6680/01

Edexcel GCE

Mechanics

Unit M4 Mock paper

Advanced Subsidiary / Advanced

Time: 1 hour 30 minutes

Materials required for the examination	Items included with these question papers
Answer Book (AB04) Graph Paper (GP02) Mathematical Formulae	Nil

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

Instructions to Candidates

In the boxes on the Answer Book provided, write the name of the Examining Body (Edexcel), your Centre Number, Candidate Number, the Unit Title (Mechanics M4), the Paper Reference (6680), your surname, other names 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 including Statistical Formulae and Tables' is provided.

Full marks may be obtained for answers to ALL questions.

This paper has *7* questions. There are no blank pages.

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 will gain no credit

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1. A smooth sphere S is moving on a smooth horizontal plane with speed u when it collides with a smooth fixed vertical wall. At the instant of collision the direction of motion of S makes an angle of 30° with the wall. The coefficient of restitution between S and the wall is $\frac{1}{3}$.

Find the speed of S immediately after the collision. **(6 marks)**

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2. A car of mass 1000 kg, moving along a straight horizontal road, is driven by an engine which produces a constant power of 12 kW. The only resistance to the motion of the car is air resistance of magnitude $10v^2$ N where v m s^{-1} is the speed of the car.

Find the distance travelled by the car as its speed increases from 5 m s^{-1} to 10 m s^{-1}.
(8 marks)

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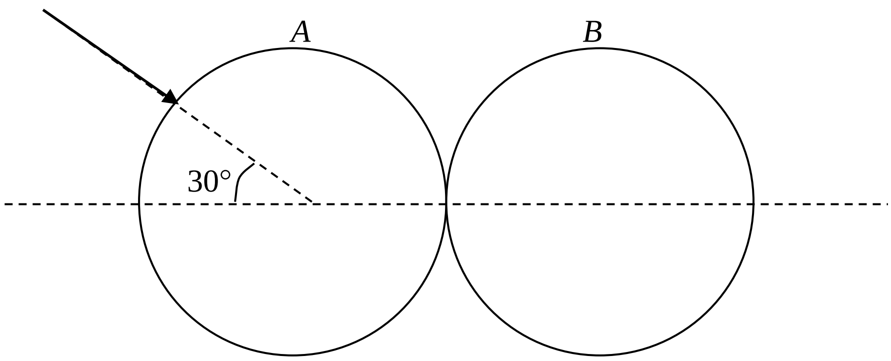
3. **Figure 1**



A smooth uniform sphere A, moving on a smooth horizontal table, collides with a second identical sphere B which is at rest on the table. When the spheres collide the line joining their centres makes an angle of 30° with the direction of motion of A, as shown in Fig. 1. The coefficient of restitution between the spheres is e. The direction of motion of A is deflected through an angle θ by the collision.

Show that $\tan\theta = \dfrac{(1+e)\sqrt{3}}{5-3e}$. **(10 marks)**

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4. A body falls vertically from rest and is subject to air resistance of a magnitude which is proportional to its speed.

Given that its terminal speed is 100 m s^{-1}, find the time it takes for the body to attain a speed of 60 m s^{-1}. **(10 marks)**

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5. A particle P of mass m is fixed to one end of a light elastic string, of natural length a and modulus of elasticity $2man^2$. The other end of the string is attached to a fixed point O. The particle P is released from rest at a point which is a distance $2a$ vertically below O. The air resistance is modelled as having magnitude $2mnv$, where v is the speed of P.

(a) Show that, when the extension of the string is x,

$$\frac{\mathrm{d}^2 x}{\mathrm{d}t^2} + 2n\frac{\mathrm{d}x}{\mathrm{d}t} + 2n^2 x = g\,.$$ **(5 marks)**

(b) Find x in terms of t. **(7 marks)**

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6. Two particles P and Q have constant velocity vectors $\mathbf{v}_P$ and $\mathbf{v}_Q$ respectively. The magnitude of the velocity of P relative to Q is equal to the speed of P. If the direction of motion of one of the particles is reversed, the magnitude of the velocity of P relative to Q is doubled.

Find

(a) the ratio of the speeds of P and Q, **(9 marks)**

(b) the cosine of the angle between the directions of motion of P and Q. **(3 marks)**

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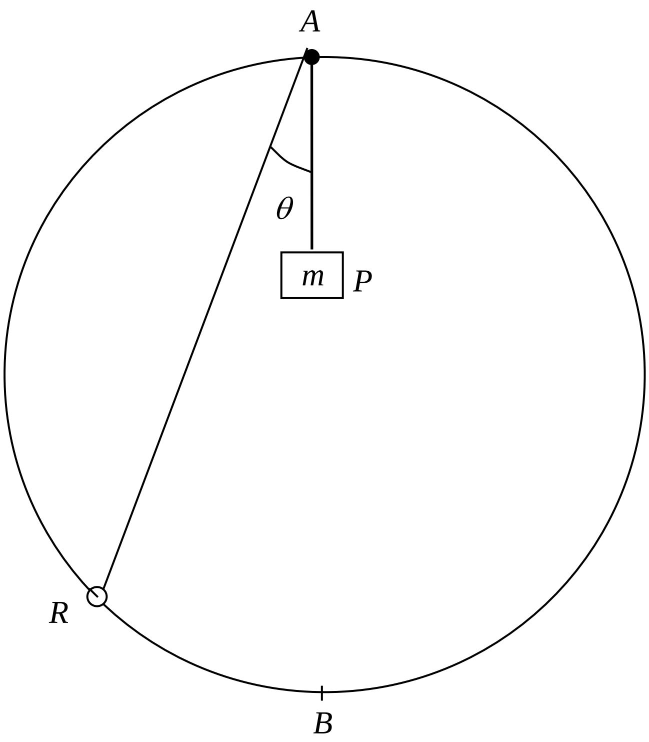
7. **Figure 2**



A smooth wire AB, in the shape of a circle of radius r, is fixed in a vertical plane with AB vertical. A small smooth ring R of mass m is threaded on the wire and is connected by a light inextensible string to a particle P of mass m. The length of the string is greater than the diameter of the circle. The string passes over a small smooth pulley which is fixed at the highest point A of the wire and angle $R\hat{A}P = \theta$, as shown in Fig. 2.

(a) Show that the potential energy of the system is given by

$$2mgr(\cos\theta - \cos^2\theta) + \text{constant}.$$ **(6 marks)**

(b) Hence determine the values of θ, $\theta \geq 0$, for which the system is in equilibrium. **(6 marks)**

(c) Determine the stability of each position of equilibrium. **(5 marks)**

END