Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 22 January 2014 – 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 ▶

P43012A

5/5/5/5/

P 4 3 0 1 2 A 0 1 2 8

PEARSON

Leave blank

1. A truck P of mass $2M$ is moving with speed U on smooth straight horizontal rails. It collides directly with another truck Q of mass $3M$ which is moving with speed $4U$ in the opposite direction on the same rails. The trucks join so that immediately after the collision they move together. By modelling the trucks as particles, find

(a) the speed of the trucks immediately after the collision,

(3)

(b) the magnitude of the impulse exerted on P by Q in the collision.

(3)

Question Number	Scheme	Marks
1. (a)	$12MU - 2MU = 5MV$ $2U = V$	M1 A1 A1 (3)
(b)	$I = 2M\left(V - -U\right)$ OR $I = 3M\left(-V - -4U\right)$ $= 6MU$	M1 A1 A1 (3) **6**
Notes		
1. (a)	M1 for attempt at CLM equation, with correct no. of terms, dimensionally correct. Allow consistent extra g's and cancelled *M*'s and sign errors. First A1 for a correct equation. Second A1 for $2U$ ($-2U$ A0) N.B. Allow *U*'s to be dropped or omitted in the equation if *U* is inserted in answer at the end. (Full marks can be scored). However, if *U* is not inserted then M0.	
(b)	M1 for attempt at impulse = difference in momenta, for either particle, (must be considering *one* particle) (M0 if g's are included or if mass omitted or if equation is dimensionally incorrect) Allow $\pm 2M(V - U)$ or $\pm 3M(-V - 4U)$ where *V* is their speed which does *not* need to be substituted. First A1 for $\pm 2M(2U - -U)$ or $\pm 3M(-2U - -4U)$ A1 for $6MU$ cao ($-6MU$ is A0) Allow change of sign at end to obtain magnitude.	

Leave blank

2. A particle P is moving with constant velocity $(2\mathbf{i} - 3\mathbf{j})$ m s^{-1}.

(a) Find the speed of P.

(2)

The particle P passes through the point A and 4 seconds later passes through the point with position vector $(\mathbf{i} - 4\mathbf{j})$ m.

(b) Find the position vector of A.

(4)

Question Number	**Scheme**	**Marks**
2. (a)	$v = \sqrt{2^2 + (-3)^2} = \sqrt{13} = 3.61 \text{ ms}^{-1}$	M1 A1 (2)
(b)	$\mathbf{a} + 4(2\mathbf{i} - 3\mathbf{j}) = (\mathbf{i} - 4\mathbf{j})$ $\mathbf{a} = (-7\mathbf{i} + 8\mathbf{j})\text{m}$	M1 A1 DM1 A1 (4) **6**
Notes		
2. (a)	M1 for $\sqrt{}$ (sum of squares of cpt.s) allow $\sqrt{(2^2+3^2)}$ A1 for $\sqrt{13}$, 3.6 or better	
(b)	First M1 for $\mathbf{a} \pm 4(2\mathbf{i} - 3\mathbf{j}) = (\mathbf{i} - 4\mathbf{j})$ oe A1 for $\mathbf{a} + 4(2\mathbf{i} - 3\mathbf{j}) = (\mathbf{i} - 4\mathbf{j})$ oe Second DM1, dependent, for solving for a A1 for $(-7\mathbf{i} + 8\mathbf{j})$ A0 for $\begin{pmatrix} -7\mathbf{i} \\ 8\mathbf{j} \end{pmatrix}$ or $(-7\mathbf{i}, 8\mathbf{j})$	

Leave blank

3. A beam AB has length 15 m and mass 25 kg. The beam is smoothly supported at the point P, where $AP = 8$ m. A man of mass 100 kg stands on the beam at a distance of 2 m from A and another man stands on the beam at a distance of 1 m from B. The beam is modelled as a non-uniform rod and the men are modelled as particles. The beam is in equilibrium in a horizontal position with the reaction on the beam at P having magnitude 2009 N. Find the distance of the centre of mass of the beam from A.

(5)

Question Number	**Scheme**	**Marks**
3.	*M(X),* $25g(14 - x) + 100g.\ 12 = 2009 \times 6$ $x = 12.8,\ 13$ (m)	M1 A1 A1 DM1 A1 **5**
	Notes	
3.	First M1 for producing an equation in a relevant unknown length *only*. Usual rules, correct no. of terms, dim correct. (If more than one equation is used, rules apply to *each* equation) First A2 for a correct equation; -1 each error (omission of *g*'s counts as one error) Second DM1, dependent, for solving for AG. Third A1 for 12.8, 13 oe. S.C. If they use *M* in their equation(s) and never find it or just assume a value for it e.g. 100, can score max M1A0A0M0A0	

Leave blank

4.

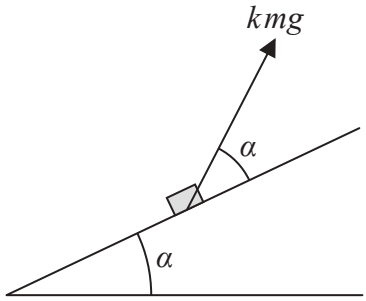


Figure 1

A fixed rough plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$

A small box of mass m is at rest on the plane. A force of magnitude kmg, where k is a constant, is applied to the box. The line of action of the force is at angle α to the line of greatest slope of the plane through the box, as shown in Figure 1, and lies in the same vertical plane as this line of greatest slope. The coefficient of friction between the box and the plane is μ. The box is on the point of slipping up the plane. By modelling the box as a particle, find k in terms of μ.

(11)

Question Number	Scheme	Marks
4.	Use of $F = \mu R$; $\cos\alpha = \frac{4}{5}$ or $\sin\alpha = \frac{3}{5}$ $kmg\cos\alpha - mg\sin\alpha = F$ $mg\cos\alpha - kmg\sin\alpha = R$ equation in k and μ only $k = \frac{3+4\mu}{4+3\mu}$	B1 ; B1 M1 A1 A1 M1 A1 A1 DM1 DM1 A1 **11**

Notes

4.

First B1 for use of $F = \mu R$ i.e. seen on the diagram or in an equation.
Second B1 for $\cos\alpha = 0.8$ or $\sin\alpha = 0.6$ seen.
First M1 for resolving parallel to the plane (usual rules)
First A2 for a correct equation; -1 each error (omission of both g's is 1 error)
Second M1 for resolving perpendicular to the plane (usual rules)
Second A2 for a correct equation; -1 each error (omission of both g's is 1 error)
N.B. In each equation, if they write cos 4/5 or sin 3/5 (or both) treat as 1 A error but allow recovery if they actually use the correct trig. ratios.
Third DM1, dependent on first two M marks, for producing an equation in *k* and *μ only*.
Fourth DM1, dependent on third M1, for solving for k, in terms of μ only.
Fifth A1 for $k = \frac{3+4\mu}{4+3\mu}$ oe
N.B. The first two M1A2 marks can be for two resolutions in any two directions.

Leave blank

5. A racing car is moving along a straight horizontal track with constant acceleration. There are three checkpoints, P, Q and R, on the track, where $PQ = 48$ m and $QR = 200$ m. The car takes 3 s to travel from P to Q and 5 s to travel from Q to R. Find

(i) the acceleration of the car,

(ii) the speed of the car as it passes P.

(7)

Question Number	**Scheme**	**Marks**
5.	$48 = 3u + \frac{1}{2}9a$ $248 = 8u + \frac{1}{2}64a$ $a = 6 \text{ ms}^{-1}$ $u = 7 \text{ ms}^{-1}$	M1 A1 M1 A1 A1 M1 A1 **7**

Notes

5.

First M1 for producing an equation in *u and a only.*
First A1 for a correct equation
Second M1 for producing an equation in *u and a only.*
(M0 for $200 = 5u + 0.5a.\ 5^2$)
Second A1 for a correct equation
Third M1 independent for solving *simultaneous* equations, in *u* and *a* only, for either *u* or *a*
Third A1 for $a = 6$
Fourth A1 for $u = 7$

Alternative using speed *v* at $t = 3$:
First M1 for attempt at: $48 = 3v - 0.5a.3^2$
First A1 for a correct equation
Second M1 attempt at : $200 = 5v + 0.5a.\ 5^2$
Second A1 for a correct equation
Third M1 independent for solving *simultaneous* equations, in *u* and *a* only, for either *u* or *a*
Third A1 for $a = 6$
Fourth A1 for $u = 7$

Alternative, using average speed = *actual speed* at half-time
$v = 48/3$ *at t = 1.5 (must be used/stated)* M1 A1
$v = 200/5$ *at t = 5.5 (must be used/stated)* M1 A1
$a = (40 - 16)/(5.5 - 1.5) = 6$ DM1 A1
$u = 16 - (6 \times 1.5) = 7$ A1

Leave blank

6.

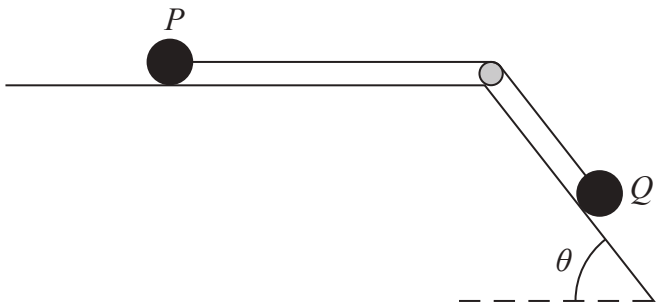


Figure 2

Two particles P and Q have masses 0.1 kg and 0.5 kg 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 pulley which is fixed to the edge of the table. Particle Q is at rest on a smooth plane which is inclined to the horizontal at an angle θ, where $\tan\theta = \frac{4}{3}$

The string lies in the vertical plane which contains the pulley and a line of greatest slope of the inclined plane, as shown in Figure 2. Particle P is released from rest with the string taut. During the first 0.5 s of the motion P does not reach the pulley and Q moves 0.75 m down the plane.

(a) Find the tension in the string during the first 0.5 s of the motion.

(6)

(b) Find the coefficient of friction between P and the table.

(5)

Question Number	Scheme	Marks
6. (a)	$0.75 = \frac{1}{2}a(0.5)^2$ $a = 6$ $0.5g\sin\theta - T = 0.5a$ $T = 0.92\ N$	M1 A1 A1 M1 A1 A1 (6)
(b)	$R = 0.1g$ $T - \mu R = 0.1a$ $0.92 - \mu 0.1g = 0.1\times 6$ $\mu = 0.327$ or 0.33	B1 M1 A1 M1 A1 (5) **11**

Notes

6. (a)	First M1 for use of $s = ut + 1/2at^2$ (or use of 2 *suvat* formulae AND eliminating v) with $u = 0$, to give equation in a *only*. First A1 for a correct equation Second A1 for $a = 6$ Second M1 for resolving parallel to the plane, up or down, for Q *only*. Third A1 for a correct equation (a does not need to be substituted) Fourth A1 for $T = 0.92$ (N)
(b)	B1 for $R = 0.1$g First M1 for resolving horizontally for P only First A1 for a correct equation (neither T, R nor a need to be substituted) Second M1 for substituting for T, R and a and solving for μ. Second A1 for $\mu = 0.327$ or 0.33 (16/49 A0) <u>Alternative:</u> B1 for $R = 0.1$g First M1 for a 'whole system' equation: $0.5g\sin\theta - \mu R = 0.6a$ First A1 for a correct equation (neither R nor a need to be substituted) Second M1 for substituting for R and a and solving for μ. Second A1 for $\mu = 0.327$ or 0.33

Leave blank

7. A force **F** is given by **F** = (9**i** + 13**j**) N.

(a) Find the size of the angle between the direction of **F** and the vector **j**.

(3)

The force **F** is the resultant of two forces **P** and **Q**. The line of action of **P** is parallel to the vector (2**i** – **j**). The line of action of **Q** is parallel to the vector (**i** + 3**j**).

(b) Find, in terms of **i** and **j**,

(i) the force **P**,

(ii) the force **Q**.

(9)

Question Number	Scheme	Marks
7. (a)	$\tan\theta = \frac{9}{13}$ $\theta = 34.7°$	M1 A1 A1 (3)
(b)	$a(2\mathbf{i}-\mathbf{j})+b(\mathbf{i}+3\mathbf{j})=(9\mathbf{i}+13\mathbf{j})$ $2a+b=9$ $-a+3b=13$ $a=2,\ b=5$ $\mathbf{P}=(4\mathbf{i}-2\mathbf{j})\text{N};\ \mathbf{Q}=(5\mathbf{i}+15\mathbf{j})\text{N}$	M1 A2 M1 M1 A1 A1 A1 A1 (9) **12**

Notes

7. (a)	M1 for $\tan\theta$ = 9/13 or 13/9 First A1 for a correct equation (allowing for a correct adjustment to their angle in the subsequent working) Second A1 for θ = 35° or better or 325° or better
(b)	First M1 for **P** + **Q** = 9**i** + 13**j** or **P** + **Q** = **F** (can occur anywhere) First A2; Treat as B1 for $a(2\mathbf{i}-\mathbf{j})$ seen or implied; B1 for $b(\mathbf{i}+3\mathbf{j})$ seen or implied. If they use the same *a* and *b*, they lose one of the B marks. Second M1 for equating their **i**- cpts *and* their **j**- cpts to produce two equations in two unknowns Third independent M1 for eliminating one unknown from 2 simultaneous equations Third A1 for *a* = 2 oe Fourth A1 for *b* = 5 oe Fifth A1 for $\mathbf{P}=(4\mathbf{i}-2\mathbf{j})$ (N) Sixth A1 for $\mathbf{Q}=(5\mathbf{i}+15\mathbf{j})$ (N) N.B. Can score all the marks if they 'spot' the answers.

Leave blank

8. Two trains, A and B, start together from rest, at time $t = 0$, at a station and move along parallel straight horizontal tracks. Both trains come to rest at the next station after 180 s.

Train A moves with constant acceleration $\frac{2}{3}$ m s^{-2} for 30 s, then moves at constant speed for 120 s and then moves with constant deceleration for the final 30 s. Train B moves with constant acceleration for 90 s and then moves with constant deceleration for the final 90 s.

(a) Sketch, on the same axes, the speed–time graphs for the motion of the two trains between the two stations.

(3)

(b) Find the acceleration of train B for the first half of its journey.

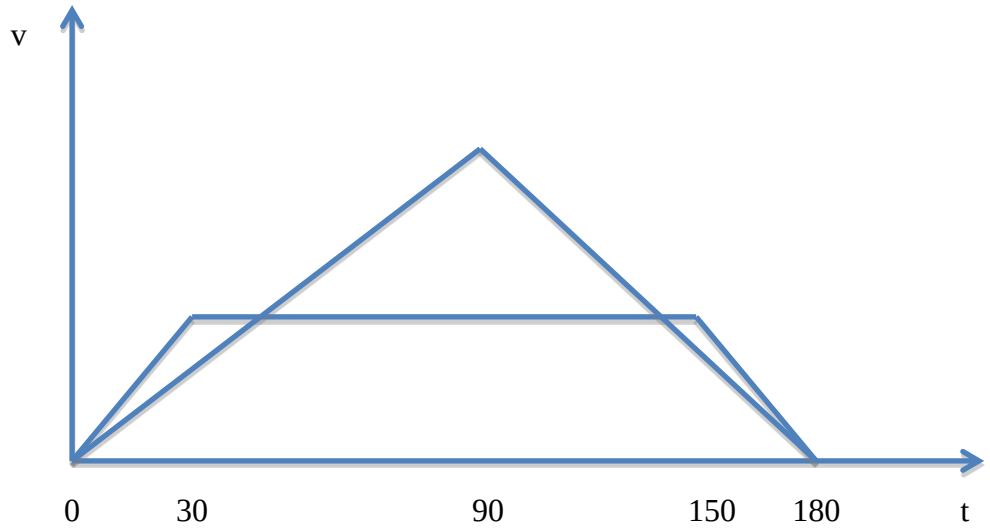
(5)

(c) Find the times when the two trains are moving at the same speed.

(4)

(d) Find the distance between the trains 96 s after they start.

(5)

Question Number	Scheme	Marks
8. (a)		B1 trapezium B1 triangle & overlap B1 figs (3)
(b)	$\frac{1}{2}(90+60).20=1500$ $1500=\frac{1}{2}a.90^2$ $a=\frac{10}{27}$ ms^{-1} or decimal	M1 A1 M1 A1 **ft** A1 (5)
(c)	$\frac{10t}{27}=20$ $t=54$ s $t=126$ s	M1 A1 A1 A1 **ft** (4)
(d)	$\frac{10}{27}\times 90\left(=\frac{100}{3}\right)$ $\frac{100}{3}\times 6-\frac{1}{2}.\frac{10}{27}.6^2\left(=\frac{580}{3}\right)$ $d=\frac{580}{3}-(20\times 6)$ $=\frac{220}{3}$m or decimal	M1 DM1 A1 DM1 A1 (5) **17**

Notes	
8. (a)	First B1 for isosceles (approx.) trapezium, from the origin, finishing on the *t*-axis. Second B1 for isosceles (approx.) triangle, from the origin, finishing on the *t*-axis at the same point *and overlapping twice.* Third B1 for 30, 90, 150, 180 placed correctly. Allow delineators
(b)	First M1 for complete method to find distance (or half the distance) between the stations First A1 for a correct expression (may not be evaluated) Second M1 for a complete method to find *a* (M0 if they use *s* = the full distance in any *suvat* equation) Second A1 ft on their distance Third A1 10/27 oe, 0.37 or better
(c)	First M1 for (their *a*) x *t* = 20 (or their *v* max for *A*) First A1 for a correct equation Second A1 for 54 (t_1) (54.1 A0) Third A1 ft for (180 – t_1), provided $30 < t_1 < 90$
(d)	First M1 for finding max speed of *B* e.g. their *a* x 90 (ans 100/3) (may have been found in (b) but must be seen in (d) Second M1 for a complete method (must have found a max *V*) to find distance moved by *B* between *t* = 90 and *t* = 96 (or between 84 and 90) First A1 for a correct expression Third DM1, dependent on first and second M marks, for a complete method to find the required distance Second A1 for 220/3 m oe, 73 m or better