

6681/01

# Edexcel GCE

## Mechanics

Unit M5 Mock paper

Advanced Subsidiary / Advanced

Time: 1 hour 30 minutes

Materials required for the examination

Items included with these question papers

Answer Book (AB04)

Nil

Graph Paper (GP02)

Mathematical Formulae

**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

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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 M5), the Paper Reference (6681), 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

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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

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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 bead of mass 0.5 kg is threaded on a smooth straight wire. The forces acting on the bead are a constant force  $(2\mathbf{i} + 3\mathbf{j} + x\mathbf{k})$  N, its weight  $(-4.9\mathbf{k})$  N, and the reaction on the bead from the wire.

(a) Explain why the reaction on the bead from the wire does no work as the bead moves along the wire. (1 mark)

The bead moves from the point  $A$  with position vector  $(\mathbf{i} + \mathbf{j} - 3\mathbf{k})$  m relative to a fixed origin  $O$  to the point  $B$  with position vector  $(3\mathbf{i} - \mathbf{j} + 2\mathbf{k})$  m. The speed of the bead at  $A$  is  $2 \text{ m s}^{-1}$  and the speed of the bead at  $B$  is  $4 \text{ m s}^{-1}$ .

(b) Find the value of  $x$ . (6 marks)

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2. A rod  $AB$  has mass  $m$  and length  $4a$ . It is free to rotate about a fixed smooth horizontal axis through the point  $O$  of the rod, where  $AO = a$ . The rod is hanging in equilibrium with  $B$  below  $O$  when it is struck by a particle  $P$ , of mass  $3m$ , moving horizontally with speed  $v$ . When  $P$  strikes the rod, it adheres to it. Immediately after striking the rod,  $P$  has speed  $\frac{2}{3}v$ .

Find the distance from  $O$  of the point where  $P$  strikes the rod. (7 marks)

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3. At time  $t$  seconds, the position vector  $\mathbf{r}$  metres of a particle  $P$ , relative to a fixed origin  $O$ , satisfies the differential equation

$$\frac{d^2\mathbf{r}}{dt^2} + 4\frac{d\mathbf{r}}{dt} + 3\mathbf{r} = \mathbf{0}.$$

At time  $t = 0$ ,  $P$  is at the point with position vector  $2\mathbf{i}$  m and is moving with velocity  $2\mathbf{j} \text{ m s}^{-1}$ .

Find the position vector of  $P$  when  $t = \ln 2$ . (10 marks)

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4. Two forces  $\mathbf{F}_1$  and  $\mathbf{F}_2$  act on a rigid body, where  $\mathbf{F}_1 = (2\mathbf{j} + 3\mathbf{k})$  N and  $\mathbf{F}_2 = (\mathbf{i} + 4\mathbf{k})$  N. The force  $\mathbf{F}_1$  acts through the point with position vector  $(\mathbf{i} + \mathbf{k})$  m relative to a fixed origin  $O$ . The force  $\mathbf{F}_2$  acts through the point with position vector  $(2\mathbf{j})$  m. The two forces are equivalent to a single force  $\mathbf{F}$ .

(a) Find the magnitude of  $\mathbf{F}$ . (3 marks)

(b) Find, in the form  $\mathbf{r} = \mathbf{a} + \lambda\mathbf{b}$ , a vector equation of the line of action of  $\mathbf{F}$ . (8 marks)

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5. A spaceship is moving in deep space with no external forces acting on it. Initially it has total mass  $M$  and is moving with speed  $V$ . The spaceship reduces its speed to  $\frac{2}{3}V$  by ejecting fuel from its front end with a speed of  $c$  relative to itself and in the same direction as its own motion.

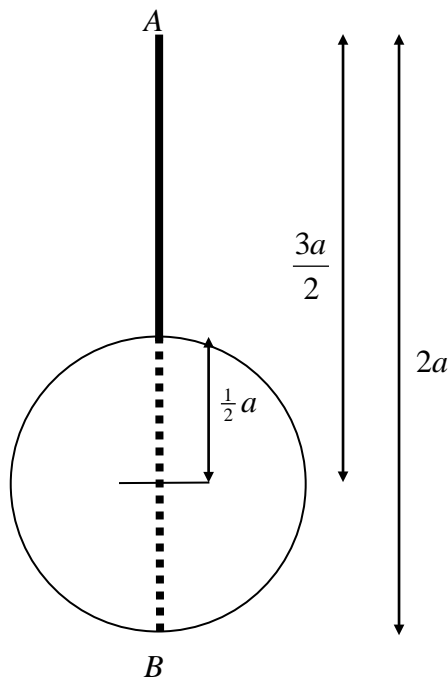
Find the mass of fuel ejected.

**(11 marks)**

6. (a) Show by integration that the moment of inertia of a uniform disc, of mass  $m$  and radius  $a$ , about an axis through the centre of disc and perpendicular to the plane of the disc is  $\frac{1}{2}ma^2$ .

**(3 marks)**

**Figure 1**



A uniform rod  $AB$  has mass  $3m$  and length  $2a$ . A uniform disc, of mass  $4m$  and radius  $\frac{1}{2}a$ , is attached to the rod with the centre of the disc lying on the rod a distance  $\frac{3}{2}a$  from  $A$ . The rod lies in the plane of the disc, as shown in Fig. 1. The disc and rod together form a pendulum which is free to rotate about a fixed smooth horizontal axis  $L$  which passes through  $A$  and is perpendicular to the plane of the pendulum.

- (b) Show that the moment of inertia of the pendulum about  $L$  is  $\frac{27}{2}ma^2$ . **(3 marks)**

The pendulum makes small oscillations about its position of stable equilibrium.

- (c) Show that the motion of the pendulum is approximately simple harmonic, and find the period of the oscillations. **(6 marks)**

7. A uniform sphere, of mass  $m$  and radius  $a$ , is free to rotate about a smooth fixed horizontal axis  $L$  which forms a tangent to the sphere. The sphere is hanging in equilibrium below the axis when it receives an impulse, causing it to rotate about  $L$  with an initial angular velocity of  $\sqrt{\frac{18g}{7a}}$ .

Show that, when the sphere has turned through an angle  $\theta$ ,

(a) the angular speed  $\omega$  of the sphere is given by  $\omega^2 = \frac{2g}{7a}(4 + 5 \cos \theta)$ , **(5 marks)**

(b) the angular acceleration of the sphere has magnitude  $\frac{5g}{7a} \sin \theta$ . **(2 marks)**

(c) Hence find the magnitude of the force exerted by the axis on the sphere when the sphere comes to instantaneous rest for the first time. **(10 marks)**

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**END**