

980/01

MATHEMATICS M1

Mechanics 1

A.M. MONDAY, 16 January 2006

(1½ hours)

NEW SPECIFICATION

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a 12 page answer book;
- a Formula Booklet;
- a calculator.

INSTRUCTIONS TO CANDIDATES

Answer **all** questions.

Take g as 9.8 ms^{-2} .

INFORMATION FOR CANDIDATES

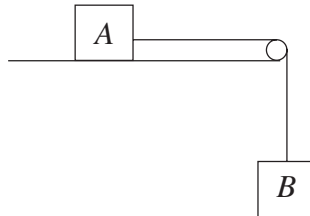
Graphical calculators may be used for this paper.

The number of marks is given in brackets at the end of each question or part-question.

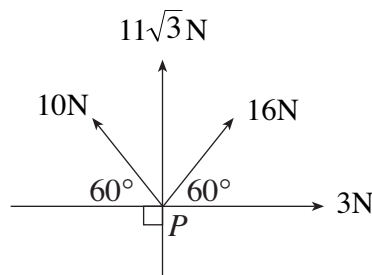
You are reminded of the necessity for good English and orderly presentation in your answers.

1. A small object, of mass 0.02 kg at the top of a building 160 m high, is dropped from rest.
- (a) Ignoring air resistance, calculate
- (i) the speed of the object as it hits the ground,
 - (ii) the time taken for the object to reach the ground. [6]
- (b) Assuming that the air resistance has magnitude 0.096 N , calculate
- (i) the magnitude of the acceleration of the object,
 - (ii) the height of the object above the ground 4 s after it was dropped. [6]
2. Two spheres A and B , of equal radii, lie at rest on a smooth horizontal table. Sphere A has mass $2m\text{ kg}$ and sphere B has mass $16m\text{ kg}$. Sphere A is projected with speed 3 ms^{-1} towards sphere B and collides directly with it. The coefficient of restitution between A and B is $\frac{1}{2}$.
- (a) Find the speeds of A and B after the collision. [7]
- (b) Determine the magnitude and direction of the impulse exerted by B on A , stating your units. [4]
3. At time $t = 0$, Car A , which is travelling at a constant speed of 20 ms^{-1} on a straight horizontal road, overtakes Car B travelling at a speed of 15 ms^{-1} . Car B immediately accelerates uniformly and, T seconds later, it overtakes Car A , which has kept its speed at 20 ms^{-1} . The distance travelled by each car in time T is 600 m .
- (a) Show that $T = 30$. [1]
- (b) Calculate the magnitude of the acceleration of car B . [3]
- (c) Find the speed of car B at the moment it overtakes car A . [3]
- (d) On the same diagram, draw velocity-time graphs for A and B . Find the time when the speeds of cars A and B are equal. [4]

4. The diagram shows a body A , of mass 9 kg, connected by a light inextensible string passing over a smooth light pulley to a body B , of mass 5 kg. Body A is on a rough horizontal table and body B is hanging freely. The coefficient of friction between the body A and the table is μ .



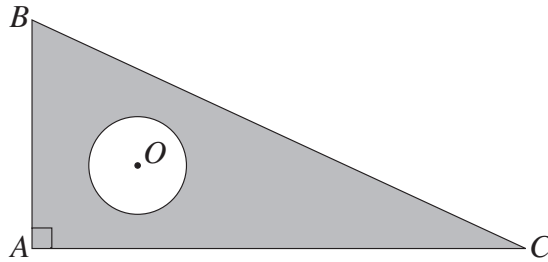
- (a) If the system is in equilibrium, show that $\mu \geq \frac{5}{9}$. [5]
- (b) If $\mu = 0.5$,
- show that the magnitude of the acceleration of the body A is 0.35 ms^{-2} ,
 - calculate the tension in the string. [8]
5. A **non-uniform** rod AB , of mass 7.5 kg and length 8 m, rests horizontally in equilibrium on two smooth supports at C and D , where $AC = 1.5 \text{ m}$ and $AD = 5.0 \text{ m}$. The reaction of the support at D on the rod is 56.7 N.
- Calculate the distance of the centre of gravity of the rod from C . [4]
 - Determine the reaction of the support at C on the rod. [2]
6. Four coplanar forces of magnitudes 10 N, $11\sqrt{3}$ N, 16 N and 3 N act at the point P in the directions as shown in the diagram.



Resolve the forces in two perpendicular directions and deduce the magnitude and direction of the resultant force. [10]

TURN OVER.

7. A uniform lamina consists of a right-angled triangle ABC with a circular hole, of radius 1.5 cm, cut out of it. Lengths $AB = 7$ cm, $AC = 10$ cm and the centre O of the circular hole is 2.5 cm from AB and 2.5 cm from AC .



- (a) Find, correct to two decimal places, the distance of the centre of mass of the lamina from
- AB ,
 - AC .
- [10]
- (b) The lamina is freely suspended from A and hangs in equilibrium. Calculate the angle AC makes with the vertical.
- [2]