Paper Reference(s)
6678/01

Edexcel GCE

Mechanics M2

Advanced /Advanced Subsidiary

Thursday 12 January 2006 – Afternoon

Time: 1 hour 30 minutes

Materials required for examination	Items included with question papers
Mathematical Formulae (Green or Lilac)	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.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 7 questions on this paper. The total mark for this paper is 75.

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.

1. A brick of mass 3 kg slides in a straight line on a horizontal floor. The brick is modelled as a particle and the floor as a rough plane. The initial speed of the brick is 8 m s^{-1}. The brick is brought to rest after moving 12 m by the constant frictional force between the brick and the floor.

(*a*) Calculate the kinetic energy lost by the brick in coming to rest, stating the units of your answer.

(2)

(*b*) Calculate the coefficient of friction between the brick and the floor.

(4)

---

2. A particle *P* of mass 0.4 kg is moving so that its position vector **r** metres at time *t* seconds is given by

$$\mathbf{r} = (t^2 + 4t)\mathbf{i} + (3t - t^3)\mathbf{j}.$$

(*a*) Calculate the speed of *P* when $t = 3$.

(5)

When $t = 3$, the particle *P* is given an impulse $(8\mathbf{i} - 12\mathbf{j})$ N s.

(*b*) Find the velocity of *P* immediately after the impulse.

(3)

---

3. A car of mass 1000 kg is moving along a straight horizontal road. The resistance to motion is modelled as a constant force of magnitude *R* newtons. The engine of the car is working at a rate of 12 kW. When the car is moving with speed 15 m s^{-1}, the acceleration of the car is 0.2 m s^{-2}.

(*a*) Show that $R = 600$.

(4)

The car now moves with constant speed *U* m s^{-1} downhill on a straight road inclined at θ to the horizontal, where $\sin\theta = \frac{1}{40}$. The engine of the car is now working at a rate of 7 kW. The resistance to motion from non-gravitational forces remains of magnitude *R* newtons.

(*c*) Calculate the value of *U*.

(5)

---

4. A particle A of mass $2m$ is moving with speed $3u$ in a straight line on a smooth horizontal table. The particle collides directly with a particle B of mass m moving with speed $2u$ in the opposite direction to A. Immediately after the collision the speed of B is $\frac{8}{3}u$ and the direction of motion of B is reversed.

(a) Calculate the coefficient of restitution between A and B.

(6)

(b) Show that the kinetic energy lost in the collision is $7mu^2$.

(3)

After the collision B strikes a fixed vertical wall that is perpendicular to the direction of motion of B. The magnitude of the impulse of the wall on B is $\frac{14}{3}mu$.

(c) Calculate the coefficient of restitution between B and the wall.

(4)

5. **Figure 1**

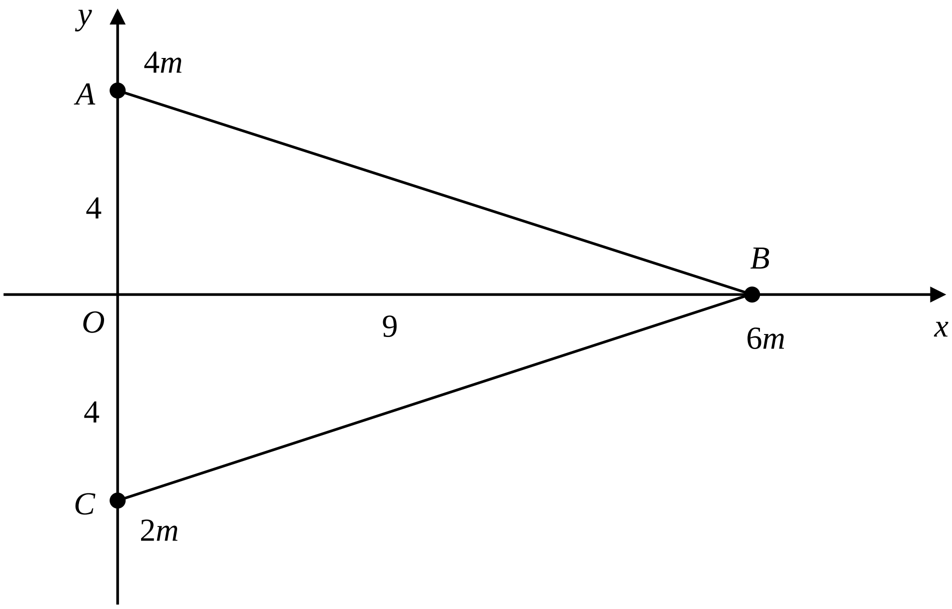


Figure 1 shows a triangular lamina *ABC*. The coordinates of *A*, *B* and *C* are (0, 4), (9, 0) and (0, –4) respectively. Particles of mass 4*m*, 6*m* and 2*m* are attached at *A*, *B* and *C* respectively.

(*a*) Calculate the coordinates of the centre of mass of the three particles, *without the lamina*.
(4)

The lamina *ABC* is uniform and of mass *km*. The centre of mass of the combined system consisting of the three particles and the lamina has coordinates (4, λ).

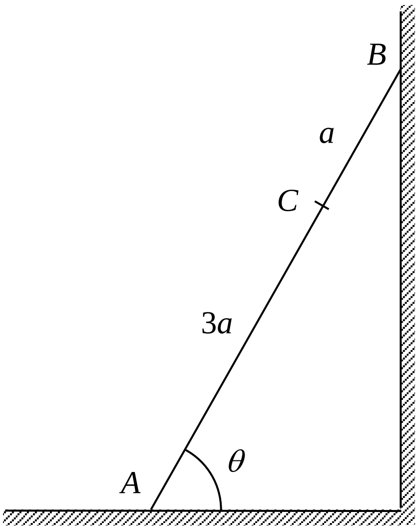
(*b*) Show that $k = 6$.
(3)

(*c*) Calculate the value of λ.
(2)

The combined system is freely suspended from *O* and hangs at rest.

(*c*) Calculate, in degrees to one decimal place, the angle between *AC* and the vertical.
(3)

6. **Figure 2**



A ladder AB, of weight W and length $4a$, has one end A on rough horizontal ground. The coefficient of friction between the ladder and the ground is μ. The other end B rests against a smooth vertical wall. The ladder makes an angle θ with the horizontal, where $\tan\theta = 2$. A load of weight $4W$ is placed at the point C on the ladder, where $AC = 3a$, as shown in Figure 2. The ladder is modelled as a uniform rod which is in a vertical plane perpendicular to the wall. The load is modelled as a particle. Given that the system is in limiting equilibrium,

(*a*) show that $\mu = 0.35$.

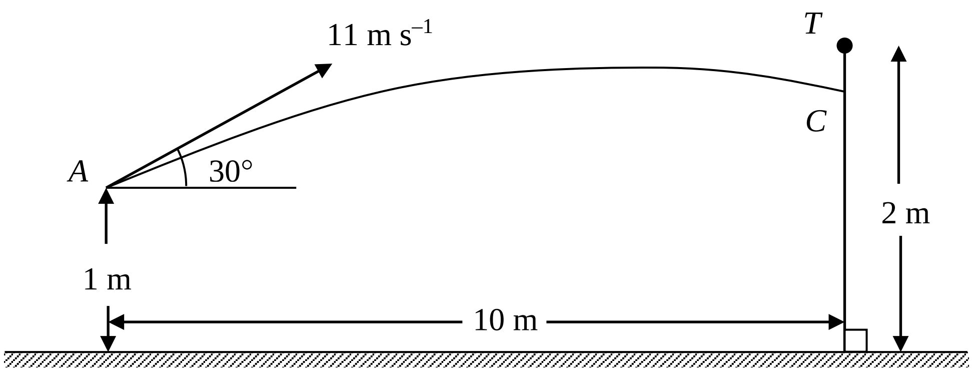
(6)

A second load of weight kW is now placed on the ladder at A. The load of weight $4W$ is removed from C and placed on the ladder at B. The ladder is modelled as a uniform rod which is in a vertical plane perpendicular to the wall. The loads are modelled as particles. Given that the ladder and the loads are in equilibrium,

(*b*) find the range of possible values of k.

(7)

7. **Figure 3**



The object of a game is to throw a ball *B* from a point *A* to hit a target *T* which is placed at the top of a vertical pole, as shown in Figure 3. The point *A* is 1 m above horizontal ground and the height of the pole is 2 m. The pole is at a horizontal distance of 10 m from *A*. The ball *B* is projected from *A* with a speed of 11 m s^{-1} at an angle of elevation of 30°. The ball hits the pole at the point *C*. The ball *B* and the target *T* are modelled as particles.

(*a*) Calculate, to 2 decimal places, the time taken for *B* to move from *A* to *C*.

(3)

(*b*) Show that *C* is approximately 0.63 m below *T*.

(4)

The ball is thrown again from *A*. The speed of projection of *B* is increased to *V* m s^{-1}, the angle of elevation remaining 30°. This time *B* hits *T*.

(*c*) Calculate the value of *V*.

(6)

(*d*) Explain why, in practice, a range of values of *V* would result in *B* hitting the target.

(1)

TOTAL FOR PAPER: 75 MARKS

END