

980/01

**MATHEMATICS M1**

**Mechanics 1**

P.M. TUESDAY, 7 June 2005

(1  $\frac{1}{2}$  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  $9.8 \text{ ms}^{-2}$ .

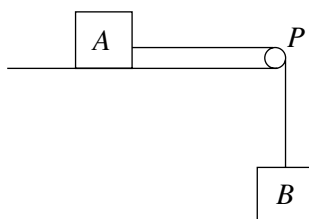
**INFORMATION FOR CANDIDATES**

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.

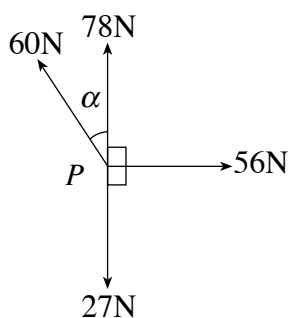
You are reminded of the necessity for good English and orderly presentation in your answers.

1. A ball, moving with speed  $2 \text{ ms}^{-1}$  on a smooth horizontal surface collides directly with another ball which is stationary. The masses of the balls are equal and the coefficient of restitution between the balls is  $0.6$ . Calculate the speed of each ball after collision. [6]
  
2. A train, travelling along a straight horizontal track, has a steady speed of  $18 \text{ ms}^{-1}$  as it passes the point  $A$ . Fifteen seconds later, it begins to slow down at a uniform rate for  $30 \text{ s}$  until its speed is  $10 \text{ ms}^{-1}$ . The train then increases its speed uniformly for  $45 \text{ s}$  until it reaches a speed of  $20 \text{ ms}^{-1}$  as it passes the point  $B$ .
  - (a) Draw a sketch of the  $v$ - $t$  graph for the motion of the train between  $A$  and  $B$ . [4]
  - (b) Calculate the acceleration of the train just before it reaches  $B$ . [2]
  - (c) Find the distance from  $A$  to  $B$ . [4]
  
3. When a lift is descending with acceleration  $a \text{ ms}^{-2}$ , the tension in the lift cable is  $11\,625 \text{ N}$ . The total mass of the lift and its contents is  $1250 \text{ kg}$ .
  - (a) Find the value of  $a$ . [3]
  - (b) A crate on the floor of the lift has a mass of  $200 \text{ kg}$ . Find the magnitude of the reaction of the floor on the crate. [2]
  
4. The diagram shows a block  $A$ , of mass  $3 \text{ kg}$ , lying on a smooth horizontal table. It is connected to an object  $B$ , of mass  $5 \text{ kg}$ , by a light inextensible string, which passes over a smooth light pulley  $P$  fixed at the edge of the table so that  $B$  hangs freely.



Initially the system is held at rest with the string taut. A horizontal force of magnitude  $75 \text{ N}$  is then applied to  $A$  in the direction  $PA$  so that  $B$  is raised. Find the magnitude of the acceleration of  $A$  and the tension in the string. [7]

5. A ball of mass  $0.7 \text{ kg}$  is thrown vertically **downwards** with an initial speed of  $u \text{ ms}^{-1}$  from a point  $0.4 \text{ m}$  vertically above the horizontal ground. It hits the ground with a speed of  $10 \text{ ms}^{-1}$  and rebounds with a speed of  $3.5 \text{ ms}^{-1}$ .
- Calculate the value of  $u$ . [3]
  - Find the coefficient of restitution between the ball and the ground. [1]
  - Determine the magnitude and direction of the impulse exerted by the ground on the ball. [3]
  - Find the speed and direction of motion of the ball  $0.5 \text{ s}$  after it first rebounded from the ground. [3]
  - Find the time between the first and second bounce of the ball. [3]
6. A box, of mass  $12.5 \text{ kg}$ , is being pulled up a rough slope inclined at an angle of  $20^\circ$  to the horizontal by a rope which is parallel to a line of greatest slope. The tension in the rope is  $95 \text{ N}$ . The coefficient of friction between the box and the slope is  $0.4$ . Modelling the box as a particle,
- calculate the frictional force on the box, [3]
  - find the magnitude of the acceleration of the box. [4]
7. Four horizontal coplanar forces have magnitudes  $78 \text{ N}$ ,  $56 \text{ N}$ ,  $27 \text{ N}$ ,  $60 \text{ N}$  and act at the point  $P$  in the directions shown on the diagram, where  $\tan \alpha = \frac{3}{4}$ .



Find the magnitude and direction of the resultant.

[8]

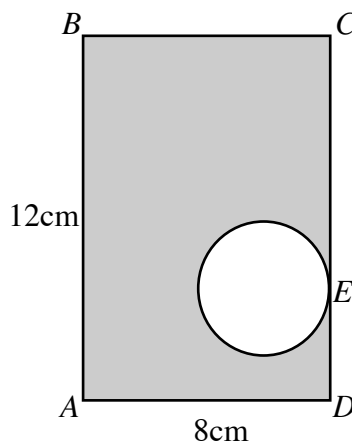
**TURN OVER.**

8. The diagram shows a uniform rod  $AB$ , with three particles attached to the rod at  $A$ ,  $B$  and  $D$ , resting horizontally in equilibrium on a smooth support at  $C$ , the mid-point of  $AB$ .



The length of  $AB$  is 1.8 m and its mass is 1.5 kg. The masses of the particles at  $A$ ,  $D$  and  $B$  are 0.8 kg, 0.5 kg and 0.4 kg respectively.

- (a) Find the magnitude of the reaction of the support at  $C$ . [2]
- (b) Calculate the distance  $CD$ . [4]
9. The diagram shows a uniform lamina formed by removing a circular section, of radius 2 cm, from a metal rectangular plate  $ABCD$ , where  $AB = 12$  cm and  $AD = 8$  cm. The circle touches the side  $CD$  at  $E$ , where  $DE = 3$  cm.



- (a) Find the distances of the centre of mass of the lamina from  $AB$  and  $AD$ , giving your answers correct to one decimal place. [9]
- (b) The lamina is suspended freely from the point  $D$  and hangs in equilibrium. Calculate the angle  $DC$  makes with the vertical. [3]
- (c) When the lamina is freely suspended from a point  $P$  on  $BC$ , it hangs in equilibrium with  $BA$  vertical. Write down the distance of  $P$  from  $B$ . [1]