Paper Reference(s)

6678

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Thursday 19 June 2003 – Morning

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 M2), the paper reference (6678), 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.

N13422A

1. A particle P moves on the x-axis. At time t seconds the velocity of P is v m s^{-1} in the direction of x increasing, where $v = 6t - 2t^2$. When $t = 0$, P is at the origin O. Find the distance of P from O when P comes to instantaneous rest after leaving O.

(5)

---

2. A tennis ball of mass 0.2 kg is moving with velocity $(-10\mathbf{i})$ m s^{-1} when it is struck by a tennis racket. Immediately after being struck, the ball has velocity $(15\mathbf{i} + 15\mathbf{j})$ m s^{-1}. Find

(*a*) the magnitude of the impulse exerted by the racket on the ball,

(4)

(*b*) the angle, to the nearest degree, between the vector **i** and the impulse exerted by the racket,

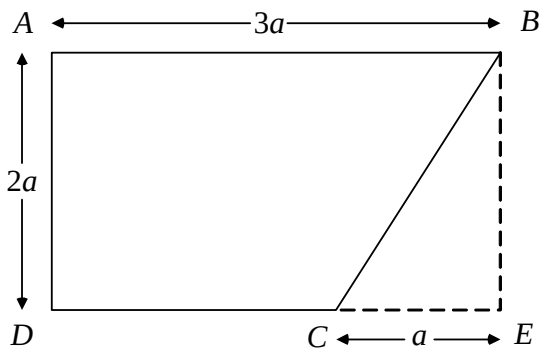
(2)

(*c*) the kinetic energy gained by the ball as a result of being struck.

(2)

---

3. **Figure 1**



A uniform lamina $ABCD$ is made by taking a uniform sheet of metal in the form of a rectangle $ABED$, with $AB = 3a$ and $AD = 2a$, and removing the triangle BCE, where C lies on DE and $CE = a$, as shown in Fig. 1.

(*a*) Find the distance of the centre of mass of the lamina from AD.

(5)

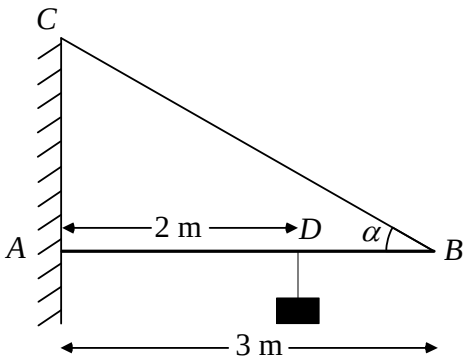
The lamina has mass M. A particle of mass m is attached to the lamina at B. When the loaded lamina is freely suspended from the mid-point of AB, it hangs in equilibrium with AB horizontal.

(*b*) Find m in terms of M.

(4)

---

4. **Figure 2**



A uniform steel girder *AB*, of mass 40 kg and length 3 m, is freely hinged at *A* to a vertical wall. The girder is supported in a horizontal position by a steel cable attached to the girder at *B*. The other end of the cable is attached to the point *C* vertically above *A* on the wall, with $\angle ABC = \alpha$, where $\tan\alpha = \frac{3}{4}$. A load of mass 60 kg is suspended by another cable from the girder at the point *D*, where $AD = 2$ m, as shown in Fig. 2. The girder remains horizontal and in equilibrium. The girder is modelled as a rod, and the cables as light inextensible strings.

(*a*) Show that the tension in the cable *BC* is 980 N.

(5)

(*b*) Find the magnitude of the reaction on the girder at *A*.

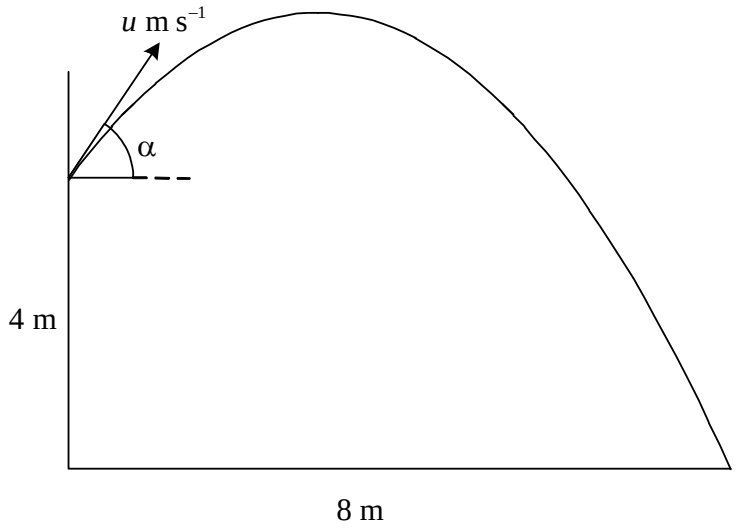
(6)

(*c*) Explain how you have used the modelling assumption that the cable at *D* is light.

(1)

---

5. **Figure 3**



A ball is thrown from a point 4 m above horizontal ground. The ball is projected at an angle α above the horizontal, where $\tan\alpha = \frac{3}{4}$. The ball hits the ground at a point which is a horizontal distance 8 m from its point of projection, as shown in Fig. 3. The initial speed of the ball is u m s^{-1} and the time of flight is T seconds.

(*a*) Prove that $uT = 10$.

(2)

(*b*) Find the value of u.

(5)

As the ball hits the ground, its direction of motion makes an angle ϕ with the horizontal.

(*c*) Find $\tan\phi$.

(5)

6. A girl and her bicycle have a combined mass of 64 kg. She cycles up a straight stretch of road which is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{14}$. She cycles at a constant speed of 5 m s^{-1}. When she is cycling at this speed, the resistance to motion from non-gravitational forces has magnitude 20 N.

(*a*) Find the rate at which the cyclist is working.

(4)

She now turns round and comes down the same road. Her initial speed is 5 m s^{-1}, and the resistance to motion is modelled as remaining constant with magnitude 20 N. She free-wheels down the road for a distance of 80 m. Using this model,

(*b*) find the speed of the cyclist when she has travelled a distance of 80 m.

(5)

The cyclist again moves down the same road, but this time she pedals down the road. The resistance is now modelled as having magnitude proportional to the speed of the cyclist. Her initial speed is again 5 m s^{-1} when the resistance to motion has magnitude 20 N.

(*c*) Find the magnitude of the resistance to motion when the speed of the cyclist is 8 m s^{-1}.

(1)

The cyclist works at a constant rate of 200 W.

(*d*) Find the magnitude of her acceleration when her speed is 8 m s^{-1}.

(4)

---

7. A uniform sphere *A* of mass *m* is moving with speed *u* on a smooth horizontal table when it collides directly with another uniform sphere *B* of mass 2*m* which is at rest on the table. The spheres are of equal radius and the coefficient of restitution between them is *e*. The direction of motion of *A* is unchanged by the collision.

(*a*) Find the speeds of *A* and *B* immediately after the collision.

(7)

(*b*) Find the range of possible values of *e*.

(2)

After being struck by *A*, the sphere *B* collides directly with another sphere *C*, of mass $4m$ and of the same size as *B*. The sphere *C* is at rest on the table immediately before being struck by *B*. The coefficient of restitution between *B* and *C* is also *e*.

(*c*) Show that, after *B* has struck *C*, there will be a further collision between *A* and *B*.

(6)

END