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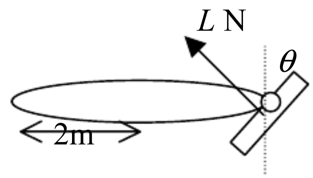
MECHANICS (C) UNIT 2 TEST PAPER 1

Take $g = 9{\cdot}8$ ms^{-2} and give all answers correct to 3 significant figures where necessary.

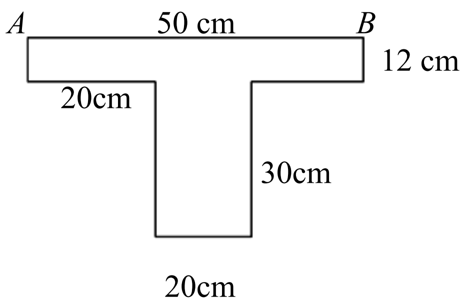
1. A car of mass 1200 kg decelerates from 30 ms^{-1} to 20 ms^{-1} in 6 seconds at a constant rate.
   (i) Find the magnitude, in N, of the decelerating force. [2]
   (ii) Find the loss, in J, in the car's kinetic energy. [2]

2. Eddie, whose mass is 71 kg, rides a bicycle of mass 25 kg up a hill inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{12}$ .When Eddie is working at a rate of 600 W, he is moving at a constant speed of 6 ms^{-1}.
   Find the magnitude of the non-gravitational resistance to his motion. [6]

3. A bird of mass 0·5 kg, flying around a vertical feeding post at a constant speed of 4 ms^{-1}, inclines its wings so as to move in a horizontal circle of radius 2 m. The lifting force L newtons acts perpendicular to the bird's wings, as shown.
   Modelling the bird as a particle, find, to the nearest degree, the angle θ that its wings make with the vertical. [7]

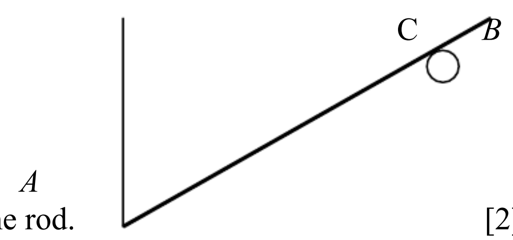


4. The diagram shows a body which may be modelled as a uniform lamina.
   The body is suspended from the point marked A and rests in equilibrium.
   (i) Calculate, to the nearest degree, the angle which the edge AB then makes with the vertical. [7]



Frank suggests that the angle between AB and the vertical would be smaller if the lamina were made from lighter material.
   (ii) State, with a brief explanation, whether Frank is correct. [2]

5. A uniform rod AB, of mass 0·8 kg and length $10a$, is supported at the end A by a light inextensible vertical string and rests in limiting equilibrium on a rough fixed peg at C, where $AC = 7a$.



   (i) Draw a diagram to show all the forces acting on the rod. [2]
   (ii) Find the magnitude of the tension in the string. [3]
   Given further that AB makes an angle of 20^0 with the horizontal,
   (iii) find the magnitude of the normal reaction exerted by the peg on the rod at C. [4]

6. Two particles A and B, of mass m and km respectively, are moving in the same direction on a smooth horizontal surface. A has speed $4u$ and B has speed u. The coefficient of restitution between A and B is e. A collides directly with B, and in the collision the direction of A's motion is reversed. Immediately after the impact, B has speed $2u$.
   (i) Show that the speed of A immediately after the impact is $u(3e - 2)$. [3]
   (ii) Deduce the range of possible values of e. [3]

(iii) Show that $4 < k \le 5$. [6]

7. A ball is projected from ground level with speed 34 ms^{-1} at an angle α above the horizontal, where $\tan \alpha = {}^{8}/_{15}$.
(i) Find the greatest height reached by the ball above ground level. [5]
While it is descending, the ball hits a horizontal ledge 6 metres above ground level.
(ii) Find the horizontal distance travelled by the ball before it hits the ledge. [5]
(iii) Find the speed of the ball at the instant when it hits the ledge. [3]

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MECHANICS 2 (C) TEST PAPER 1 : ANSWERS AND MARK SCHEME

1. (i) Deceleration = ${}^{5}/_{3}$ ms^{-2} Force = $1200 \times {}^{5}/_{3}$ = 2000 N M1 A1
(ii) K.E. lost = $600(30^2 - 20^2) = 300\ 000$ J M1 A1 4

2. $P = Fv : 600 = 6F$ $F = 100$ N M1 A1 A1
$100 = 96g \sin \alpha + R$ $R = 100 - 8g = 21{\cdot}6$ N M1 A1 A1 6

3. $L \sin \theta = 0{\cdot}5g = 4{\cdot}9$ $L \cos \theta = mv^2/r = 0{\cdot}5 \times 16 \div 2 = 4$ M1 A1 M1 A1
$\tan \theta = 4{\cdot}9 \div 4 = 1{\cdot}225$ $\theta = 50{\cdot}8^0$ 51^0 M1 A1 A1 7

4. (i) $600(25, 6) + 600(30, 27) = 1200(\bar{x}, \bar{y})$ $\bar{x} = 27{\cdot}5$, $\bar{y} = 16{\cdot}5$ M1 A1 M1 A1 A1
$\tan \theta = 16{\cdot}5 \div 27{\cdot}5 = 0{\cdot}6$ $\theta = 31^0$ M1 A1
(ii) No : centre of mass depends only on area, not on density B1 B1 9

5. (i) Diagram showing weight, tension, normal reaction, friction B2
(ii) $M(C) : T(7a \cos \alpha) = 0{\cdot}8g(2a \cos \alpha)$ $T = 2(0{\cdot}8g) \div 7 = 2{\cdot}24$ N M1 A1 A1
(iii) Resolve perp. to rod : $R + T \cos \alpha = 0{\cdot}8g \cos \alpha$ M1 A1
$R = 5{\cdot}6 \cos 20^0 = 5{\cdot}26$ N M1 A1 9

6. (i) $(v_B - v_A)/(u - 4u) = -e$ $2u - v_A = 3eu$ $v_A = u(2 - 3e)$ M1 A1
$v_A < 0$, so speed $= u(3e - 2)$ A1
(ii) Since $v_A < 0$, $2 - 3e < 0$ $\frac{2}{3} < e \le 1$ M1 A1 A1
(iii) $4mu + kmu = mvA + kmv_B$ $v_A + 2ku = 4u + ku$ M1 A1
$v_A = u(4 - k)$, so $4 - k = 2 - 3e$ $k = 3e + 2$ M1 A1
$\frac{2}{3} < e \le 1$, so $4 < k \le 5$ M1 A1 12

7. (i) $y = (u \sin \alpha)t - \frac{1}{2} gt^2 = 16t - 4{\cdot}9t^2$ M1 A1
When y is max., $16 - 9{\cdot}8t = 0$ $t = 1{\cdot}63$ $y = 13{\cdot}1$ m M1 A1 A1
(ii) When $y = 6$, $4{\cdot}9t^2 - 16t + 6 = 0$ B1
$t = (16 + \sqrt{138{\cdot}4})/9{\cdot}8 = 2{\cdot}83$ $x = (u \cos \alpha)t = 30t = 85{\cdot}0$ m M1 A1 M1 A1
(iii) $m(34^2) = mg(6) + \frac{1}{2} mv^2$ $v^2 = 1038$ $v = 32{\cdot}2$ ms^{-1} M1 A1 A1 13