

**ADVANCED GCE UNIT
MATHEMATICS**

Mechanics 2

TUESDAY 16 JANUARY 2007

4729/01

Morning

Time: 1 hour 30 minutes

Additional Materials: Answer Booklet (8 pages)
List of Formulae (MF1)

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

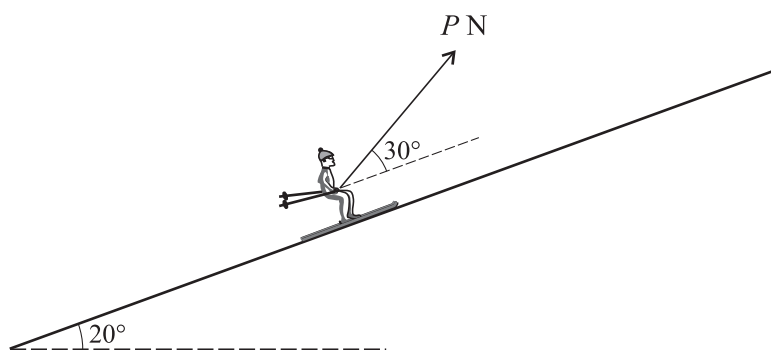
- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is 72.

ADVICE TO CANDIDATES

- Read each question carefully and make sure you know what you have to do before starting your answer.
- **You are reminded of the need for clear presentation in your answers.**

This document consists of **4** printed pages.

- 1 A uniform solid cylinder has height 20 cm and diameter 12 cm. It is placed with its axis vertical on a rough horizontal plane. The plane is slowly tilted until the cylinder topples when the angle of inclination is α . Find α . [3]
- 2 Two smooth spheres A and B , of equal radius and of masses 0.2 kg and 0.1 kg respectively, are free to move on a smooth horizontal table. A is moving with speed 4 m s^{-1} when it collides directly with B , which is stationary. The collision is perfectly elastic. Calculate the speed of A after the impact. [4]
- 3 A small sphere of mass 0.2 kg is projected vertically downwards with speed 21 m s^{-1} from a point at a height of 40 m above horizontal ground. It hits the ground and rebounds vertically upwards, coming to instantaneous rest at its initial point of projection. Ignoring air resistance, calculate
- (i) the coefficient of restitution between the sphere and the ground, [6]
- (ii) the magnitude of the impulse which the ground exerts on the sphere. [2]
- 4 A skier of mass 80 kg is pulled up a slope which makes an angle of 20° with the horizontal. The skier is subject to a constant frictional force of magnitude 70 N. The speed of the skier increases from 2 m s^{-1} at the point A to 5 m s^{-1} at the point B , and the distance AB is 25 m.
- (i) By modelling the skier as a small object, calculate the work done by the pulling force as the skier moves from A to B . [5]
- (ii)



It is given that the pulling force has constant magnitude $P \text{ N}$, and that it acts at a constant angle of 30° above the slope (see diagram). Calculate P . [3]

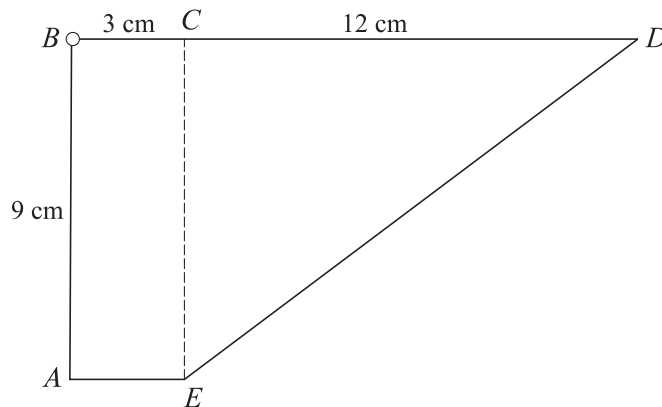
- 5 A model train has mass 100 kg. When the train is moving with speed $v \text{ m s}^{-1}$ the resistance to its motion is $3v^2 \text{ N}$ and the power output of the train is $\frac{3000}{v} \text{ W}$.

- (i) Show that the driving force acting on the train is 120 N at an instant when the train is moving with speed 5 m s^{-1} . [2]
- (ii) Find the acceleration of the train at an instant when it is moving horizontally with speed 5 m s^{-1} . [2]

The train moves with constant speed up a straight hill inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{98}$.

- (iii) Calculate the speed of the train. [5]

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A uniform lamina $ABCDE$ of weight 30 N consists of a rectangle and a right-angled triangle. The dimensions are as shown in the diagram.

- (i) Taking x - and y -axes along AE and AB respectively, find the coordinates of the centre of mass of the lamina. [8]

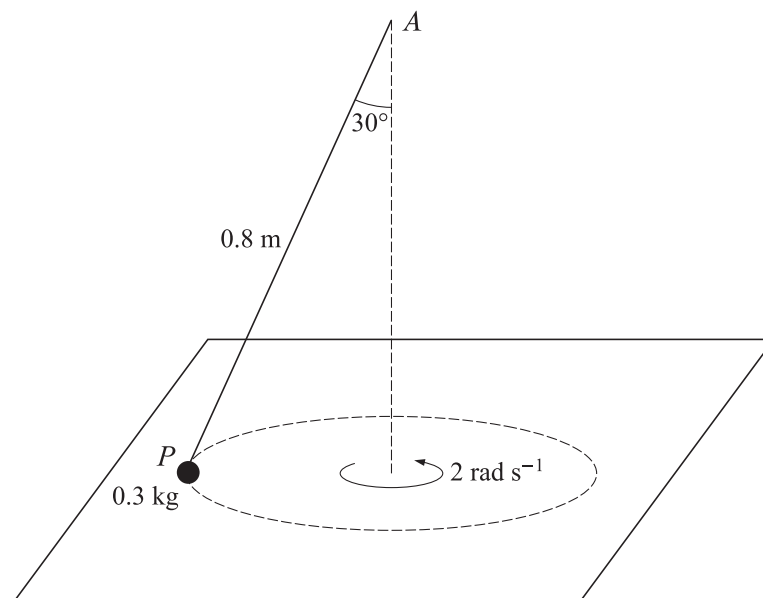
The lamina is freely suspended from a hinge at B .

- (ii) Calculate the angle that AB makes with the vertical. [2]

The lamina is now held in a position such that BD is horizontal. This is achieved by means of a string attached to D and to a fixed point 15 cm directly above the hinge at B .

- (iii) Calculate the tension in the string. [3]

[Questions 7 and 8 are printed overleaf.]



One end of a light inextensible string of length 0.8 m is attached to a fixed point A which lies above a smooth horizontal table. The other end of the string is attached to a particle P , of mass 0.3 kg, which moves in a horizontal circle on the table with constant angular speed 2 rad s^{-1} . AP makes an angle of 30° with the vertical (see diagram).

(i) Calculate the tension in the string. [4]

(ii) Calculate the normal contact force between the particle and the table. [3]

The particle now moves with constant speed $v \text{ m s}^{-1}$ and is on the point of leaving the surface of the table.

(iii) Calculate v . [6]

8 A missile is projected with initial speed 42 m s^{-1} at an angle of 30° above the horizontal. Ignoring air resistance, calculate

(i) the maximum height of the missile above the level of the point of projection, [3]

(ii) the distance of the missile from the point of projection at the instant when it is moving **downwards** at an angle of 10° to the horizontal. [11]