Paper Reference(s)

6679

Edexcel GCE

Mechanics M3

Advanced/Advanced Subsidiary

Monday 24 May 2004 – Morning

Time: 1 hour 30 minutes

Materials required for examination	Items included with question papers
Answer Book (AB16) Mathematical Formulae (Lilac) Graph Paper (ASG2)	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 names and signature.
Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$.
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.

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Turn over

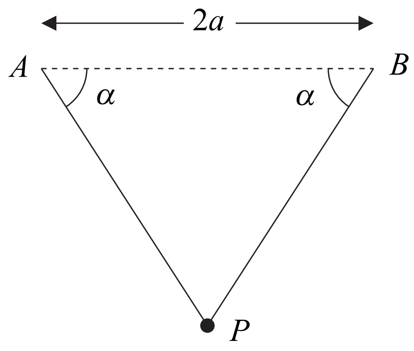
1. A circular flywheel of diameter 7 cm is rotating about the axis through its centre and perpendicular to its plane with constant angular speed 1000 revolutions per minute.

Find, in m s^{-1} to 3 significant figures, the speed of a point on the rim of the flywheel.

(3)

2.

Figure 1



Two light elastic strings each have natural length a and modulus of elasticity λ. A particle P of mass m is attached to one end of each string. The other ends of the strings are attached to points A and B, where AB is horizontal and $AB = 2a$. The particle is held at the mid-point of AB and released from rest. It comes to rest for the first time in the subsequent motion when PA and PB make angles α with AB, where $\tan \alpha = \frac{4}{3}$, as shown in Fig. 1.

Find λ in terms of m and g.

(7)

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3. A particle P of mass m kg slides from rest down a smooth plane inclined at 30° to the horizontal. When P has moved a distance x metres down the plane, the resistance to the motion of P from non-gravitational forces has magnitude mx^2 newtons.

Find

(a) the speed of P when $x = 2$,

(7)

(b) the distance P has moved when it comes to rest for the first time.

(3)

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4. A rough disc rotates in a horizontal plane with constant angular velocity ω about a fixed vertical axis. A particle P of mass m lies on the disc at a distance $\frac{4}{3}a$ from the axis. The coefficient of friction between P and the disc is $\frac{3}{5}$. Given that P remains at rest relative to the disc,

(a) prove that $\omega^2 \leqslant \dfrac{9g}{20a}$.

(4)

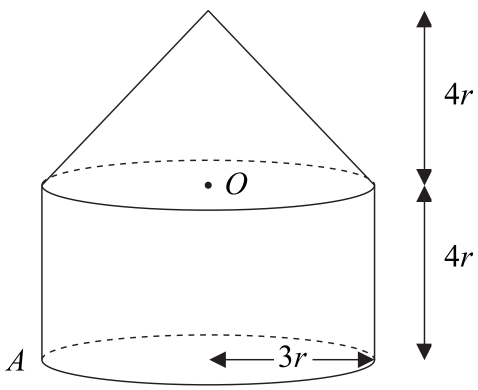
The particle is now connected to the axis by a horizontal light elastic string of natural length a and modulus of elasticity $2mg$. The disc again rotates with constant angular velocity ω about the axis and P remains at rest relative to the disc at a distance $\frac{4}{3}a$ from the axis.

(b) Find the greatest and least possible values of ω^2.

(7)

5.

Figure 2



A toy is formed by joining a uniform solid right circular cone, of base radius $3r$ and height $4r$, to a uniform solid cylinder, also of radius $3r$ and height $4r$. The cone and the cylinder are made from the same material, and the plane face of the cone coincides with a plane face of the cylinder, as shown in Fig. 2. The centre of this plane face is O.

(a) Find the distance of the centre of mass of the toy from O.

(5)

The point A lies on the edge of the plane face of the cylinder which forms the base of the toy. The toy is suspended from A and hangs in equilibrium.

(b) Find, in degrees to one decimal place, the angle between the axis of symmetry of the toy and the vertical.

(4)

The toy is placed with the curved surface of the cone on horizontal ground.

(c) Determine whether the toy will topple.

(4)

6.

Figure 3

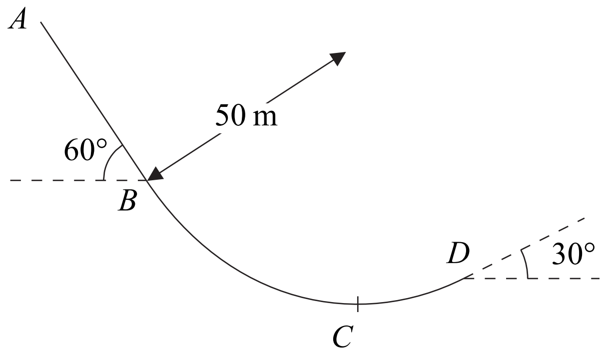


Figure 3 represents the path of a skier of mass 70 kg moving on a ski-slope *ABCD*. The path lies in a vertical plane. From *A* to *B*, the path is modelled as a straight line inclined at 60° to the horizontal. From *B* to *D*, the path is modelled as an arc of a vertical circle of radius 50 m. The lowest point of the arc *BD* is *C*.

At *B*, the skier is moving downwards with speed 20 m s^{-1}. At *D*, the path is inclined at 30° to the horizontal and the skier is moving upwards. By modelling the slope as smooth and the skier as a particle, find

(a) the speed of the skier at *C*,

(3)

(b) the normal reaction of the slope on the skier at *C*,

(3)

(c) the speed of the skier at *D*,

(3)

(d) the change in the normal reaction of the slope on the skier as she passes *B*.

(4)

The model is refined to allow for the influence of friction on the motion of the skier.

(e) State briefly, with a reason, how the answer to part (b) would be affected by using such a model. (No further calculations are expected.)

(2)

7. A particle P of mass 0.3 kg is attached to one end of a light elastic spring. The other end of the spring is attached to a fixed point O on a smooth horizontal table. The spring has natural length 2 m and modulus of elasticity 21.6 N. The particle P is placed on the table at the point A, where $OA = 2$ m. The particle P is now pulled away from O to the point B, where OAB is a straight line with $OB = 3.5$ m. It is then released from rest.

(a) Prove that P moves with simple harmonic motion of period $\frac{\pi}{3}$ s.

(4)

(b) Find the speed of P when it reaches A.

(2)

The point C is the mid-point of AB.

(c) Find, in terms of π, the time taken for P to reach C for the first time.

(3)

Later in the motion, P collides with a particle Q of mass 0.2 kg which is at rest at A.

After the impact, P and Q coalesce to form a single particle R.

(d) Show that R also moves with simple harmonic motion and find the amplitude of this motion.

(7)

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