Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Mechanics M4

Advanced/Advanced Subsidiary

Wednesday 13 June 2018 – Morning
Time: 1 hour 30 minutes

Paper Reference
6680/01

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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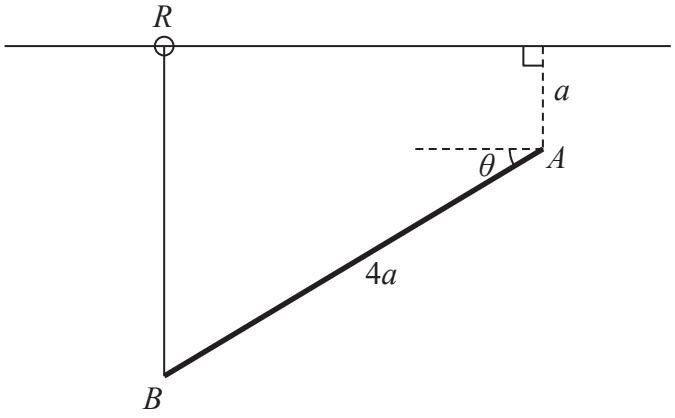


Figure 1

A uniform rod AB has mass m and length $4a$. The end A of the rod is freely hinged to a fixed point. One end of a light elastic string, of natural length a and modulus $\frac{1}{4}mg$, is attached to the end B of the rod. The other end of the string is attached to a small light smooth ring R. The ring can move freely on a smooth horizontal wire which is fixed at a height a above A, and in a vertical plane through A. The angle between the rod and the horizontal is θ, where $0 < \theta < \frac{\pi}{2}$, as shown in Figure 1. Given that the elastic string is vertical,

(a) show that the potential energy of the system is

$$2mga(\sin^2\theta - \sin\theta) + \text{constant}$$

(4)

(b) Show that when $\theta = \frac{\pi}{6}$ the rod is in stable equilibrium.

(7)

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Question 1 continued

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2. A small ball B, moving on a smooth horizontal plane, collides with a fixed smooth vertical wall. Immediately before the collision the angle between the direction of motion of B and the wall is α. The coefficient of restitution between B and the wall is $\frac{3}{4}$. The kinetic energy of B immediately after the collision is 60% of its kinetic energy immediately before the collision.

Find, in degrees, the size of angle α.

(8)

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Question 2 continued

Q2

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3. When a man walks due West at a constant speed of 4 km h^{-1}, the wind appears to be blowing from due South. When he runs due North at a constant speed of 8 km h^{-1}, the speed of the wind appears to be 5 km h^{-1}.
The velocity of the wind relative to the Earth is constant with magnitude w km h^{-1}.

Find the two possible values of w.

(7)

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Question 3 continued

Q3

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4. A particle P of mass 0.5 kg moves in a horizontal straight line. At time t seconds ($t \geqslant 0$), the displacement of P from a fixed point O of the line is x metres, the speed of P is v m s^{-1} and P is moving in the direction of x increasing. A force of magnitude kx newtons acts on P in the direction PO. The motion of P is also subject to a resistance of magnitude λv newtons.

Given that

$$x = (1.5 + 10t)e^{-4t}$$

find

(a) the value of k and the value of λ,

(8)

(b) the distance from P to O when P is instantaneously at rest.

(3)

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5. A horizontal square field, *PQRS*, has sides of length 75 m. Ali is at corner *P* of the field and Beth is at corner *Q* of the field. Ali starts to walk in a straight line along the diagonal of the field from *P* to *R* at a constant speed of 1.5 m s^{-1}. Beth sees Ali start to walk, waits 10 seconds, and then walks from *Q* to intercept Ali. Beth walks in a straight line at a constant speed of 2 m s^{-1}.

Find

(i) the time from the instant Beth leaves *Q* until the instant that she intercepts Ali,

(ii) the direction Beth should take.

(11)

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6. A particle of mass m is projected vertically upwards in a resisting medium. As the particle moves upwards, the speed v of the particle is given by

$$v^2 = kg\left(5e^{-\frac{x}{2k}} - 4\right)$$

where x is the distance of the particle above the point of projection and k is a positive constant.

(a) Show that the magnitude of the resistance to the motion of the particle is $\frac{mv^2}{4k}$.

(4)

(b) Find, in terms of k, the greatest height reached by the particle above the point of projection.

(3)

(c) Show that the time taken by the particle to reach its greatest height above the point of projection is $\sqrt{\frac{4k}{g}}\arctan\left(\frac{1}{2}\right)$

(7)

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7. Two smooth uniform spheres A and B, of mass 2 kg and 3 kg respectively, and of equal radius, are moving on a smooth horizontal plane when they collide.
Immediately before the collision the velocity of A is $(3\mathbf{i} + \mathbf{j})$ m s^{-1} and the velocity of B is $(-\mathbf{i} + 2\mathbf{j})$ m s^{-1}. Immediately after the collision the velocity of A is $(\mathbf{i} + 3\mathbf{j})$ m s^{-1}.

(a) Show that, at the instant when A and B collide, their line of centres is parallel to $-\mathbf{i} + \mathbf{j}$.

(4)

(b) Find the velocity of B immediately after the collision.

(3)

(c) Find the coefficient of restitution between A and B.

(6)

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TOTAL FOR PAPER: 75 MARKS

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