m	A1	
		(4)	See over for Alt (c)
		12	

Alt (c)	$M(A)$: $15gAY + 6g \times 2 = 1.5 \times 21g$	M1	Requires all terms present and of the correct structure. No additional terms
		A2	Correct unsimplified equation -1 each error
	$AY = 1.3$ m	A1	
		(4)	
Alt (c)	$M(C)$: $6g \times 0.5 = 15g\left(1.5 - AY\right)$	M1	
		A2	-1 each error
	$AY = 1.3$ m	A1	
		(4)	
7.	$(2\mathbf{i} + 9\mathbf{j}) - (-3\mathbf{i} - 3\mathbf{j})$	M1	Use of $\mathbf{v} - \mathbf{u}\left(= \mathbf{a}t\right)$ seen or implied
	$= (5\mathbf{i} + 12\mathbf{j})$	A1	
	$k^2(5^2 + 12^2) = 2.6^2 \quad (k = 1/t)$	M1	Use magnitude = 2.6 = $k\lvert\mathbf{a}\rvert$ (linking 2.6 & 13)
	$c = 5\text{x}0.2 = 1$	A1	
	$d = 12\text{x}0.2 = 2.4$	A1	
		(5)	

Leave blank

7. A particle P moves from point A to point B with constant acceleration $(c\mathbf{i} + d\mathbf{j})$ m s^{-2}, where c and d are positive constants. The velocity of P at A is $(-3\mathbf{i} - 3\mathbf{j})$ m s^{-1} and the velocity of P at B is $(2\mathbf{i} + 9\mathbf{j})$ m s^{-1}. The magnitude of the acceleration of P is 2.6 m s^{-2}.

Find the value of c and the value of d.

(5)

Alt (c)	$M(A)$: $15gAY + 6g \times 2 = 1.5 \times 21g$	M1	Requires all terms present and of the correct structure. No additional terms
		A2	Correct unsimplified equation -1 each error
	$AY = 1.3$ m	A1	
		(4)	
Alt (c)	$M(C)$: $6g \times 0.5 = 15g\left(1.5 - AY\right)$	M1	
		A2	-1 each error
	$AY = 1.3$ m	A1	
		(4)	
7.	$(2\mathbf{i} + 9\mathbf{j}) - (-3\mathbf{i} - 3\mathbf{j})$	M1	Use of $\mathbf{v} - \mathbf{u}\left(= \mathbf{a}t\right)$ seen or implied
	$= (5\mathbf{i} + 12\mathbf{j})$	A1	
	$k^2(5^2 + 12^2) = 2.6^2 \quad (k = 1/t)$	M1	Use magnitude = 2.6 = $k\lvert\mathbf{a}\rvert$ (linking 2.6 & 13)
	$c = 5\text{x}0.2 = 1$	A1	
	$d = 12\text{x}0.2 = 2.4$	A1	
		(5)	

Leave blank

8.

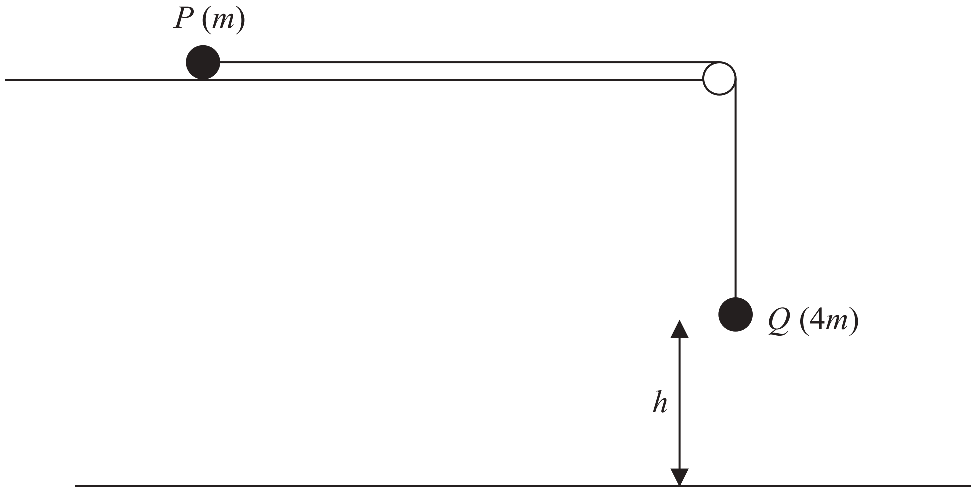


Figure 3

Two particles P and Q have masses m and $4m$ respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a rough horizontal table. The string lies along the table and passes over a small smooth light pulley which is fixed at the edge of the table. Particle Q hangs at rest vertically below the pulley, at a height h above a horizontal plane, as shown in Figure 3. The coefficient of friction between P and the table is 0.5. Particle P is released from rest with the string taut and slides along the table.

(a) Find, in terms of mg, the tension in the string while both particles are moving.
(8)

The particle P does not reach the pulley before Q hits the plane.

(b) Show that the speed of Q immediately before it hits the plane is $\sqrt{1.4gh}$
(2)

When Q hits the plane, Q does not rebound and P continues to slide along the table. Given that P comes to rest before it reaches the pulley,

(c) show that the total length of the string must be greater than $2.4h$
(6)

8(a)	$R = mg$	B1	Forces acting vertically on P
	$F = 0.5R$	B1	Use of $F = \mu R$
		M1	One equation of motion. Requires all terms but condone sign errors
	$4mg - T = \pm 4ma$	A1	
		M1	A second equation of motion of P. Requires all terms but condone sign errors
	$T - F = \pm ma$	A1	Signs of a must be consistent
			Condone use of $4mg - F = 5ma$ in place of either of the above equations.
	$4mg - 0.5mg = 5ma$ $a = 0.7g$ or $4mg - T = 4T - 2mg$	DDM1	Solve for T Dependent on the two preceding M marks
	$T = 1.2mg$	A1	
		(8)	
(b)	$v^2 = 2 \text{ x } 0.7\text{gh}$	M1	Complete method to an equation in v or v^2
	$v = \sqrt{1.4gh}$ *	A1	Obtain **given answer** or exact equivalent from exact working with no errors seen.
		(2)	
(c)	$-0.5mg = ma'$	M1	Complete method to find the deceleration of P
	$\Rightarrow a' = -0.5g$	A1	
		M1	Complete method to find additional distance on terms of h $(a \neq 0.7g, a \neq g)$
	$0^2 = 1.4gh - 2 \text{ x } 0.5g \text{ x } d$	A1	Correctly substituted equation. Follow their $a \neq 0.7g$, $a \neq g$.
	$d = 1.4h$	A1	
	Hence, length of string is greater than $1.4h + h = 2.4h$	A1	Obtain **given answer** with no errors seen. Their statement needs to reflect the inequality.
		(6)	
		16	