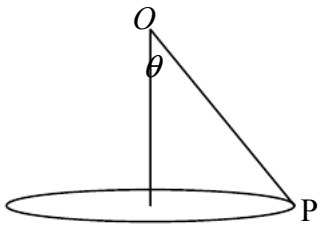
MECHANICS (C) UNIT 2 TEST PAPER 2

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

1. A constant force acts on a particle of mass 200 grams, moving it 50 cm in a straight line on a rough horizontal surface at a constant speed. The coefficient of friction between the particle and the surface is $\frac{1}{4}$. Calculate, in J, the work done by the force. [4]

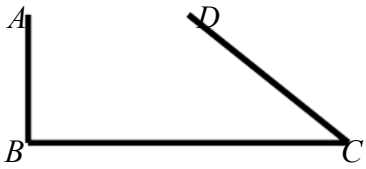
2. A plank of wood AB, of mass 8 kg and length 6 m, rests on a support at P, where $AP = 4$ m. When particles of mass 1 kg and k kg are suspended from A and B respectively, the plank rests horizontally in equilibrium.
   Modelling the plank as a uniform rod, find
   (i) the value of k, [2]
   (ii) the magnitude of the force exerted by the support on the plank at P. [2]

3. A particle P of mass m kg moves in a horizontal circle at one end of a light inextensible string of length 40 cm, as shown. The other end of the string is attached to a fixed point O. The angular velocity of P is ω rad s^{-1}. If the angle θ which the string makes with the vertical must not exceed 60^0, calculate the greatest possible value of ω. [7]



4. A small car, of mass 850 kg, moves on a straight horizontal road. Its engine is working at its maximum rate of 25 kW, and a constant resisting force of magnitude 900 N opposes the car's motion.
   (i) Find the acceleration of the car when it is moving with speed 15 ms^{-1}. [3]
   (ii) Find the maximum speed of the car on the horizontal road. [3]
   With the engine still working at 25 kW and the non-gravitational resistance remaining at 900 N, the car now climbs a hill inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{10}$.
   (iii) Find the maximum speed of the car on this hill. [4]

5. A uniform wire $ABCD$ is bent into the shape shown, where the sections AB, BC and CD are straight and of length $3a$, $10a$ and $5a$ respectively and AD is parallel to BC.



   (i) Show that the cosine of angle BCD is $\frac{4}{5}$. [2]
   (ii) Find the distances of the centre of mass of the bent wire from (a) AB, (b) BC. [5]
   The wire is hung over a smooth peg at B and rests in equilibrium.
   (iii) Find, to the nearest $0{\cdot}1^0$, the angle between BC and the vertical in this position. [4]

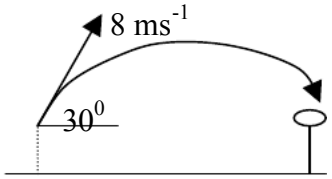
6. Two particles P and Q, of masses 0·3 kg and 0·2 kg respectively, are moving towards each other along a straight line. P has speed 4 ms^{-1}. They collide directly. After the collision the direction of motion of both particles has been reversed, and Q has speed 2 ms^{-1}. The coefficient of restitution between P and Q is $\frac{1}{3}$. Find

(i) the speed of Q before the collision, [4]

(ii) the speed of P after the collision, [4]

(iii) the kinetic energy, in J, lost in the impact. [3]

7. In a fairground game, a contestant bowls a ball at a coconut 6 metres away on the same horizontal level. The ball is thrown with an initial speed of 8 ms^{-1} in a direction making an angle of 30^0 with the horizontal.



(i) Find the time taken by the ball to travel 6 m horizontally. [2]

(ii) Showing your method clearly, decide whether or not the ball will hit the coconut. [3]

(iii) Find the greatest height reached by the ball above the level from which it was thrown. [3]

(iv) Find the maximum horizontal distance from which it is possible to hit the coconut if the ball is thrown with the same initial speed of 8 m s^{-1}. [3]

(v) State two assumptions that you have made about the ball and the forces which act on it as it travels towards the coconut. [2]

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

1. $F = \frac{1}{4}(0{\cdot}2g) = 0.49$ N $W = Fd = 0{\cdot}49 \times 0{\cdot}5 = 0{\cdot}245$ J M1 A1 M1 A1 4

2. (i) Moments about P : $4g + 8g = 2kg$ $k = 6$ M1 A1
   (ii) Resolve vertically : $R = 9g + kg$ $R = 15g = 147$ N M1 A1 4

3. $T\cos\theta = mg$, $T\sin\theta = m(0{\cdot}4\sin\theta)\omega 2$. $g = 0{\cdot}4\omega^2\cos\theta$ M1 A1 M1 A1
   $\theta \le 60^0$, so $\cos\theta \ge 0{\cdot}5$ $g \ge 0{\cdot}2\omega^2$ $\omega^2 \le 49$ $\omega \le 7$ B1 M1 A1 7

4. (i) $25000 = 15(900 + 850a)$ $a = 0{\cdot}902$ ms^{-2} M1 A1 A1
   (ii) $25000 = 900\, v_{max}$ $v_{max} = 27{\cdot}8$ ms^{-1} M1 A1 A1
   (iii) $25000 = v(85g + 900)$ $v = 14{\cdot}4$ ms^{-1} M1 A1 M1 A1 10

5. (i) $\sin C = {}^3/_5$ so $\cos C = {}^4/_5$ (3, 4, 5 triangle) M1 A1
   (ii) (a) $3a(0) + 10a(5a) + 5a(8a) = 18a\bar{x}$ $\bar{x} = 5a$ M1 A1
   (b) $3a(1{\cdot}5a) + 10a(0) + 5a(1{\cdot}5a) = 18a\bar{y}$ $\bar{y} = \frac{2}{3}a$ M1 A1 A1
   (iii) $\tan\alpha = \frac{2}{3}a \div 5a = {}^2/_{15}$ $\alpha = 7{\cdot}6^0$ M1 A1 M1 A1 11

6. Momentum : $1{\cdot}2 + 0{\cdot}2u = 0{\cdot}3v + 0{\cdot}4$ $\quad 3v - 2u = 8$ M1 A1

Elasticity : $(2 - v)/(u - 4) = -\frac{1}{3}$ $\quad 3v - u = 2$ M1 A1

Solve : $u = -6$, $v = -\frac{4}{3}$ A1 A1

(i) Q before collision : 6 ms^{-1} (ii) P after collision : $\frac{4}{3}$ ms^{-1} A1 A1

(iii) K.E. before = $0.15(16) + 0.1(36) = 6$ J B1

K.E. after = $0.15(\,^{16}/_{9}\,) + 0.1(4) = \frac{2}{3}$ J Loss = $5\frac{1}{3}$ J B1 B1 11

7. (i) $x = 8 \cos 30^0\, t$ When $x = 6$, $t = 0{\cdot}866$ s M1 A1

(ii) Then $y = 8 \sin 30^0\, t - 4{\cdot}9t^2 = -0{\cdot}21$ m, so does not hit coconut M1 A1 A1

(iii) When $v_y = 0$, $8 \sin 30^0 - 9{\cdot}8t = 0$ $\quad t = 0{\cdot}408$ M1 A1

Then $y = 4(0{\cdot}408) - 4.9(0{\cdot}408^2) = 0{\cdot}816$ m A1

(iv) Max range when projected at 45^0 $\quad y = 0$ when $t = 1{\cdot}154$ B1 M1

Then $x = 1{\cdot}154\ (8 \cos 45^0) = 6{\cdot}53$ m A1

(v) Ball = particle; assumed gravity is only force acting on ball B1 B1 13