OCR
RECOGNISING ACHIEVEMENT

Thursday 6 June 2013 – Morning

AS GCE MATHEMATICS

4728/01 Mechanics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4728/01
- List of Formulae (MF1)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found in the centre of the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

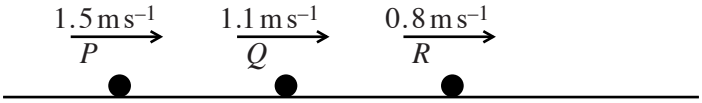
This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

1



Three particles P, Q and R have masses 0.1 kg, 0.3 kg and 0.6 kg respectively. The particles travel along the same straight line on a smooth horizontal table and have velocities $1.5\,\text{m s}^{-1}$, $1.1\,\text{m s}^{-1}$ and $0.8\,\text{m s}^{-1}$ respectively (see diagram). P collides with Q and then Q collides with R. In the second collision Q and R coalesce and subsequently move with a velocity of $1\,\text{m s}^{-1}$.

(i) Find the speed of Q immediately before the second collision. **[3]**

(ii) Calculate the change in momentum of P in the first collision. **[3]**

2 A particle P is projected vertically upwards and reaches its greatest height 0.5 s after the instant of projection. Calculate

(i) the speed of projection of P, **[2]**

(ii) the greatest height of P above the point of projection. **[3]**

It is given that the point of projection is 0.539 m above the ground.

(iii) Find the speed of P immediately before it strikes the ground. **[3]**

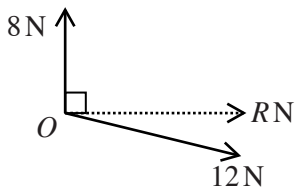
3 Two forces of magnitudes 8 N and 12 N act at a point O.

(i) Given that the two forces are perpendicular to each other, find

(a) the angle between the resultant and the 12 N force, **[2]**

(b) the magnitude of the resultant. **[2]**

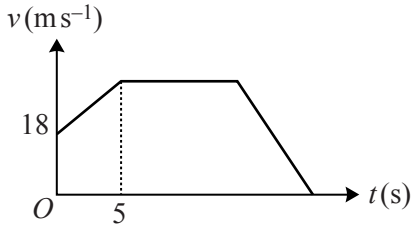
(ii) It is given instead that the resultant of the two forces has magnitude R N and acts in a direction perpendicular to the 8 N force (see diagram).



(a) Calculate the angle between the resultant and the 12 N force. **[3]**

(b) Find R. **[2]**

4



The diagram shows the (t, v) graph of a car moving along a straight road, where $v\,\text{m s}^{-1}$ is the velocity of the car at time t s after it passes through the point A. The car passes through A with velocity $18\,\text{m s}^{-1}$, and moves with constant acceleration $2.4\,\text{m s}^{-2}$ until $t = 5$. The car subsequently moves with constant velocity until it is 300 m from A. When the car is more than 300 m from A, it has constant deceleration $6\,\text{m s}^{-2}$, until it comes to rest.

(i) Find the greatest speed of the car. **[2]**

(ii) Calculate the value of t for the instant when the car begins to decelerate. **[5]**

(iii) Calculate the distance from A of the car when it is at rest. **[3]**

5 A particle P is projected with speed $u\,\text{m s}^{-1}$ from the top of a smooth inclined plane of length $2d$ metres. After its projection P moves downwards along a line of greatest slope with acceleration $4\,\text{m s}^{-2}$. At the instant 3 s after projection P has moved half way down the plane. P reaches the foot of the plane 5 s after the instant of projection.

(i) Form two simultaneous equations in u and d, and hence calculate the speed of projection of P and the length of the plane. **[6]**

(ii) Find the inclination of the plane to the horizontal. **[2]**

(iii) Given that the contact force exerted on P by the plane has magnitude 6 N, calculate the mass of P. **[2]**

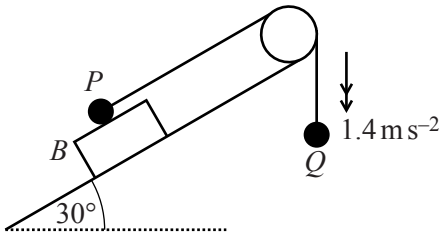
6 A particle P moves in a straight line. At time t s after passing through a point O of the line, the displacement of P from O is x m. Given that $x = 0.06t^3 - 0.45t^2 - 0.24t$, find

(i) the velocity and the acceleration of P when $t = 0$, **[6]**

(ii) the value of x when P has its minimum velocity, and the speed of P at this instant, **[5]**

(iii) the positive value of t when the direction of motion of P changes. **[3]**

7



A block B is placed on a plane inclined at 30° to the horizontal. A particle P of mass 0.6 kg is placed on the upper surface of B. The particle P is attached to one end of a light inextensible string which passes over a smooth pulley fixed to the top of the plane. A particle Q of mass 0.5 kg is attached to the other end of the string. The portion of the string attached to P is parallel to a line of greatest slope of the plane, the portion of the string attached to Q is vertical and the string is taut. The particles are released from rest and start to move with acceleration $1.4\,\text{m s}^{-2}$ (see diagram). It is given that B is in equilibrium while P moves on its upper surface.

(i) Find the tension in the string while P and B are in contact. **[3]**

(ii) Calculate the coefficient of friction between P and B. **[5]**

(iii) Given that the weight of B is 7 N, calculate the set of possible values of the coefficient of friction between B and the plane. **[7]**

Question			Answer	Marks	Guidance
1	(i)			M1	Momentum for Q/R, no g, at least 3 correct terms
			$0.3u + 0.6 \times 0.8 = (0.3 + 0.6) \times 1$	A1	NB 0.48 in "before" from 0.8×0.6; not $1.5 \times 0.1 + 1.1 \times 0.3$ (A0)
			$u = 1.4$ m s^{-1}	A1	
				[3]	
1	(ii)		$0.1 \times 1.5 + 0.3 \times 1.1 = \pm 0.1v + 0.3 \times 1.4$	M1	P,Q +ve "before", allow P –ve "after". Accept cv (1.4)
			$v = 0.6$	A1	Velocity of P, will be –ve if $-0.1v$ in momentum equation, accept $v = \pm 0.6$
			Momentum change $= \pm 0.09$ kg m s^{-1}	A1	Tolerate loss of – sign if "small – large" has +ve answer
			OR	**[3]**	
			Momentum change $Q = \pm 0.3(1.4 - 1.1) = \pm 0.09$	M1A1	Change for P is the change for Q
			Momentum change $P = \pm 0.09$	A1	
			OR		
			$0.1 \times 1.5 + 0.3 \times 1.1 + 0.6 \times 0.8 = (\pm)0.1v + 0.9(\times 1)$	M1A1	Overall equation
			Momentum change $P = \pm 0.09$	A1	From $\pm$ $(0.9 \times 1 - 0.3 \times 1.1 - 0.6 \times 0.8)$
2	(i)		$U = 0.5g$ *OR* $U - 0.5g = 0$	M1	Consider descent *OR* ascent. $v = u + at$ with consistent signs for non-zero terms. $U + 0.5g = 0$ is M0 hence A0.
			$U = 4.9$ m s^{-1}	A1	Allow use of 4.9 without penalty in (ii) and (iii) even if 0/2 here.
				[2]	
2	(ii)		$U^2 = \pm 2gs$	M1	$v^2 = u^2 + 2as$
			$4.9^2 = \pm 2 \times 9.8 \times s$	A1	
			$s = 1.225$ m	A1	+ve, 49/40, 1.22 or 1.23 BoD loss of – sign in final answer
				[3]	
			OR		
			$s = \pm(ut \pm gt^2/2)$ *OR* $s = \pm gt^2/2$	M1	Rise to/fall from greatest height. $S = \pm(vt \pm g\frac{t^2}{2})$ is similar.
			$s = \pm(4.9 \times 0.5 - g \times 0.5^2/2)$ *OR* $s = \pm g \times 0.5^2/2$	A1	
			$s = 1.225$ m	A1	+ve, 1.22 or 1.23 BoD loss of – sign in final answer
			OR		
			$s = \pm Ut/2$	M1	$s = (u + v)t/2$
			$s = \pm 4.9 \times 0.5/2$	A1	
			$s = 1.225$ m	A1	+ve, 1.22 or 1.23 BoD loss of – sign in final answer

Question			Answer	Marks	Guidance
2	(iii)		$v^2 = 2g(s \pm 0.539)$	M1	Overall descent, zero initial speed
			$v^2 = 2 \times 9.8 \times (0.539 + 1.225)$	A1ft	ft cv (1.225), tolerate sign change from (ii)
			$v = 5.88$ ms^{-1}	A1	Exact, isw rounding of 5.88 to 5.9 if 5.88 seen
			OR	**[3]**	
			$v^2 = u^2 \pm 2g \times 0.539$	M1	Motion from projection level down, non-zero initial speed
			$v^2 = 4.9^2 + 2g \times 0.539$	A1ft	ft cv (4.9), tolerate sign change from (i)
			$v = 5.88$ ms^{-1}	A1	Exact, isw rounding of 5.88 to 5.9 if 5.88 seen
3	(i)	(a)	$\tan\theta = 8/12$	M1	Must be correct angle.
			$\theta = 33.7°$	A1	
				[2]	
			OR correct trig using ans **(i)(b)**		
			$\sin\theta = 8/\text{cv}(14.4)$ or $\cos\theta = 12/\text{cv}(14.4)$	M1	Must be correct angle
			$\theta = 33.7°$	A1	A1 needs 2/2 in (i)(b). $\cos\theta = 12/14.4$ gives $\theta = 33.6$ A1
3	(i)	(b)	$R^2 = 8^2 + 12^2$	M1	Pythagoras, 3 squared terms, R as hypotenuse
			$R = 14.4$ N	A1	Accept $4\sqrt{13}$ not $\sqrt{208}$
				[2]	
3	(ii)	(a)	$12\text{CorS}\theta = \pm 8$	M1	Either angle.
			$12\sin\theta = 8$	A1	If other angle is targeted, this A1 requires "90 –". *OR* $12\cos\theta = 8.94$, $8.94\tan\theta = 8$.
			$\theta = 41.8°$	A1	cao
				[3]	
			OR correct trig using **(ii)(b)**		
			$12\text{CorS}\,\theta = \text{cv}(8.94)$, $\text{cv}(8.94)\tan\theta = 8$, or $8\tan\theta = \text{cv}(8.94)$	M1	Either angle
			$12\cos\theta = 8.94$ or $8.94\tan\theta = 8$	A1	If other angle is targeted, this A1 requires "90 –"
			$\theta = 41.8°$	A1	Both A1 marks require 2/2 in (ii)(b)
3	(ii)	(b)	$R = 12\cos 41.8$	M1	Using candidate's angle from 3iia. *OR* $R^2 = 12^2 - 8^2$, $R^2 + 8^2 = 12^2$
			$R = 8.94$ N	A1	Accept 8.9 or 8.95, $4\sqrt{5}$, not 9 or 9.0 not $\sqrt{80}$. For A1, the trig solution requires 3/3 in (ii)(a)
				[2]	

Question			Answer	Marks	Guidance
4	(i)		$v = 18 + 2.4 \times 5$ $v = 30$	M1 A1 **[2]**	$v = u + at$
4	(ii)		Distance while accelerating = $(18 + 30) \times 5/2$ Distance at constant speed = $30(t - 5)$ $30(t - 5) + (18 + 30) \times 5/2 = 300$ $t = 11$ *OR* Distance while accelerating = $(18 + 30) \times 5/2$ (=120) Distance at constant speed = $300 - cv(120)$ Time at constant speed = $\frac{(300 - cv(120))}{30}$ Time at constant speed = 6 $t = 11$ *OR* Distance = $30t$ Distance = $(30 - 18) \times 5/2$ $30t - (30 - 18) \times 5/2 = 300$ $t = 11$ *OR* Distance while accelerating = $(18 + 30) \times 5/2$ Distance at constant speed = $30(t - 5)$ Distance at constant speed = $300 - 120 = 30(t - 5)$ $t = 11$	B1 B1 M1 A1 A1 **[5]** B1 M1 B1 A1 A1 B1 B1 M1A1 A1 B1 B1 M1A1 A1	Or $30 \times 5 - (30 - 18) \times 5/2$ etc = 120, or 45 + 75. Numerical. Tolerate $30t$. Algebraic. Adds their areas to get 300 $30T = 300 - 120$, $30t + 45 + 75 = 300$, etc Or $30 \times 5 - (30 - 18) \times 5/2$ etc = 120, or 45 + 75. Numerical. Subtracts their area from 300 Equivalent to "distance at constant speed algebraic" Rectangle, comprising 300 + area of "missing triangle" "Missing triangle", to be removed Subtracts their areas to get 300 120 May be implied. Tolerate $30t$. Algebraic. *OR* $180 = 30t$ M1, $t = 6$ A1

Question			Answer	Marks	Guidance
4	(iii)		$S = 30^2/(2 \times (\pm 6))$	M1	$0^2 = 30^2 \pm 2 \times 6S$, with candidate's v(i)
			$S = 75$	A1	
			Distance = 375 m	A1ft	300 + cv(75)
				[3]	
			OR	M1	Accept $T = 5$ if no working or from 30/–6, with candidate's v(i)
			$T = 30/6$ and $S = 30T/2$		
			$S = 75$	A1	
			Distance = 375m	A1ft	300 + cv(75)
5	(i)		$d = 3u + 4 \times 3^2/2$ $(= 3u + 18)$	B1	
			$2d = 5u + 4 \times 5^2/2$ $(= 5u + 50)$	B1	*OR* $d = (5 - 3)(u + 3 \times 4) + 4 \times 2^2/2$ for lower half of slope $(d = 2u + 32)$
			$6u + 36 = 5u + 50$	M1	Attempts to solve 2 SE in u and d, at least one with 3 terms. Tolerate u, d switch to x, y for solving reasons
			$u = 14$ ms^{-1}	A1	
			$2d = 5 \times 14 + 4 \times 5^2/2$	M1	Substitutes in 3 term eqn, starts *suvat* again, or solves SEs again.
			OR $d = 3 \times 14 + 18$ *OR* $d = 2 \times 14 + 32$		If u is negative, allow substitution of +ve equivalent.
			Length = 120 m	A1	
				[6]	
5	(ii)		$4(m) = (m)g\sin\theta$	M1	Mass may be omitted on both sides. Allow $4(m) = (m)g\cos\theta$
			$\theta = 24.1°$	A1	
				[2]	
5	(iii)		$6 = mg\cos 24.1$	M1	Or $6 = mg\sin 24.1$, uses numerical answer referring to (ii)
			$m = 0.671$ kg	A1	www
				[2]	
6	(i)		$V = d(0.06t^3 - 0.45t^2 - 0.24t)/dt$	M1	Differentiates displacement
			$V = 0.18t^2 - 0.9t - 0.24$	A1	Accept with $+c$, unsimplified coefficients
			$A = d(0.18t^2 - 0.9t - 0.24)/dt$	M1	Differentiates velocity
			$A = 0.36t - 0.9$	A1	Accept with $+c$, unsimplified coefficients
			$V(0) = -0.24$ m s^{-1}	A1	cao, if coeffs in $V(t)$ wrong A0
			$A(0) = -0.9$ m s^{-2}	A1 ft	ft cv(–0.9), the constant in expression for A. Tolerate wrong coeff t
				[6]	

Question			Answer	Marks	Guidance
6	(ii)		Solves $A = 0$ for t $0.36t - 0.9 = 0$ $t = 2.5$ $x(2.5) = -2.475$ Speed = $\lvert v(2.5) \rvert = 1.365$ m s^{-1}	M1 A1 A1 A1 A1 **[5]**	Not if A(t) includes $+c$ in this section Final answer must be negative. Accept –2.47 and –2.48. Final answer must be positive. Accept 1.36 or 1.37.
6	(iii)		Uses $v = 0$ $0.18t^2 - 0.9t - 0.24 = 0$ $t = 5.25$ s	M1 A1ft A1 **[3]**	 Forms and offers solution of 3 term QE using cv(V(i)) Must select +ve answer explicitly. Accept 5.3, not 5.2
7	(i)		$0.5g - T = \pm 0.5 \times 1.4$ $0.5g - T = 0.5 \times 1.4$ $T = 4.2$ N	M1 A1 A1 **[3]**	N2L for Q, difference of 2 force terms
7	(ii)		$4.2 - F - 0.6g\sin 30 = 0.6 \times 1.4$ *OR* $4.2 - \mu R - 0.6g\sin 30 = 0.6 \times 1.4$ Friction (= $4.2 - 0.6g\sin 30 - 0.6 \times 1.4$) = 0.42 Reaction = 0.6gcos30 $0.42 = 0.6g\cos 30\mu$ *OR* $\mu = 0.42/ 0.6g\cos 30$ $\mu = 0.0825$	M1 A1 B1 M1 A1 **[5]**	N2L for P, 3 forces including a component of weight of P and cv(4.2) May be implied May be implied $F = \mu R$, R a component of weight of P and F has been found using a component of the weight of P. Tolerate F –ve and |–veF|. Accept 0.082, not 0.083.
7	(iii)		$R = (0.6g + 7)\cos 30$ $R = 11.2$ Fr = $7\sin 30 - 0.42$ Fr = 3.08 $\mu = 3.08/11.2$ $\mu = 0.276$ $\mu \geq 0.276$	M1 A1 M1* A1 D*M1 A1 B1 ft **[7]**	Includes weight cmpts of P and B, allow $7g$ 11.154… May be implied Wt cmpt B (allow $7g$) – Fr(ii) must be difference. May be implied. Both quantities +ve, F and R both from 2 term equations Value of μ, accept 0.28, disregard inequality sign ft cv (μ found in (iii)) direction of greater than or equal to sign; isw any work relating to an upper limit for μ

APPENDIX 1

Method marks which include a wrong value calculated by the candidate in earlier work can automatically gain M1 for the correct method.

A1 ft marks identify the occasions when a wrong value or expression is given an accuracy mark, a consequence of a candidate obtaining an erroneous earlier value.

A candidate may answer part (i) wrongly, then calculate the correct answers to part (i) at the start of (ii). These correct answers should not be regarded as later attempts to do (i), but do mean that the candidate can get part (ii) fully correct and gain all the marks available.

A candidate may when working out part (i) of a question actually discover some quantity which the scheme expects to be calculated in part (ii). If reference is made to this quantity in (ii), allow in (ii) all the marks available for what was seen in (i).

Notes:
Q1i
Inclusion of P is automatically M0. Inclusion of 0.1 (unless a MR) is automatically M0 even in the case
$0.1 \times 1.5 + 0.3u + 0.6 \times 0.8 = 0.1 \times 1.5 + (0.3\ \ 0.6) \times 1$
$u = 1.4$
Exceptions: use of 0.6 or v(ii) instead of 1.5 in the example above **is** valid
part (ii) can be done first, then $0.1 \times 0.6 + 0.3u = 0.1 \times 1.5 + 0.3 \times 1.1$, $u = 1.4$

Q2
If using $g = 9.81$ the answers are: (i) $u = 4.905$, so accept 4.9(0) or 4.91. (ii) $s = 1.226..$, so accept 1.23 but not 1.2. (iii) $v = 5.8851..$, so accept 5.89 but not 5.9.

Q3
(iia)(iib) numbers must be +ve for A marks.
(iib) $R + 12\cos 41.8 = 0$ is M0
(iib) Squaring, adding and square rooting $12\cos\theta$ and $(8 - 12\sin\theta)$ with candidate's value of θ from (iia) is a valid method.

Q4ii
Splitting area horizointally

Distance = $18t$	B1	Lower portion of area
Distance = $(t + [t - 5]) \times (30 - 18)/2$	B1	Upper portion of area
$18t + (t + [t - 5]) \times (30 - 18)/2 = 300$	M1A1	$30t - 30 = 300$
$t = 11$	A1	