OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

MATHEMATICS

4728

Mechanics 1

Candidates answer on the Answer Booklet

OCR Supplied Materials:
- 8 page Answer Booklet
- List of Formulae (MF1)

Other Materials Required:
None

Monday 25 January 2010
Morning

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- 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 $g\,\text{m}\,\text{s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

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

1 A particle P is projected vertically downwards from a fixed point O with initial speed $4.2\,\text{m s}^{-1}$, and takes 1.5 s to reach the ground. Calculate

(i) the speed of P when it reaches the ground, **[2]**

(ii) the height of O above the ground, **[2]**

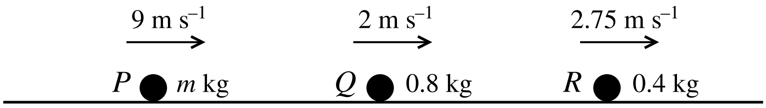
(iii) the speed of P when it is 5 m above the ground. **[2]**

2 Two horizontal forces of magnitudes 12 N and 19 N act at a point. Given that the angle between the two forces is $60°$, calculate

(i) the magnitude of the resultant force, **[5]**

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

3



Three particles P, Q and R, are travelling in the same direction in the same straight line on a smooth horizontal surface. P has mass m kg and speed $9\,\text{m s}^{-1}$, Q has mass 0.8 kg and speed $2\,\text{m s}^{-1}$ and R has mass 0.4 kg and speed $2.75\,\text{m s}^{-1}$ (see diagram).

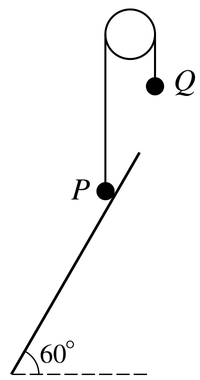
(i) A collision occurs between P and Q, after which P and Q move in opposite directions, each with speed $3.5\,\text{m s}^{-1}$. Calculate

(a) the value of m, **[4]**

(b) the change in the momentum of P. **[2]**

(ii) When Q collides with R the two particles coalesce. Find their subsequent common speed. **[3]**

4



Particles P and Q, of masses 0.4 kg and 0.3 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley and the sections of the string not in contact with the pulley are vertical. P rests in limiting equilibrium on a plane inclined at 60° to the horizontal (see diagram).

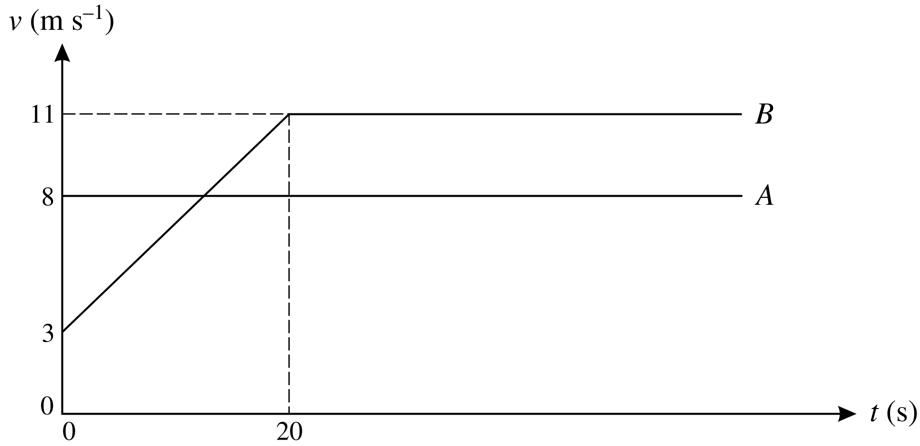
(i) **(a)** Calculate the components, parallel and perpendicular to the plane, of the contact force exerted by the plane on P. **[4]**

(b) Find the coefficient of friction between P and the plane. **[2]**

P is held stationary and a particle of mass 0.2 kg is attached to Q. With the string taut, P is released from rest.

(ii) Calculate the tension in the string and the acceleration of the particles. **[4]**

5



The (t, v) diagram represents the motion of two cyclists A and B who are travelling along a horizontal straight road. At time $t = 0$, A, who cycles with constant speed 8 m s^{-1}, overtakes B who has initial speed 3 m s^{-1}. From time $t = 0$ B cycles with constant acceleration for 20 s. When $t = 20$ her speed is 11 m s^{-1}, which she subsequently maintains.

(i) Find the value of t when A and B have the same speed. **[3]**

(ii) Calculate the value of t when B overtakes A. **[5]**

(iii) On a single diagram, sketch the (t, x) graphs for the two cyclists for the time from $t = 0$ until after B has overtaken A. **[3]**

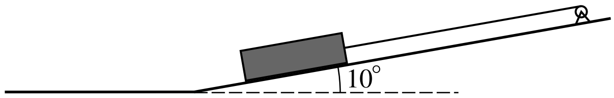
6 A swimmer C swims with velocity $v\,\text{m s}^{-1}$ in a swimming pool. At time t s after starting, $v = 0.006t^2 - 0.18t + k$, where k is a constant. C swims from one end of the pool to the other in 28.4 s.

(i) Find the acceleration of C in terms of t. **[2]**

(ii) Given that the minimum speed of C is $0.65\,\text{m s}^{-1}$, show that $k = 2$. **[5]**

(iii) Express the distance travelled by C in terms of t, and calculate the length of the pool. **[5]**

7



A winch drags a log of mass 600 kg up a slope inclined at 10° to the horizontal by means of an inextensible cable of negligible mass parallel to the slope (see diagram). The coefficient of friction between the log and the slope is 0.15, and the log is initially at rest at the foot of the slope. The acceleration of the log is $0.11\,\text{m s}^{-2}$.

(i) Calculate the tension in the cable. **[5]**

The cable suddenly breaks after dragging the log a distance of 10 m.

(ii) (a) Show that the deceleration of the log while continuing to move up the slope is $3.15\,\text{m s}^{-2}$, correct to 3 significant figures. **[2]**

(b) Calculate the time taken, after the cable breaks, for the log to return to its original position at the foot of the slope. **[9]**

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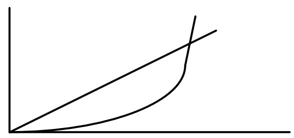
1 i	$v = 4.2 + 9.8 \times 1.5$ $v = 18.9\ ms^{-1}$.	M1 A1 [2]	Uses $v = u + gt$ 18.9(15) from g = 9.81
ii	$s = 4.2 \times 1.5 + 9.8 \times 1.5^2/2$ or $18.9^2 = 4.2^2 + 2 \times 9.8s$ $s = 17.325$ m	M1 A1 [2]	Uses $s = ut + gt^2/2$ or $v^2 = u^2 + 2gs$ Accept 17.3
iii	$v^2 = 4.2 + 2 \times 9.8 \times (17.3(25) – 5)$ $v = 16.1\ ms^{-1}$	M1 A1 [2]	$18.9^2 = u^2 + 2 \times 9.8 \times 5$ $u = 16.1\ ms^{-1}$. Accept answers close to 16.1 from correct working
2 i	Resolves a force in 2 perpendicular directions Uses Pythagoras $R^2 = (12+19\cos 60)^2 + (19\sin 60)^2$ R = 27.1 N $\{R = \sqrt{((19+12\cos 60)^2 + (12\sin 60)^2)} = 27.1\}$	M1 DM1 A1 A1 A1 [5]	*Diagram for vector addition/subtraction* *Uses Cosine Rule* $R^2 = 12^2 + 19^2 - 2 \times 12 \times 19\cos 120$ *R = 27.1*
ii	Trig on a valid triangle for correct angle $\tan\theta = (19\sin 60)/(12 + 19\cos 60)$ etc Angle is 37.4°, 37.5°	M1 A1 A1 [3]	Either Pythagoras or vector add/sub triangle *sinθ/19 = sin120/ (27.1) etc*
3ia **ib**	$+/-(9m + 2 \times 0.8)$ $\{+/-(3.5\times0.8-2\times0.8)\}$ $+/-(-3.5m + 3.5 \times 0.8)$ $\{+/-(9m + 3.5m)\}$ $+/-(9m + 2 \times 0.8) = +/-(-3.5m + 3.5 \times 0.8)$ m = 0.096 kg +/-0.096(9+/-3.5) *OR +/-0.8(3.5 -2)* $+/-1.2\ kgms^{-1}$	B1 B1 M1 A1 [4] M1 A1ft [2]	Before mom, or mom change Q, OK with g After mom, or mom change P, OK with g Equates moms, or changes, accept with g Do not award if g used Using before & after speeds of P or Q, no g ft 12.5 × cv(0.096)
ii	(0.8+0.4)v or 0.8v + 0.4v $3.5 \times 0.8 + 0.4 \times 2.75 = (0.8+0.4)v$ $v = 3.25\ ms^{-1}$	M1 A1 A1 [3]	Using Q and R common speed after, no g 2.8 +1.1 = 1.2v
4ia **ib**	0.3gcos 60 and 0.3gsin60 0.4gcos60 and 0.4gsin60 Calculates either relevant difference Perp = 0.1gcos60 and Para = +/- 0.1gsin60 0.1gsin60 = μ0.1gcos60 = 1.73 (= √3)	B1 B1 M1 A1 [4] M1 A1 [2]	Accept use of "m = 0.1 kg" for M1 and 0.1gcos60 (B1) 0.1gsin60 (B1) = 0.49 and = 0.849 (accept 0.85 and 0.84) F = μR, F>R>0 From correct R, F values

4 ii	$0.5g - T = 0.5a$ $T - 0.4g = 0.4a$ $a = 1.09\ ms^{-2}$ $T = 4.36$ N	M1 A1 B1 B1 [4]	N2L for either particle no resolving, at least 1 unknown Formula round the pulley, M0A0. But award M1 for $T-0.4g = 0.4 \times 1.09$ etc later Both equations correct
5 i	$11 = 3 + 20a$ $(a = 0.4)$ $8 = 3 + (11-3)t/20$ $t = 12.5$	M1 M1 A1 [3]	Uses $v = u + at$, no zero terms Their a>0. $t/20 = (8-3)/(11-3)$ is M1M1
ii	$s(A,20) = 8 \times 20$ (=160) $s(B,20) = (3 + 11) \times 20/2 =$ $3 \times 20 + 0.4 \times 20^2/2$ (=140) $8T = (3+11) \times 20/2 + 11 \times (T-20)$ or $(160 - 140) = 11t - 8t$ $T = 26\ 2/3$	B1 B1 M1 A1 A1 [5]	Or $s(A) = 8T$ or as stage of $s(B)=(3+11)\times20/2 + 11\times(T-20)$ 3 part equation balancing distances Accept 26.6 or 26.7
iii		B1 B1 B1 [3]	Linear rising graph (for A) starting at B's start Non-linear rising graph for B below A's initially. Accept 2 straight lines as non-linear. Single valued graphs graphs intersect and continue
6 i	$a = 2 \times 0.006t - 0.18$ $a = 0.012t - 0.18$	M1 A1 [2]	Differentiates v (not v/t) Award for unsimplified form, accept +c, not +k
ii	$0.012t - 0.18 = 0$ $t = 15$ $0.006 \times 15^2 - 0.18 \times 15 + k = 0.65$ $k = 2$ AG	M1* A1 D*M1 A1 A1 [5]	Sets a = 0, and solves for t Substitutes t(v(min)) in v(t)
iii	$s = 0.006t^3/3 - 0.18t^2/2 + 2t$ (+c) $(s = 0.002t^3 - 0.09t^2 + 2t$ (+c)) $t = 0, s = 0$ hence $c = 0$ $L = 0.002 \times 28.4^3 - 0.09 \times 28.4^2 + 2 \times 28.4$ $L = 30.0$ m	M1A1 B1 M1 A1 [5]	Integrates v (not multiplies by t). Award if +c omitted, accept kt Explicit, not implied (or uses limits 0, 28.4) Substitutes 28.4 or 14.2 in s(t), (and k=2) Accept a r t 30(.0), accept +c

7 i	(Fr =) 0.15 × 600gcos10 (Wt cmpt =) 600gsin10 600 × 0.11 = T - 0.15 × 600gcos10 - 600gsin10 (66 = T - 868.6 – 1021) T = 1960 N	B1 B1 M1 A1 A1 [5]	Implied by Fr = 0.15×600gcos10 (=868.6..) N2L. T with at least 1 resolved forces and 600 × 0.11 1955.6..
ii a	a(up) = +/-(600gsin10+.15×600gcos10)/600 a(up) = +/-3.15 ms^{-2} AG	M1 A1 [2]	2 resolved forces and 600a or "unit mass" Disregard sign, accept 3.149
b	UP $v^2 = 2 \times 0.11 \times 10$ v = 1.48 when cable breaks t = 1.48/3.149 (t = 0.471 time for log to come to rest) $s = 1.48^2/(2 \times 3.149)$ s = 0.349 distance for log to come to rest DOWN a(down) = (600gsin10-0.15×600gcos10)/600 $10+0.349= 0.254t^2/2$ t = 9.025 T = (9.025 + 0.471) = 9.5 s	M1 A1 M1 M1 A1 B1 M1 A1 A1 [9]	 Correct, need not be accurate Or 1.48 = 0 + 3.15t Correct, need not be accurate = 0.254 Needs a< 3.15, s>10. Or V^2= 2×0.254× (10+0.349) [V= 2.29..], V=0.254t Correct, need not be accurate Accept 9.49