Paper Reference(s)

6679

Edexcel GCE

Mechanics M3

Advanced/Advanced Subsidiary

Monday 13 January 2003 – Afternoon

Time: 1 hour 30 minutes

Materials required for examination
Answer Book (AB16)
Mathematical Formulae (Lilac)
Graph Paper (ASG2)

Items included with question papers
Nil

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

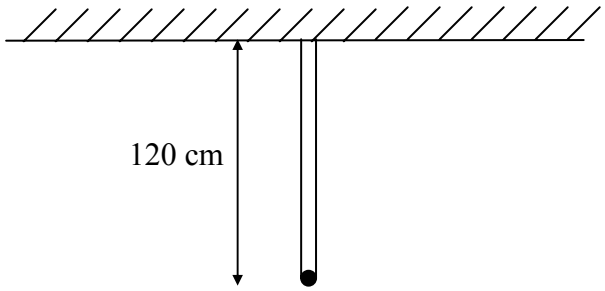
A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
This paper has seven questions. Pages 6, 7 and 8 are blank.

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.

N10814A

1. **Figure 1**



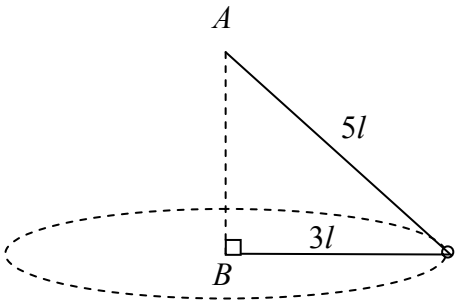
A particle of mass 5 kg is attached to one end of two light elastic strings. The other ends of the strings are attached to a hook on a beam. The particle hangs in equilibrium at a distance 120 cm below the hook with both strings vertical, as shown in Fig. 1. One string has natural length 100 cm and modulus of elasticity 175 N. The other string has natural length 90 cm and modulus of elasticity λ newtons.

Find the value of λ.

(5)

---

2. **Figure 2**



A light inextensible string of length $8l$ has its ends fixed to two points A and B, where A is vertically above B. A small smooth ring of mass m is threaded on the string. The ring is moving with constant speed in a horizontal circle with centre B and radius $3l$, as shown in Fig. 2. Find

(a) the tension in the string,

(3)

(b) the speed of the ring.

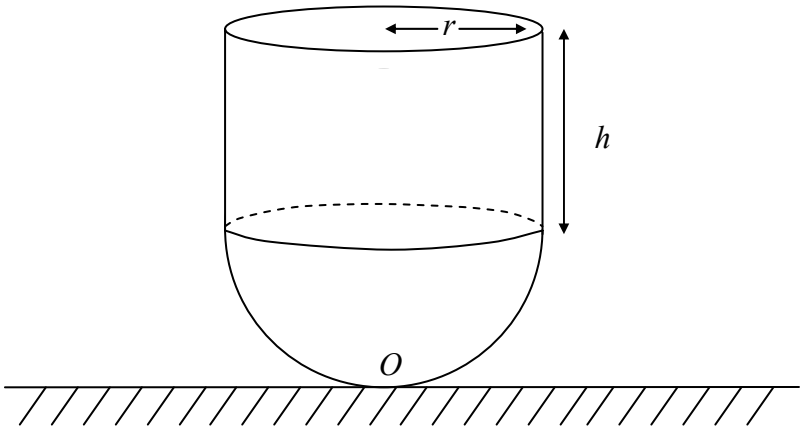
(5)

(c) State briefly in what way your solution might no longer be valid if the ring were firmly attached to the string.

(1)

---

3. **Figure 3**



A child's toy consists of a uniform solid hemisphere attached to a uniform solid cylinder. The plane face of the hemisphere coincides with the plane face of the cylinder, as shown in Fig. 3. The cylinder and the hemisphere each have radius r, and the height of the cylinder is h. The material of the hemisphere is 6 times as dense as the material of the cylinder. The toy rests in equilibrium on a horizontal plane with the cylinder above the hemisphere and the axis of the cylinder vertical.

(*a*) Show that the distance d of the centre of mass of the toy from its lowest point O is given by

$$d = \frac{h^2 + 2hr + 5r^2}{2(h + 4r)}.$$

(7)

When the toy is placed with any point of the curved surface of the hemisphere resting on the plane it will remain in equilibrium.

(*b*) Find h in terms of r.

(3)

---

4. A piston P in a machine moves in a straight line with simple harmonic motion about a point O, which is the centre of the oscillations. The period of the oscillations is π s. When P is 0.5 m from O, its speed is 2.4 m s^{-1}. Find

(a) the amplitude of the motion,

(4)

(b) the maximum speed of P during the motion,

(1)

(c) the maximum magnitude of the acceleration of P during the motion,

(1)

(d) the total time, in s to 2 decimal places, in each complete oscillation for which the speed of P is greater than 2.4 m s^{-1}.

(5)

---

5. A car of mass 800 kg moves along a horizontal straight road. At time t seconds, the resultant force acting on the car has magnitude $\frac{48\,000}{(t+2)^2}$ newtons, acting in the direction of the motion of the car. When $t = 0$, the car is at rest.

(a) Show that the speed of the car approaches a limiting value as t increases and find this value.

(6)

(b) Find the distance moved by the car in the first 6 seconds of its motion.

(6)

---

6. A light elastic string has natural length 4 m and modulus of elasticity 58.8 N. A particle P of mass 0.5 kg is attached to one end of the string. The other end of the string is attached to a vertical point A. The particle is released from rest at A and falls vertically.

(a) Find the distance travelled by P before it immediately comes to instantaneous rest for the first time.

(7)

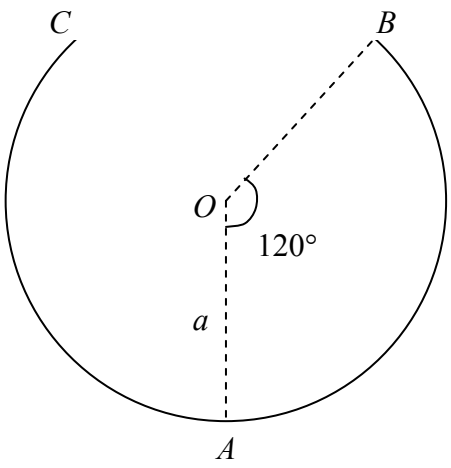
The particle is now held at a point 7 m vertically below A and released from rest.

(b) Find the speed of the particle when the string first becomes slack.

(5)

---

7. **Figure 4**



Part of a hollow spherical shell, centre O and radius a, is removed to form a bowl with a plane circular rim. The bowl is fixed with the circular rim uppermost and horizontal. The point A is the lowest point of the bowl. The point B is on the rim of the bowl and $\angle AOB = 120°$, as shown in Fig. 4. A smooth small marble of mass m is placed inside the bowl at A and given an initial horizontal speed u. The direction of motion of the marble lies in the vertical plane AOB. The marble stays in contact with the bowl until it reaches B. When the marble reaches B, its speed is v.

(a) Find an expression for v^2.

(3)

(b) For the case when $u^2 = 6ga$, find the normal reaction of the bowl on the marble as the marble reaches B.

(3)

(c) Find the least possible value of u for the marble to reach B.

(3)

The point C is the other point on the rim of the bowl lying in the vertical plane OAB.

(d) Find the value of u which will enable the marble to leave the bowl at B and meet it again at the point C.

(7)

END