RECOGNISING ACHIEVEMENT

ADVANCED GCE

MATHEMATICS

Mechanics 2

4729

Candidates answer on the Answer Booklet

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

Other Materials Required:
None

Monday 15 June 2009
Afternoon

Duration: 1 hour 30 minutes

4729

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 boy on a sledge slides down a straight track of length 180 m which descends a vertical distance of 40 m. The combined mass of the boy and the sledge is 75 kg. The initial speed is $3\,\mathrm{m\,s^{-1}}$ and the final speed is $12\,\mathrm{m\,s^{-1}}$. The magnitude, R N, of the resistance to motion is constant. By considering the change in energy, calculate R. **[5]**

2 A car of mass 1100 kg has maximum power of 44 000 W. The resistive forces have constant magnitude 1400 N.

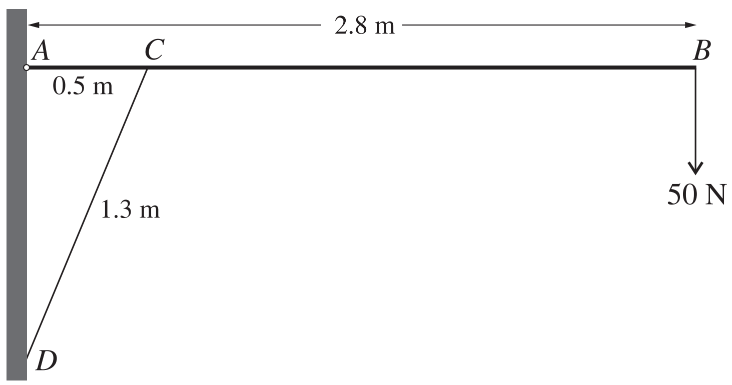
(i) Calculate the maximum steady speed of the car on the level. **[2]**

The car is moving on a hill of constant inclination α to the horizontal, where $\sin\alpha = 0.05$.

(ii) Calculate the maximum steady speed of the car when ascending the hill. **[3]**

(iii) Calculate the acceleration of the car when it is descending the hill at a speed of $10\,\mathrm{m\,s^{-1}}$ working at half the maximum power. **[3]**

3



A uniform beam AB has weight 70 N and length 2.8 m. The beam is freely hinged to a wall at A and is supported in a horizontal position by a strut CD of length 1.3 m. One end of the strut is attached to the beam at C, 0.5 m from A, and the other end is attached to the wall at D, vertically below A. The strut exerts a force on the beam in the direction DC. The beam carries a load of weight 50 N at its end B (see diagram).

(i) Calculate the magnitude of the force exerted by the strut on the beam. **[4]**

(ii) Calculate the magnitude of the force acting on the beam at A. **[6]**

4 A light inextensible string of length 0.6 m has one end fixed to a point A on a smooth horizontal plane. The other end of the string is attached to a particle B, of mass 0.4 kg, which rotates about A with constant angular speed $2\,\mathrm{rad\,s^{-1}}$ on the surface of the plane.

(i) Calculate the tension in the string. **[2]**

A particle P of mass 0.1 kg is attached to the mid-point of the string. The line APB is straight and rotation continues at $2\,\mathrm{rad\,s^{-1}}$.

(ii) Calculate the tension in the section of the string AP. **[4]**

(iii) Calculate the total kinetic energy of the system. **[5]**

5 **(i)**

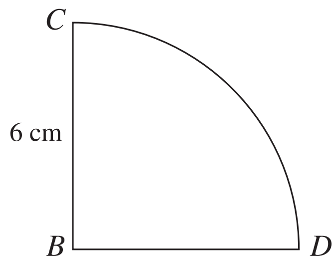


Fig. 1

Fig. 1 shows a uniform lamina BCD in the shape of a quarter circle of radius 6 cm. Show that the distance of the centre of mass of the lamina from B is 3.60 cm, correct to 3 significant figures. **[2]**

A uniform rectangular lamina $ABDE$ has dimensions $AB = 12$ cm and $AE = 6$ cm. A single plane object is formed by attaching the rectangular lamina to the lamina BCD along BD (see Fig. 2). The mass of $ABDE$ is 3 kg and the mass of BCD is 2 kg.

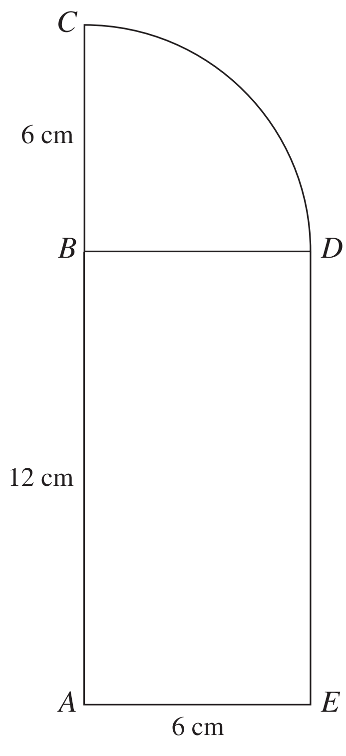


Fig. 2

(ii) Taking x- and y-axes along AE and AB respectively, find the coordinates of the centre of mass of the object. **[7]**

The object is freely suspended at C and rests in equilibrium.

(iii) Calculate the angle that AC makes with the vertical. **[2]**

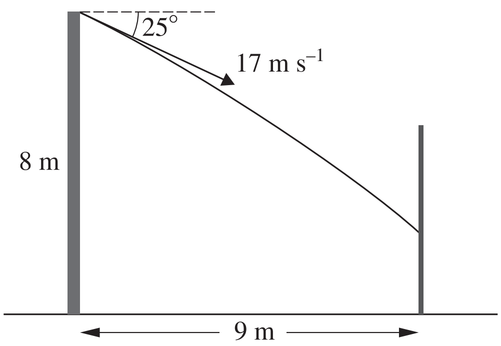
6 Two uniform spheres, A and B, have the same radius. The mass of A is 0.4 kg and the mass of B is 0.2 kg. The spheres A and B are travelling in the same direction in a straight line on a smooth horizontal surface, A with speed $5\,\text{m s}^{-1}$, and B with speed $v\,\text{m s}^{-1}$, where $v < 5$. A collides directly with B and the impulse between them has magnitude 0.9 N s. Immediately after the collision, the speed of B is $6\,\text{m s}^{-1}$.

(i) Calculate v. **[3]**

B subsequently collides directly with a stationary sphere C of mass 0.1 kg and the same radius as A and B. The coefficient of restitution between B and C is 0.6.

(ii) Determine whether there will be a further collision between A and B. **[10]**

7



A ball is projected with an initial speed of $17\,\text{m s}^{-1}$ at an angle of 25° below the horizontal from a point on the top of a vertical wall. The point of projection is 8 m above horizontal ground. The ball hits a vertical fence which is at a horizontal distance of 9 m from the wall (see diagram).

(i) Calculate the height above the ground of the point where the ball hits the fence. **[5]**

(ii) Calculate the direction of motion of the ball immediately before it hits the fence. **[5]**

(iii) It is given that 30% of the kinetic energy of the ball is lost when it hits the fence. Calculate the speed of the ball immediately after it hits the fence. **[4]**

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1 (i)	½×75×12^2 or ½×75×3^2 (either KE) 75×9.8×40 (PE) R×180 (change in energy = 24337) ½×75×12^2=½×75×3^2+75×9.8×40–R×180 R = 135 N	B1 B1 B1 M1 A1 **5**	M1 $12^2 = 3^2 + 2a \times 180$ A1 a = 0.375 (3/8) M1 75 × 9.8 × sinθ – R = 75a A1 R = 135 (max 4 for no energy) **5**

2 (i)	$R = F = P/v$ = 44 000/v = 1400 v = 31.4 m s^{-1}	M1 A1 **2**	
(ii)	44 000/v = 1400 + 1100 × 9.8 × 0.05 v = 22.7 m s^{-1}	M1 A1 A1 **3**	must have g
(iii)	22 000/10 + 1100×9.8×0.05 – 1400 = 1100a a = 1.22 m s^{-2}	M1 A1 A1 **3**	**8**

3 (i)	cosθ = 5/13 or sinθ = 12/13 or θ = 67.4° 0.5×Fsinθ = 70×1.4 + 50 × 2.8 F = 516 N	B1 M1 A1 A1 **4**	any one of these moments about A (ok without 70) 0.5sinθ = 0.4615 **SR** 1 for 303 (omission of beam)
(ii)	F sinθ = 120 + Y (resolving vertically) Y = 356 ✓ their F × 12/13 – 120 X = Fcosθ (resolving horizontally) X = 198 ✓ their F × 5/13 Force = √(356^2 + 198^2) 407 or 408 N	M1 A1 ✓ M1 A1 ✓ M1 A1 **6**	M1/A1 for moments (B)Y×2.8+1.4×70=2.3×516✓×12/13 (C) 0.5×Y = 0.9×70 + 2.3×50 (D) 1.2X = 1.4×70 +2.8×50 **10**

4 (i)	$T = 0.4 \times 0.6 \times 2^2$ T = 0.96 N	M1 A1 **2**	
(ii)	$S - T$ $S - T = 0.1 \times 0.3 \times 2^2$ S = 1.08	B1 M1 A1 A1 **4**	may be implied
(iii)	$v = r\omega$ v_P = 0.6 v_B = 1.2 ½×0.1×0.6^2 + ½×0.4×1.2^2 0.306	M1 A1 A1 M1 A1 **5**	(0.018 + 0.288) separate speeds **11**

5 (i)	$\bar{d} = (2\times 6 \sin\pi/4)/3\pi/4$ $\bar{d} = 3.60$	M1 A1 **2**	must be correct formula with rads AG
(ii)	$\bar{d}\cos 45° = $ "2.55" $5\bar{x} = 3\times 3 + 2\times$ "2.55" $\bar{x} = 2.82$ $5\bar{y} = 3\times 6 + 2\times(12 +$ "2.55") $\bar{y} = 9.42$	B1 M1 A1 A1 M1 A1 A1 **7**	 may be implied moments must not have areas 2kg/3kg misread (swap) gives (2.73,11.13) θ = 21.7° (MR – 2) (max 7 for (ii) + (iii)) SR -1 for $\bar{x}$, $\bar{y}$ swap
(iii)	$\tan\theta = 2.82/8.58$ $\theta = 18.2°$ ✓	M1 A1 **2**	M0 for their $\bar{x}$ / $\bar{y}$ ✓ their $\bar{x}/(18 - \bar{y})$ **11**

6 (i)	$I = 0.9 = 6\times 0.2 - v\times 0.2$ $v = 1.5$	M1 A1 A1 **3**	needs to be mass 0.2
(ii)	$0.6 = (c - b)/6$ $6\times 0.2 = 0.2b + 0.1c$ $b = 2.8$ $0.4\times 5 + 0.2\times 1.5 = 0.4a + 0.2\times 6$ or $I = 0.9 = -0.4a - - 0.4\times 5$ $a = 2.75$ $2.75 < 2.8$ no further collision	M1 A1 M1 A1 A1 M1 A1 A1 M1 A1 **10**	restitution (allow 1.5 for M1) momentum (allow 1.5 for M1) 1st collision (needs their 1.5 for M1) compare v's of A and B (calculated) **13**

7(i)	$9 = 17\cos 25°\times t$ $t = 0.584$ (or 9/17cos25°) $d = 17\sin 25°\times 0.584 + ½\times 9.8\times 0.584^2$ (d = ht lost (5.87) $h = 2.13$	M1 A1 M1 A1 A1 **5**	B1 $y = x\tan\theta - 4.9x^2/v^2\cos^2\theta$ M1/A1 $y = 9\tan(-25°) - 4.9\times 9^2/17^2\cos^2 25°$ A1 y = -5.87 2.13
(ii)	$v_h = 17\cos 25°$ (15.4) $v_v = 17\sin 25° + 9.8\times 0.584$ or $v_v^2 = (17\sin 25°)^2 + 2\times 9.8\times 5.87$ $v_v = 12.9$ $\tan\theta = 12.9/15.4$ $\theta = 40.0°$ below horizontal	B1 M1 A1 M1 A1 **5**	M1/A1 $dy/dx =$ $\tan\theta - 9.8x/v^2\cos^2\theta$ A1 $dy/dx = -0.838$ M1 $\tan^{-1}(-.838)$ or 50.0° to vertical
(iii)	speed = $\sqrt{(12.9^2 + 15.4^2)}$ $½mv^2 = ½m\times 20.1^2\times 0.7$ $v = 16.8$ m s^{-1}	M1 A1 ✓ M1 A1 **4**	(20.1) NB 0.3 instead of 0.7 gives 11.0 (M0) **14**