6679

Edexcel GCE

Mechanics M3
(New Syllabus)
Advanced/Advanced Subsidiary
Thursday 7 June 2001 – Afternoon
Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Answer Book (AB16)	Nil
Graph Paper (ASG2)	
Mathematical Formulae (Lilac)	

Candidates may use any calculator EXCEPT those with the facility for symbolic algebra, differentiation and/or integration. Thus candidates may NOT use calculators such as the Texas Instruments TI 89, TI 92, Casio CFX 9970G, Hewlett Packard HP 48G

Instructions to Candidates

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M3), the paper reference (6679), your surname, other name and signature.
Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
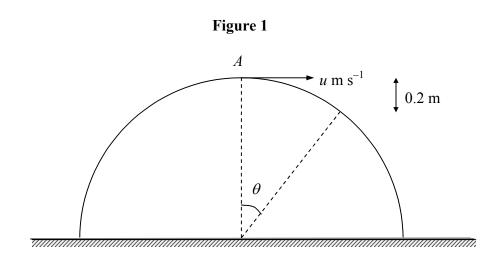This paper has seven questions.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

1. A particle P moves along the x-axis in the positive direction. At time t seconds, the velocity of P is v m s^{-1} and its acceleration is $\frac{1}{2}e^{-\frac{1}{6}t}$ m s^{-2}. When $t = 0$ the speed of P is 10 m s^{-1}.

   (a) Express v in terms of t.

   (4)

   (b) Find, to 3 significant figures, the speed of P when $t = 3$.

   (2)

   (c) Find the limiting value of v.
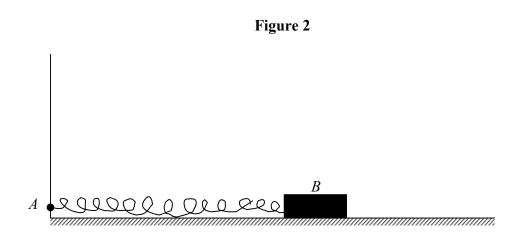
   (1)

2.

Figure 1

A smooth solid hemisphere, of radius 0.8 m and centre O, is fixed with its plane face on a horizontal table. A particle of mass 0.5 kg is projected horizontally with speed u m s^{-1} from the highest point A of the hemisphere. The particle leaves the hemisphere at the point B, which is a vertical distance of 0.2 m below the level of A. The speed of the particle at B is v m s^{-1} and the angle between OA and OB is θ, as shown in Fig. 1.

   (a) Find the value of $\cos \theta$.

   (1)

   (b) Show that $v^2 = 5.88$.

   (3)

   (c) Find the value of u.

   (3)

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3. <center>**Figure 2**</center>

A light horizontal spring, of natural length 0.25 m and modulus of elasticity 52 N, is fastened at one end to a point *A*. The other end of the spring is fastened to a small wooden block *B* of mass 1.5 kg which is on a horizontal table, as shown in Fig. 2. The block is modelled as a particle.

The table is initially assumed to be smooth. The block is released from rest when it is a distance 0.3 m from *A*. By using the principle of the conservation of energy,

(*a*) find, to 3 significant figures, the speed of *B* when it is a distance 0.25 m from *A*.

(5)

It is now assumed that the table is rough and the coefficient of friction between *B* and the table is 0.6.

(*b*) Find, to 3 significant figures, the minimum distance from *A* at which *B* can rest in equilibrium.

(5)

4. A projectile P is fired vertically upwards from a point on the earth's surface. When P is at a distance x from the centre of the earth its speed is v. Its acceleration is directed towards the centre of the earth and has magnitude $\dfrac{k}{x^2}$, where k is a constant. The earth may be assumed to be a sphere of radius R.

(*a*) Show that the motion of P may be modelled by the differential equation

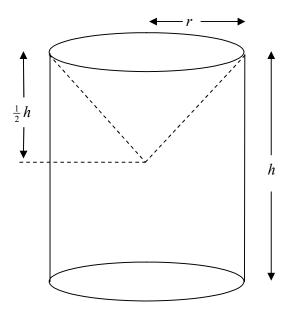$$v\frac{\mathrm{d}v}{\mathrm{d}x} = -\frac{gR^2}{x^2}.$$

(4)

The initial speed of P is U, where $U^2 < 2gR$. The greatest distance of P from the centre of the earth is X.

(*b*) Find X in terms of U, R and g.

(6)

5.

Figure 3
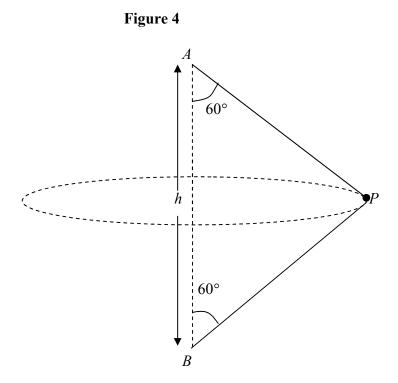

An ornament S is formed by removing a solid right circular cone, of radius r and height $\frac{1}{2}h$, from a solid uniform cylinder, of radius r and height h, as shown in Fig. 3.

(*a*) Show that the distance of the centre of mass S from its plane face is $\frac{17}{40}h$.

(7)

The ornament is suspended from a point on the circular rim of its open end. It hangs in equilibrium with its axis of symmetry inclined at an angle α to the horizontal. Given that $h = 4r$,

(*b*) find, in degrees to one decimal place, the value of α.

(4)

6.   **Figure 4**

A particle P of mass m is attached to two light inextensible strings. The other ends of the string are attached to fixed points A and B. The point A is a distance h vertically above B. The system rotates about the line AB with constant angular speed ω. Both strings are taut and inclined at $60°$ to AB, as shown in Fig. 4. The particle moves in a circle of radius r.

(*a*) Show that $r = \dfrac{\sqrt{3}}{2} h$.

(2)

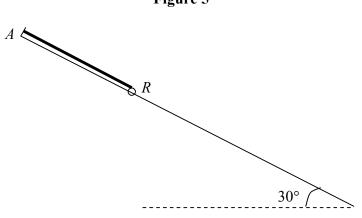(*b*) Find, in terms of m, g, h and ω, the tension in AP and the tension in BP.

(8)

The time taken for P to complete one circle is T.

(*c*) Show that $T < \pi \sqrt{\left(\dfrac{2h}{g}\right)}$.

(4)

7.

Figure 5

A small ring R of mass m is free to slide on a smooth straight wire which is fixed at an angle of $30°$ to the horizontal. The ring is attached to one end of a light elastic string of natural length a and modulus of elasticity λ. The other end of the string is attached to a fixed point A of the wire, as shown in Fig. 5. The ring rests in equilibrium at the point B, where $AB = \frac{9}{8}a$.

(*a*) Show that $\lambda = 4mg$.

(3)

The ring is pulled down to the point C, where $BC = \frac{1}{4}a$, and released from rest. At time t after R is released the extension of the string is $(\frac{1}{8}a + x)$.

(*b*) Obtain a differential equation for the motion of R while the string remains taut, and show that it represents simple harmonic motion with period $\pi\sqrt{\left(\dfrac{a}{g}\right)}$.

(6)

(*c*) Find, in terms of g, the greatest magnitude of the acceleration of R while the string remains taut.

(2)

(*d*) Find, in terms of a and g, the time taken for R to move from the point at which it first reaches maximum speed to the point where the string becomes slack for the first time.

(5)

END