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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 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 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 ms^{-1} as it passes the point *A*. Fifteen seconds later, it begins to slow down at a uniform rate for 30 s until its speed is 10 ms^{-1}. The train then increases its speed uniformly for 45 s until it reaches a speed of 20 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]

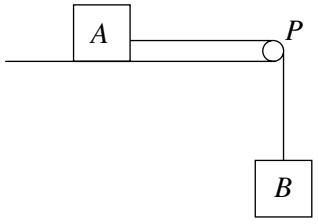
(c) Find the distance from *A* to *B*. [4]

3. When a lift is descending with acceleration a ms^{-2}, the tension in the lift cable is 11 625 N. The total mass of the lift and its contents is 1250 kg.

(a) Find the value of a. [3]

(b) A crate on the floor of the lift has a mass of 200 kg. Find the magnitude of the reaction of the floor on the crate. [2]

4. The diagram shows a block *A*, of mass 3 kg, lying on a smooth horizontal table. It is connected to an object *B*, of mass 5 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 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 kg is thrown vertically **downwards** with an initial speed of u ms^{-1} from a point 0·4 m vertically above the horizontal ground. It hits the ground with a speed of 10 ms^{-1} and rebounds with a speed of 3·5 ms^{-1}.

(a) Calculate the value of u. [3]

(b) Find the coefficient of restitution between the ball and the ground. [1]

(c) Determine the magnitude and direction of the impulse exerted by the ground on the ball. [3]

(d) Find the speed and direction of motion of the ball 0·5 s after it first rebounded from the ground. [3]

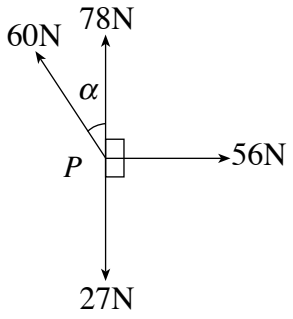
(e) Find the time between the first and second bounce of the ball. [3]

6. A box, of mass 12·5 kg, is being pulled up a rough slope inclined at an angle of 20° to the horizontal by a rope which is parallel to a line of greatest slope. The tension in the rope is 95 N. The coefficient of friction between the box and the slope is 0·4.
Modelling the box as a particle,

(a) calculate the frictional force on the box, [3]

(b) find the magnitude of the acceleration of the box. [4]

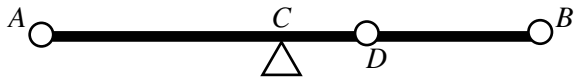
7. Four horizontal coplanar forces have magnitudes 78 N, 56 N, 27 N, 60 N and act at the point P in the directions shown on the diagram, where $\tan\alpha = \frac{3}{4}$.



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.

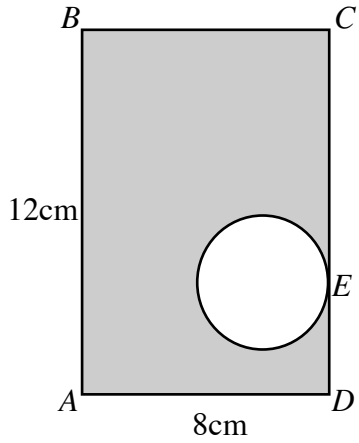


The length of AB is 1·8 m and its mass is 1·5 kg. The masses of the particles at A, D and B are 0·8 kg, 0·5 kg and 0·4 kg respectively.

(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]