Paper Reference(s)

6678

Edexcel GCE

Mechanics M2
Advanced/Advanced Subsidiary

Wednesday 22 January 2003 – Afternoon
Time: 1 hour 30 minutes

Materials required for examination	Items included with question papers
Answer Book (AB16)	Nil
Mathematical Formulae (Lilac)	
Graph Paper (ASG2)	

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 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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1. Three particles of mass $3m$, $5m$ and λm are placed at points with coordinates (4, 0), (0, −3) and (4, 2) respectively. The centre of mass of the system of three particles is at $(2, k)$.

(*a*) Show that $\lambda = 2$.

(4)

(*b*) Calculate the value of k.

(3)

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2. A car of mass 1000 kg is moving along a straight horizontal road with a constant acceleration of f m s^{-2}. The resistance to motion is modelled as a constant force of magnitude 1200 N. When the car is travelling at 12 m s^{-1}, the power generated by the engine of the car is 24 kW.

(*a*) Calculate the value of f.

(4)

When the car is travelling at 14 m s^{-1}, the engine is switched off and the car comes to rest, without braking, in a distance of d metres. Assuming the same model for resistance,

(*b*) use the work-energy principle to calculate the value of d.

(3)

(*c*) Give a reason why the model used for the resistance to motion may not be realistic.

(1)

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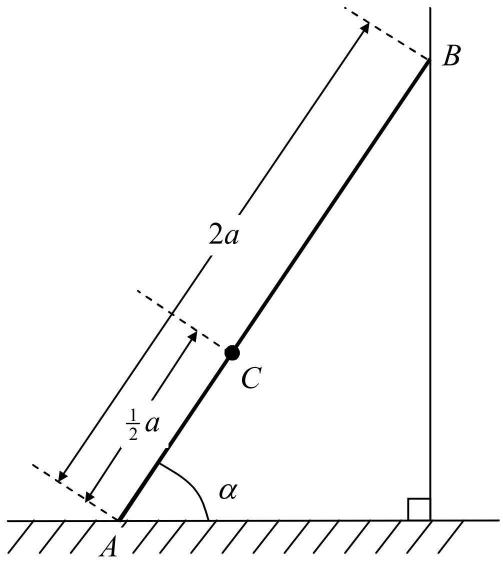
3. **Figure 1**



A uniform ladder AB, of mass m and length $2a$, has one end A on rough horizontal ground. The other end B rests against a smooth vertical wall. The ladder is in a vertical plane perpendicular to the wall. The ladder makes an angle α with the horizontal, where $\tan \alpha = \frac{4}{3}$. A child of mass $2m$ stands on the ladder at C where $AC = \frac{1}{2}a$, as shown in Fig. 1. The ladder and the child are in equilibrium.

By modelling the ladder as a rod and the child as a particle, calculate the least possible value of the coefficient of friction between the ladder and the ground.

(9)

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4. **Figure 2**

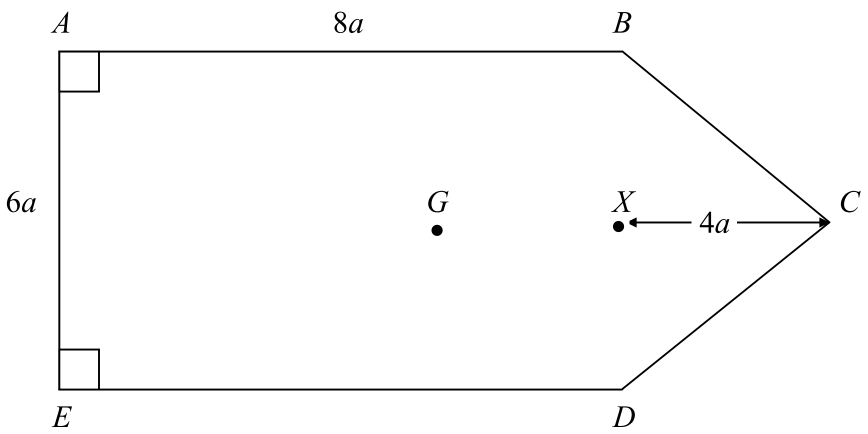

Figure 2 shows a uniform lamina $ABCDE$ such that $ABDE$ is a rectangle, $BC = CD$, $AB = 8a$ and $AE = 6a$. The point X is the mid-point of BD and $XC = 4a$. The centre of mass of the lamina is at G.

(a) Show that $GX = \frac{44}{15}a$.

(6)

The mass of the lamina is M. A particle of mass λM is attached to the lamina at C. The lamina is suspended from B and hangs freely under gravity with AB horizontal.

(b) Find the value of λ.

(3)

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5. A particle P moves on the x-axis. The acceleration of P at time t seconds is $(4t - 8)$ m s^{-2}, measured in the direction of x increasing. The velocity of P at time t seconds is v m s^{-1}. Given that $v = 6$ when $t = 0$, find

(a) v in terms of t,

(4)

(b) the distance between the two points where P is instantaneously at rest.

(7)

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6. A smooth sphere P of mass $2m$ is moving in a straight line with speed u on a smooth horizontal table. Another smooth sphere Q of mass m is at rest on the table. The sphere P collides directly with Q. The coefficient of restitution between P and Q is $\frac{1}{3}$. The spheres are modelled as particles.

(*a*) Show that, immediately after the collision, the speeds of P and Q are $\frac{5}{9}u$ and $\frac{8}{9}u$ respectively.

(7)

After the collision, Q strikes a fixed vertical wall which is perpendicular to the direction of motion of P and Q. The coefficient of restitution between Q and the wall is e. When P and Q collide again, P is brought to rest.

(*b*) Find the value of e.

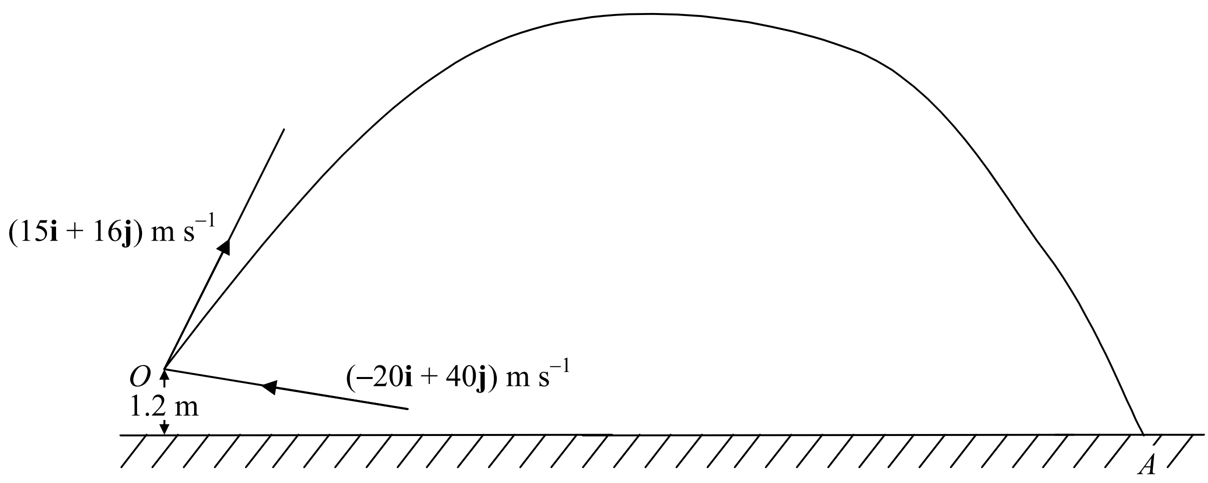
(7)

(*c*) Explain why there must be a third collision between P and Q.

(1)

TURN OVER FOR QUESTION 7

7. **Figure 3**



A ball *B* of mass 0.4 kg is struck by a bat at a point *O* which is 1.2 m above horizontal ground. The unit vectors **i** and **j** are respectively horizontal and vertical. Immediately before being struck, *B* has velocity (−20**i** + 4**j**) m s^{-1}. Immediately after being struck it has velocity (15**i** + 16**j**) m s^{-1}.

After *B* has been struck, it moves freely under gravity and strikes the ground at the point *A*, as shown in Fig. 3. The ball is modelled as a particle.

(*a*) Calculate the magnitude of the impulse exerted by the bat on *B*.

(4)

(*b*) By using the principle of conservation of energy, or otherwise, find the speed of *B* when it reaches *A*.

(6)

(*c*) Calculate the angle which the velocity of *B* makes with the ground when *B* reaches *A*.

(4)

(*d*) State two additional physical factors which could be taken into account in a refinement of the model of the situation which would make it more realistic.

(2)

END