Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Tuesday 20 January 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 ▶

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1. A railway truck A of mass m and a second railway truck B of mass $4m$ are moving in opposite directions on a smooth straight horizontal track when they collide directly. Immediately before the collision the speed of truck A is $3u$ and the speed of truck B is $2u$. In the collision the trucks join together. Modelling the trucks as particles, find

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

(3)

(b) the direction of motion of A immediately after the collision,

(1)

(c) the magnitude of the impulse exerted by A on B in the collision.

(3)

Jan 2015 (IAL) Post QPEC
6677 Mechanics M1
Mark Scheme

Question Number	Scheme	Marks
1.(a)	$8mu - 3mu = 5mv$	M1 A1
	$v = u$	A1 (3)
(b)	Original direction of motion of B o.e.	B1 (1)
(c)	For A: $I = m(u - -3u)$ **OR** For B: $I = 4m(-u - -2u)$	M1 A1
	$= 4mu$ $= 4mu$	A1 (3)
		7
	NOTES **Question 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. (M1 if they find the impulse on each particle *and eliminate* the impulse to give an equation – then use above criteria for their equation) First A1 for a correct equation. ($3mu - 8mu = 5mv$ or $-5mv$ oe) Second A1 for u ($-u$ 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. **Question 1(b)** B1 for (original) direction of B or opposite to original direction (of A) oe. (B0 for 'left' or direction changed). **N.B.** Must follow from $v = u$ or $-u$ obtained in (a). **Question 1(c)** M1 for attempt at impulse = difference in momenta, for either particle, (must be considering *one* particle) (M0 if g's are included or if m omitted or if mass doesn't match velocities used) A1 for $\pm m(-u - 3u)$ or $\pm 4m(-u - (-2u))$ A1 for $4mu$ cao ($-4mu$ is A0) Allow change of sign at end to obtain magnitude.	

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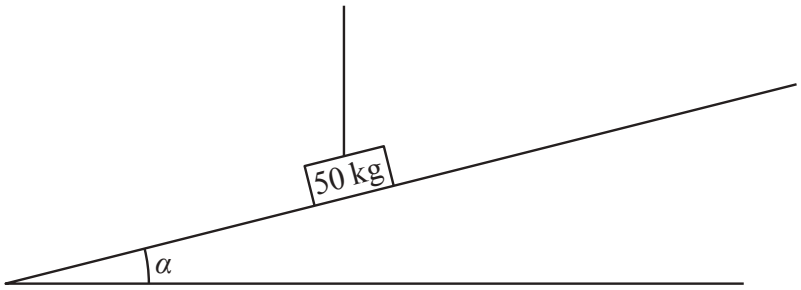

Figure 1

A block of mass 50 kg lies on a rough plane which is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{7}{24}$. The block is held at rest by a vertical rope, as shown in Figure 1, and is on the point of sliding down the plane. The block is modelled as a particle and the rope is modelled as a light inextensible string. Given that the friction force acting on the block has magnitude 65.8 N, find

(a) the tension in the rope,

(4)

(b) the coefficient of friction between the block and the plane.

(4)

2. (a)	$T\sin\alpha + 65.8 = 50g\sin\alpha$ $T = 255$ N or 260 N	M1 A1 **DM**1A1 (4)
(b)	$65.8\cos\alpha = R\sin\alpha$ $\mu = 65.8/R = \tan\alpha = 7/24,$ 0.29 or better	M1 A1 M1 A1 (4) **8**

NOTES

Question 2(a)
First M1 for resolving parallel to the plane (or an equation in *T* only)
First A1 for a correct equation.
Second M1 dependent for producing a value for *T*.
Second A1 for 255 (N) or 260 (N).

Question 2(b)
First M1for **any** equation containing *R*.
First A1 for a correct equation. (If equation includes a *T* term, they must be using a correct value of *T* to score this mark)
Second M1 for (65.8/their *R*).
Second A1 for 7/24, 0.29 or better.

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3. [*In this question* **i** *and* **j** *are unit vectors directed due east and due north respectively*.]

A particle P is moving with constant velocity $(-6\mathbf{i} + 2\mathbf{j})$ m s^{-1}. At time $t = 0$, P passes through the point with position vector $(21\mathbf{i} + 5\mathbf{j})$ m, relative to a fixed origin O.

(a) Find the direction of motion of P, giving your answer as a bearing to the nearest degree.

(3)

(b) Write down the position vector of P at time t seconds.

(1)

(c) Find the time at which P is north-west of O.

(3)

3.(a)	$\tan\alpha = 1/3 \quad \Rightarrow \quad \alpha = 18.4^{o}$	M1 A1
	Bearing is 288° (nearest degree)	A1 (3)
(b)	$\mathbf{r} = (21\mathbf{i} + 5\mathbf{j}) + t(-6\mathbf{i} + 2\mathbf{j})$	B1 (1)
(c)	$21 - 6t = -(5 + 2t)$	M1 A1
	$t = 6.5$	A1 (3)
		7

NOTES

Question 3(a)

First M1 for $\arctan(\frac{\pm 2}{\pm 6})$

First A1 for a correct value from their expression, usually 18.4^{o} or 71.6^{o}

Second A1 for 288 (nearest degree)

Question 3(b)

B1 for $(21\mathbf{i} + 5\mathbf{j}) + t(-6\mathbf{i} + 2\mathbf{j})$

Question 3(c)

M1 for equating the negative of their **i**-component to their **j**-component oe

Allow equating the components for the M mark.

First A1 for a correct equation.

Second A1 for $t = 6.5$

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4. The points P and Q are at the same height h metres above horizontal ground. A small stone is dropped from rest from P. Half a second later a second small stone is thrown vertically downwards from Q with speed $7.35\,\text{m s}^{-1}$. Given that the stones hit the ground at the same time, find the value of h.

(7)

4.	$h = \frac{1}{2}gt^2$ $h = 7.35(t-\frac{1}{2}) + \frac{1}{2}g(t-\frac{1}{2})^2$ $\frac{1}{2}gt^2 = 7.35(t-\frac{1}{2}) + \frac{1}{2}g(t-\frac{1}{2})^2$ $t = 1$ $h = 4.9$	B1 M1 A1 **DM**1 M1 A1 A1 **7**
	NOTES **Question 4** B1 for $h = \frac{1}{2}gt^2$ or $h = \frac{1}{2}g(t+\frac{1}{2})^2$ First M1 for $h = 7.35(t-\frac{1}{2}) + \frac{1}{2}g(t-\frac{1}{2})^2$ or $h = 7.35t + \frac{1}{2}gt^2$ M0 if different *t* used in the two terms and M0 if two terms have opposite signs. First A1 for appropriate *t* value used Second M1, dependent, for equating their two expressions for *h*, but must have different *t*'s in the two expressions Third M1, independent, for solving for their *t* (must have used two expressions etc.) Second A1 for $t = 1$ (or $t = ½$) Third A1 for $h = 4.9$ **N.B.** See alternative below where *t* is eliminated: $h = \frac{1}{2}gt^2$ B1 $h = 7.35(t-\frac{1}{2}) + \frac{1}{2}g(t-\frac{1}{2})^2$ M1A1 $h = 7.35(\sqrt{\frac{2h}{g}}-\frac{1}{2}) + \frac{1}{2}g(\sqrt{\frac{2h}{g}}-\frac{1}{2})^2$ **DM**1 $h = 7.35\sqrt{\frac{2h}{g}} - 3.675 + 4.9(\frac{2h}{g} - \sqrt{\frac{2h}{g}} + 0.25)$ A1 $h = 4.9$ M1 A1	

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5.

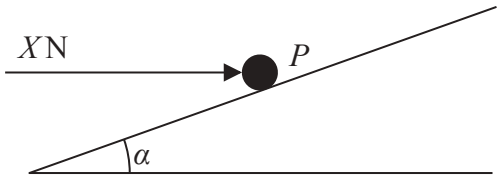

Figure 2

A particle P of mass 2 kg is pushed up a line of greatest slope of a rough plane by a horizontal force of magnitude X newtons, as shown in Figure 2. The force acts in the vertical plane which contains P and a line of greatest slope of the plane. The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$

The coefficient of friction between P and the plane is 0.5

Given that the acceleration of P is 1.45 m s^{-2}, find the value of X.

(10)

5.	$R = X\sin\alpha + 2g\cos\alpha$ $X\cos\alpha - F - 2g\sin\alpha = 2\times 1.45$ $F = 0.5R$ Eliminating R: solving for X $X = 45$	M1 A2 M1 A2 B1 **DM**1;**DM**1 A1 **10**
	NOTES **Question 5** First M1 for resolving perp to the plane.. First A2 for a correct equation; -1 each error. Second M1 for resolving parallel to the plane. Second A2 for a correct equation; -1 each error. (Allow F at this stage) B1 for $F = ½ R$ Third M1 dependent on previous two M's for eliminating R. Fourth M1 dependent on previous M for solving for X Third A1 for $X = 45$.	

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6. A uniform rod AC, of weight W and length $3l$, rests horizontally on two supports, one at A and one at B, where $AB = 2l$. A particle of weight $2W$ is placed on the rod at a distance x from A. The rod remains horizontal and in equilibrium.

(a) Find the greatest possible value of x.

(5)

The magnitude of the reaction of the support at A is R. Due to a weakness in the support at A, the greatest possible value of R is $2W$,

(b) find the least possible value of x.

(5)

6. (a)	x is greatest when rod is about to tip about B *i.e.* $R_A = 0$ (can be implied) $M(B),\ \ 2W(x-2l) = W\frac{1}{2}l$ $x = 2.25l$	B1 M1 A1 **DM**1 A1 (5)
(b)	Use of $R_A = 2W$ in an equation $M(B),\quad 2W(2l-x)+W\frac{1}{2}l = 2W.2l$ $x = 0.25l$	M1 M1 A1 A1 A1 (5) **10**
	NOTES **Question 6(a)** B1 for x greatest when $R_A = 0$ (usually implied in moments equation) or correct use of $R_A \geq 0$. First M1 for an equation in x and l ONLY (usually moments about B but could come from two equations). Allow if there is W (uncancelled) in each term. (M0 if R_A term included unless it subsequently becomes zero) First A1 for a correct equation –again allow even if W has not been cancelled. Second M1, dependent on previous M, for solving for x in terms of l. Second A1 for $x = 2.25l$. **N.B.** If 'l' omitted consistently and then inserted at end award full marks. If not inserted then can score max B1M1A0M1A0 **Question 6(b) Scheme change** First M1 for use of $R_A = 2W$ in any equation (vertical resolution or moments) or for correct use of $R_A \leq 2W$. Second M1 for an equation in x and l ONLY (usually moments about B but could come from two equations). Allow if there is W (uncancelled) in each term. A2 for the equation, again allow even if W has not been cancelled, -1 each error. Third A1 for $x = 0.25l$. **N.B.** If 'l' omitted consistently and then inserted at end award full marks. If not inserted then can score max M1M1A0A0A0.	

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7. A train travels along a straight horizontal track between two stations A and B. The train starts from rest at A and moves with constant acceleration until it reaches its maximum speed of 108 km h^{-1}. The train then travels at this speed before it moves with constant deceleration coming to rest at B. The journey from A to B takes 8 minutes.

(a) Change 108 km h^{-1} into m s^{-1}.

(2)

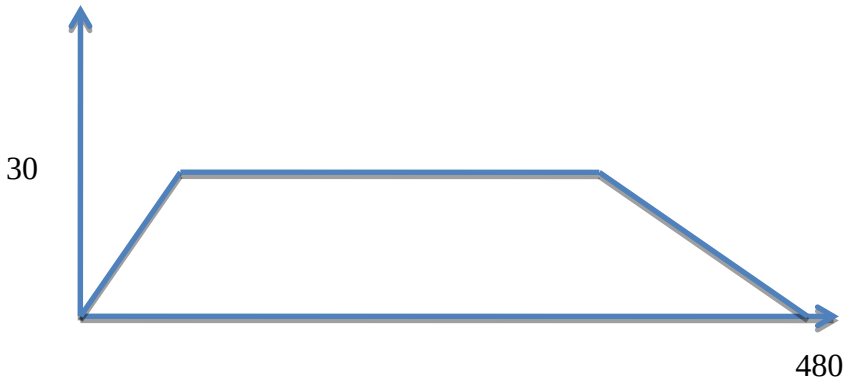
(b) Sketch a speed-time graph for the motion of the train between the two stations A and B.

(2)

Given that the distance between the two stations is 12 km and that the time spent decelerating is three times the time spent accelerating,

(c) find the acceleration, in m s^{-2}, of the train.

(6)

7 (a)	$108\times1000/3600 = 30 \text{ m s}^{-1}$	M1 A1 (2)
(b)		B1 shape **DB1 ft** figs (2)
(c)	$12000 = \frac{1}{2}\times30(480+480-4T)$ $T = 40$ $a = 30/40 = 0.75 \text{ m s}^{-2}$	M1 A2 A1 M1 A1 (6) **10**

NOTES

Question 7(a)
M1 for 108 x 1000/3600 oe
A1 for 30

Question 7(b)
First B1 for trapezium (B0 for triangle), from the origin, finishing on the *t*-axis.
Second dependent B1 **ft** on their '30' and 480 or 108 and (8/60 oe).

Question 7(c)
First M1 for clear attempt at equating *total* area under a trapezium to distance travelled oe (equation must include at least one '1/2') to give equation in ONE unknown.
A2 for a correct equation , -1 each error. **N.B.** Repeated use of an incorrect v from part (a) is ONE error.
Third A1 for $T = 40$ (or 120)
N.B. (First M1 **only** for ½(480 + *x*).30 = 12000
First A1 for 480 – *x* = 160; Second A1 if they divide 160 in ratio 1:3)
(First M0 if they use *s* = the full distance in any single *suvat* equation)
Second M1 (independent) for a complete method to find *a*.
Fourth A1 for 0.75

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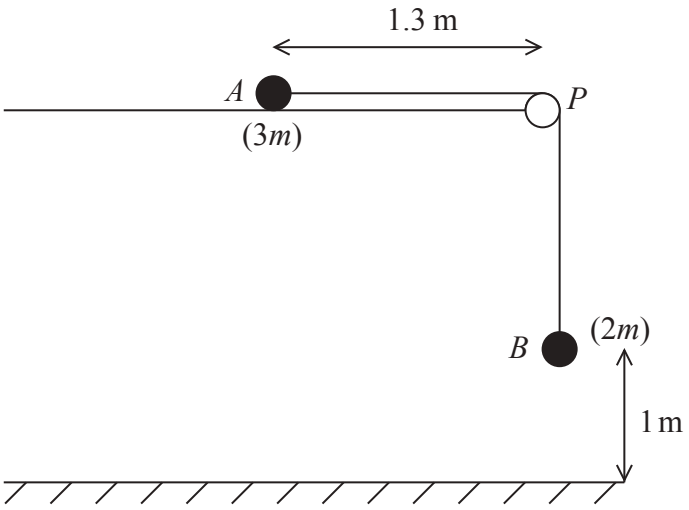

Figure 3

A particle A of mass $3m$ is held at rest on a rough horizontal table. The particle is attached to one end of a light inextensible string. The string passes over a small smooth pulley P which is fixed at the edge of the table. The other end of the string is attached to a particle B of mass $2m$, which hangs freely, vertically below P. The system is released from rest, with the string taut, when A is 1.3 m from P and B is 1 m above the horizontal floor, as shown in Figure 3.

Given that B hits the floor 2 s after release and does not rebound,

(a) find the acceleration of A during the first two seconds,

(2)

(b) find the coefficient of friction between A and the table,

(8)

(c) determine whether A reaches the pulley.

(6)

8 (a)	For B: $1 = \frac{1}{2}a.2^2 \quad \Rightarrow \quad a = \frac{1}{2}$ m s^{-2}	M1 A1 (2)
(b)	$R = 3mg$; F=μR	B1 ; B1
	$T - F = 3m \times 0.5$	M1 A1**ft**
	$2mg - T = 2m \times 0.5$	M1 A1 **ft**
	Solving for μ	**DM**1
	$\mu = 0.58$ or 0.582	A1 (8)
(c)	$v = \frac{1}{2} \times 2 = 1$	B1 **ft**
	$-\mu \ 3mg = 3ma$	M1
	$0 = 1^2 - 2\mu gs$	M1
	$s = 0.0877\ldots$(.0.09 or better)	A1
	$s < 0.3$ correct conclusion,	**DM**1A1 cso (6)
		16

NOTES

Question 8(a)
First M1 for a complete method to find *a*. M0 if s =1.3 is used
First A1 for a =0.5

Question 8(b)
First B1 for $R = 3mg$
Second B1 for $F = \mu R$ seen (could be on diagram)
First M1 for resolving horizontally for A (this M mark can be scored if they just use *m* for mass but M0 if no mass used)
First A1ft on their *a*, for correct equation. (allow *F*)
Second M1 for resolving vertically for B (this M mark can be scored if they just use *m* for mass but M0 if no mass used)
Second A1ft on their *a*, for correct equation.
(Allow M2A2 for 'whole system' equation but M0 if not using 5*m*)
Third M1 dependent on both previous M marks for solving for μ
N.B. If *m* omitted consistently throughout (b), can score max B0B1M1A0M1A0M1A0

Question 8(c)
B1 **ft** for (their *a* x 2) oe to find *v*
First M1 for resolving horizontally for A with $T = 0$
Second M1 for a complete method (must have found a new '*a*') to find distance moved by *A*.
First A1 for 0.09 or better (0.087719..)
Third M1, dependent on first and second M marks, for comparison with 0.3 or 1.3 (Must explicitly refer to either 0.3 or 1.3 or an appropriate equivalent)
Second A1 **cso** for does not reach pulley.