Paper Reference(s)

6678/01

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Friday 24 June 2005 – Morning

Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Lilac or Green)	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 7 questions.
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.

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1. A car of mass 1200 kg moves along a straight horizontal road. The resistance to motion of the car from non-gravitational forces is of constant magnitude 600 N. The car moves with constant speed and the engine of the car is working at a rate of 21 kW.

(*a*) Find the speed of the car.

(3)

The car moves up a hill inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{14}$.

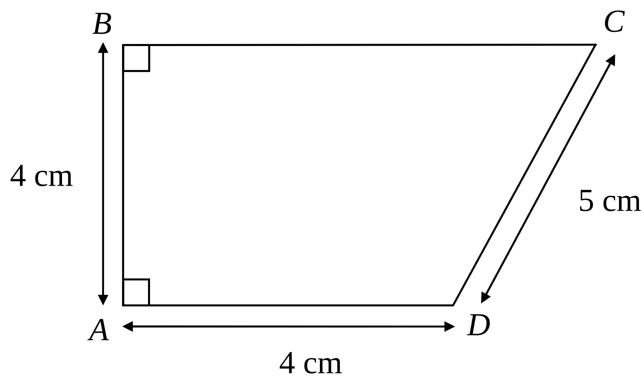
The car's engine continues to work at 21 kW and the resistance to motion from non-gravitational forces remains of magnitude 600 N.

(*b*) Find the constant speed at which the car can move up the hill.

(4)

2.

Figure 1



A thin uniform wire, of total length 20 cm, is bent to form a frame. The frame is in the shape of a trapezium *ABCD*, where *AB* = *AD* = 4 cm, *CD* = 5 cm and *AB* is perpendicular to *BC* and *AD*, as shown in Figure 1.

(*a*) Find the distance of the centre of mass of the frame from *AB*.

(5)

The frame has mass *M*. A particle of mass *kM* is attached to the frame at *C*. When the frame is freely suspended from the mid-point of *BC*, the frame hangs in equilibrium with *BC* horizontal.

(*b*) Find the value of *k*.

(3)

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3. A particle P moves in a horizontal plane. At time t seconds, the position vector of P is $\mathbf{r}$ metres relative to a fixed origin O, and $\mathbf{r}$ is given by

$$\mathbf{r} = (18t - 4t^3)\mathbf{i} + ct^2\mathbf{j},$$

where c is a positive constant. When $t = 1.5$, the speed of P is 15 m s^{-1}. Find

(a) the value of c,

(6)

(b) the acceleration of P when $t = 1.5$.

(3)

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4. A darts player throws darts at a dart board which hangs vertically. The motion of a dart is modelled as that of a particle moving freely under gravity. The darts move in a vertical plane which is perpendicular to the plane of the dart board. A dart is thrown horizontally with speed 12.6 m s^{-1}. It hits the board at a point which is 10 cm below the level from which it was thrown.

(a) Find the horizontal distance from the point where the dart was thrown to the dart board.

(4)

The darts player moves his position. He now throws a dart from a point which is at a horizontal distance of 2.5 m from the board. He throws the dart at an angle of elevation α to the horizontal, where $\tan \alpha = \frac{7}{24}$. This dart hits the board at a point which is at the same level as the point from which it was thrown.

(b) Find the speed with which the dart is thrown.

(6)

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5. Two small spheres A and B have mass $3m$ and $2m$ respectively. They are moving towards each other in opposite directions on a smooth horizontal plane, both with speed $2u$, when they collide directly. As a result of the collision, the direction of motion of B is reversed and its speed is unchanged.

(a) Find the coefficient of restitution between the spheres.

(7)

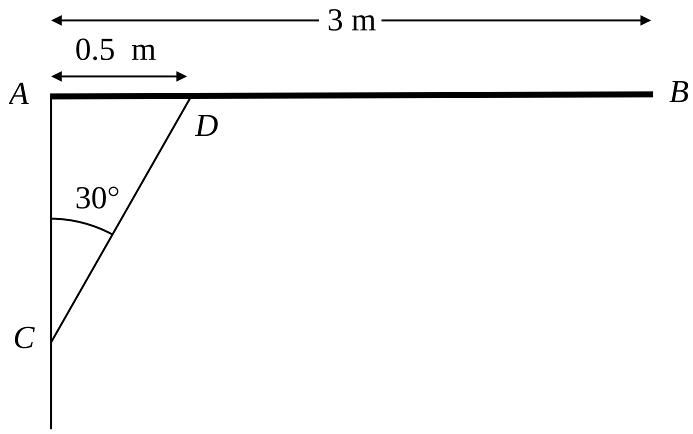
Subsequently, B collides directly with another small sphere C of mass $5m$ which is at rest. The coefficient of restitution between B and C is $\frac{3}{5}$.

(b) Show that, after B collides with C, there will be no further collisions between the spheres.

(7)

6.

Figure 2



A uniform pole AB, of mass 30 kg and length 3 m, is smoothly hinged to a vertical wall at one end A. The pole is held in equilibrium in a horizontal position by a light rod CD. One end C of the rod is fixed to the wall vertically below A. The other end D is freely jointed to the pole so that $\angle ACD = 30°$ and $AD = 0.5$ m, as shown in Figure 2. Find

(*a*) the thrust in the rod CD,

(4)

(*b*) the magnitude of the force exerted by the wall on the pole at A.

(6)

The rod CD is removed and replaced by a longer light rod CM, where M is the mid-point of AB. The rod is freely jointed to the pole at M. The pole AB remains in equilibrium in a horizontal position.

(*c*) Show that the force exerted by the wall on the pole at A now acts horizontally.

(2)

7. At a demolition site, bricks slide down a straight chute into a container. The chute is rough and is inclined at an angle of 30° to the horizontal. The distance travelled down the chute by each brick is 8 m. A brick of mass 3 kg is released from rest at the top of the chute. When it reaches the bottom of the chute, its speed is 5 m s^{-1}.

(*a*) Find the potential energy lost by the brick in moving down the chute.

(2)

(*b*) By using the work-energy principle, or otherwise, find the constant frictional force acting on the brick as it moves down the chute.

(5)

(*c*) Hence find the coefficient of friction between the brick and the chute.

(3)

Another brick of mass 3 kg slides down the chute. This brick is given an initial speed of 2 m s^{-1} at the top of the chute.

(*d*) Find the speed of this brick when it reaches the bottom of the chute.

(5)

TOTAL FOR PAPER: 75 MARKS

END