OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

MATHEMATICS

4729/01

Mechanics 2

MONDAY 16 JUNE 2008

Afternoon

Time: 1 hour 30 minutes

Additional materials: Answer Booklet (8 pages)
List of Formulae (MF1)

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- 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.
- The total number of marks for this paper is 72.
- **You are reminded of the need for clear presentation in your answers.**

This document consists of **6** printed pages and **2** blank pages.

[Turn over

1 A car is pulled at constant speed along a horizontal straight road by a force of 200 N inclined at 35° to the horizontal. Given that the work done by the force is 5000 J, calculate the distance moved by the car. [3]

2 A bullet of mass 9 grams passes horizontally through a fixed vertical board of thickness 3 cm. The speed of the bullet is reduced from $250\,\mathrm{m\,s^{-1}}$ to $150\,\mathrm{m\,s^{-1}}$ as it passes through the board. The board exerts a constant resistive force on the bullet. Calculate the magnitude of this resistive force. [4]

3 The resistance to the motion of a car of mass 600 kg is kv N, where $v\,\mathrm{m\,s^{-1}}$ is the car's speed and k is a constant. The car ascends a hill of inclination α, where $\sin\alpha = \frac{1}{10}$. The power exerted by the car's engine is 12 000 W and the car has constant speed $20\,\mathrm{m\,s^{-1}}$.

(i) Show that $k = 0.6$. [3]

The power exerted by the car's engine is increased to 16 000 W.

(ii) Calculate the maximum speed of the car while ascending the hill. [3]

The car now travels on horizontal ground and the power remains 16 000 W.

(iii) Calculate the acceleration of the car at an instant when its speed is $32\,\mathrm{m\,s^{-1}}$. [3]

4 A golfer hits a ball from a point O on horizontal ground with a velocity of $35\,\mathrm{m\,s^{-1}}$ at an angle of θ above the horizontal. The horizontal range of the ball is R metres and the time of flight is t seconds.

(i) Express t in terms of θ, and hence show that $R = 125\sin 2\theta$. [5]

The golfer hits the ball so that it lands 110 m from O.

(ii) Calculate the two possible values of t. [5]

5

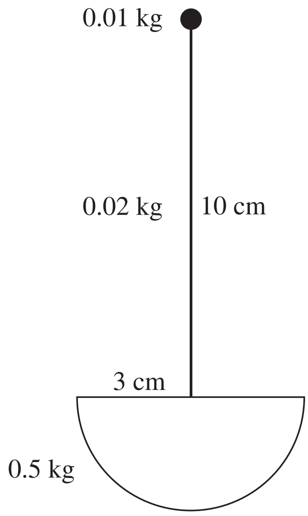


Fig. 1

A toy is constructed by attaching a small ball of mass 0.01 kg to one end of a uniform rod of length 10 cm whose other end is attached to the centre of the plane face of a uniform solid hemisphere with radius 3 cm. The rod has mass 0.02 kg, the hemisphere has mass 0.5 kg and the rod is perpendicular to the plane face of the hemisphere (see Fig. 1).

(i) Show that the distance from the ball to the centre of mass of the toy is 10.7 cm, correct to 1 decimal place. [4]

(ii)

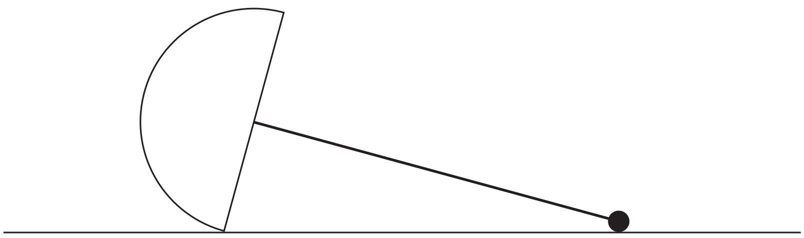
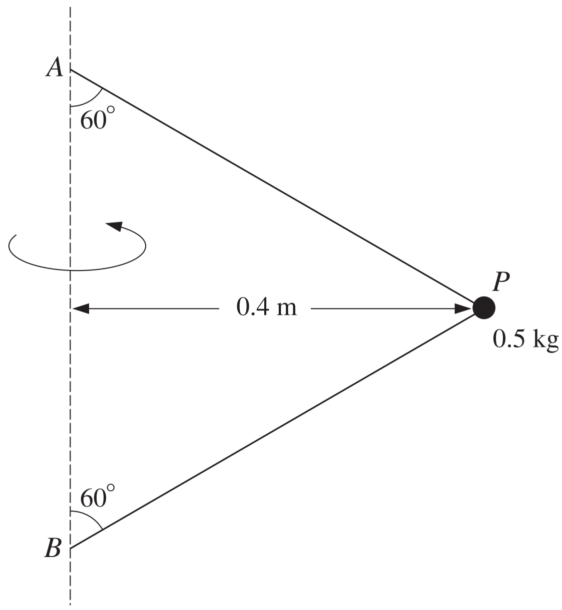


Fig. 2

The toy lies on horizontal ground in a position such that the ball is touching the ground (see Fig. 2). Determine whether the toy is lying in equilibrium or whether it will move to a position where the rod is vertical. [4]

6



A particle P of mass 0.5 kg is attached to points A and B on a fixed vertical axis by two light inextensible strings of equal length. Both strings are taut and each is inclined at 60° to the vertical (see diagram). The particle moves with constant speed 3 m s^{-1} in a horizontal circle of radius 0.4 m.

(i) Calculate the tensions in the two strings. [7]

The particle now moves with constant angular speed $\omega \text{ rad s}^{-1}$ and the string BP is on the point of becoming slack.

(ii) Calculate ω. [5]

7

Two small spheres A and B of masses 2 kg and 3 kg respectively lie at rest on a smooth horizontal platform which is fixed at a height of 4 m above horizontal ground (see diagram). Sphere A is given an impulse of 6 N s towards B, and A then strikes B directly. The coefficient of restitution between A and B is $\frac{2}{3}$.

(i) Show that the speed of B after it has been hit by A is 2 m s^{-1}. [6]

Sphere B leaves the platform and follows the path of a projectile.

(ii) Calculate the speed and direction of motion of B at the instant when it hits the ground. [7]

8 (i)

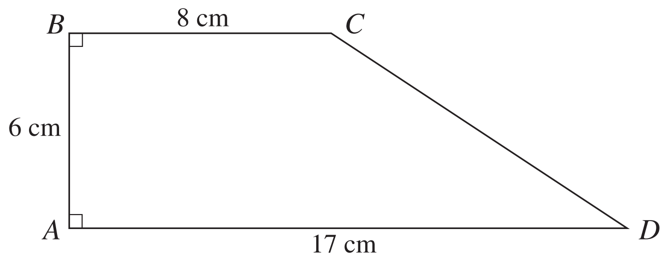


Fig. 1

A uniform lamina $ABCD$ is in the form of a right-angled trapezium. $AB = 6$ cm, $BC = 8$ cm and $AD = 17$ cm (see Fig. 1). Taking x- and y-axes along AD and AB respectively, find the coordinates of the centre of mass of the lamina. [8]

(ii)

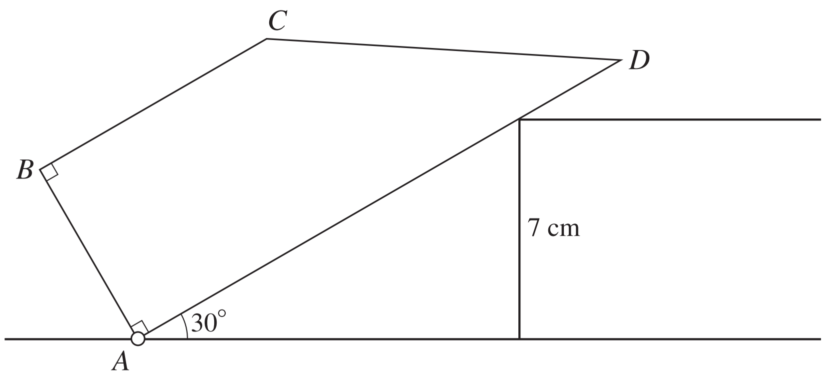


Fig. 2

The lamina is smoothly pivoted at A and it rests in a vertical plane in equilibrium against a fixed smooth block of height 7 cm. The mass of the lamina is 3 kg. AD makes an angle of 30° with the horizontal (see Fig. 2). Calculate the magnitude of the force which the block exerts on the lamina. [5]

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1	200cos35°	B1	
	200cos35° x d = 5000	M1	
	d = 30.5 m	A1 **3**	**3**

2	$0.03R = ½x0.009(250^2 – 150^2)$	M1	$150^2 = 250^2 + 2a \times 0.03$
	0.03R	B1	$a = ±2x10^6/3$ or ±666,667 (A1)
	either K.E.	B1	F = 0.009a (M1)
	R = 6000 N	A1 ✓ **4**	✓ unit errors **4**

3 (i)	D = 12000/20	B1	
	12000/20=k x 20 + 600 x 9.8 x 0.1	M1	
	k = 0.6	A1 **3**	**AG**
(ii)	16000/v = 0.6v + 600 x 9.8 x 0.1	M1	
	$0.6 v^2 + 588v – 16000 = 0$	M1	attempt to solve quad. (3 terms)
	v = 26.5 m s^{-1}	A1 **3**	
(iii)	16000/32 – 0.6 x 32 = 600a	M1	
		A1	
	a = 0.801 m s^{-2}	A1 **3**	0.80 or 0.8 **9**

4 (i)	$0 = 35\sin\theta \times t – 4.9t^2$	M1	$R=u^2\sin2\theta/g$ only ok if proved
	t = 35sinθ/4.9 50sinθ/7	A1	or 70sinθ/g aef
	R = 35cosθ x t aef	B1	their t
	$R = 35^2\sin\theta.\cos\theta/4.9$	M1	eliminate t
	R = 125sin2θ	A1 **5**	**AG**
(ii)	110 = 125sin2θ	M1	
	θ = 30.8° or 59.2°	A1+1	
	t = 3.66 s or 6.13 s	A1+1 **5**	**10**

5 (i)	3/8 x 3 (1.125)	B1	c.o.m. hemisphere
	0.53d = 5x0.02 + (10 + 3/8x3) x 0.5	M1	0.53e=3x5/8x0.5+8x0.02+13x .01
		A1	0.53f=3x3/8x0.5-5x0.02-10x0.01
	d = 10.7	A1 **4**	**AG (**e = 2.316 f = 0.684**)**
(ii)	Attempt to calc a pair relevant to P,G	M1	distance / angle
	OP=0.9 (pair) , p= 73.3° q=16.7° r=76.9° (77.2°) , s=13.1°(12.8°) AC=0.86 , BC=0.67 , AD=10.4 BD=10.2	A1	not a complimentary pair
	r > p , s < q , p + s < 90 , 0.67 < 0.86 , 10.2 < 10.4	M1	make relevant comparison 0.7 < 0.9 (OG < OP) 10.7 < 10.9
	it is in equilibrium	A1 **4**	**8**

6 (i)	$T\cos60° = S\cos60° + 4.9$	M1 A1		Resolving vertically nb for M1: (must be components – all 4 cases)
	$T\sin60° + S\sin60° = 0.5 \times 3^2/0.4$	M1 A1		Res. Horiz. $mr\omega^2$ ok if $\omega \neq 3$ If equal tensions $2T=45/4$ M1 only
	$(S + 9.8)\sin60° + S\sin60° = 45/4$	M1		
	$S = 1.60$ N	A1		
	$T = 11.4$ N	A1	7	
(ii)	$T\cos60° = 4.9$ $T = 9.8$	M1 A1		Resolving vertically (component)
	$T\sin60° = 0.5 \times 0.4\omega^2$	M1 A1		Resolving horiz. (component)
	$\omega = 6.51$ rad s^{-1}	A1	5	or 6.5 **12**
7 (i)	$u = 3$ m s^{-1}	B1		
	$6 = 2x + 3y$	M1 A1		
	$e = (y – x)/3$	M1 A1		($e = ⅔$) (equs must be consistent)
	$y = 2$	A1	6	**AG**
(ii)	$v_h = 2$	B1		or (B1) $½mx2^2$
	$v_v^2 = 2 \times 9.8 \times 4$	M1		(B1) $½mxv^2$
	$v_v = 8.85$ $(14\sqrt{10}/5)$	A1		(B1) mx9.8x4
	speed $= \sqrt{(8.85^2 + 2^2)}$	M1		$v = \sqrt{(2^2 + 2x9.8x4)}$
	9.08 m s^{-1}	A1		
	$\tan^{-1}(8.85/2)$	M1		or $\cos^{-1}(2/9.08)$
	77.3° to horizontal	A1	7	12.7° to vertical **13**
8 (i)	com of Δ 3 cm right of C	B1		
	$(48+27)\bar{x} = 48x4 + 27x11$	M1 A1		
	$\bar{x} = 6.52$	A1		
	com of Δ 2 cm above AD	B1		
	$(48+27)\bar{y} = 48x3 + 27x2$	M1 A1		
	$\bar{y} = 2.64$	A1	8	
(ii)	14F	B1		can be implied e.g. 7/sin30°. F
	$3g\cos30° \times 6.52$	B1		7.034 (AG) or (6.52-2.64tan30°)
	$3g\sin30° \times 2.64$	B1		52.0° (GAH) or (above)xcos30° (5.00)xcos30° (4.33)
	$14F=3g\cos30°6.52- 3g\sin30°2.64$	M1		14F = 3x9.8x7.034xcos52.0°
	$F = 9.09$ N	A1	5	**13**