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MATHEMATICS M1

Mechanics 1

A.M. FRIDAY, 14 January 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

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 uniform rod AB, of mass 4·5 kg, has length 1·6 m. A particle of mass M kg is attached to end A and a particle of mass 3 kg is attached to the end B. The diagram shows the rod resting horizontally in equilibrium on a smooth support at the point C, where $AC = 0{\cdot}5$ m.

Calculate the value of M and the reaction of the support at C. [6]

2. A train travels on a straight horizontal track. Initially, it is at rest at signal A, which is red. The signal changes to green and the train accelerates at a constant rate for 60 s until it reaches a speed of 45 ms^{-1}. It travels at this constant speed for 16 **minutes** before decelerating at a constant rate of 0·25 ms^{-2} to stop at its destination B.

(a) Calculate

(i) the magnitude of the acceleration of the train,
(ii) the length of time for which the train is decelerating. [3]

(b) Draw a v-t graph for the motion of the train. [4]

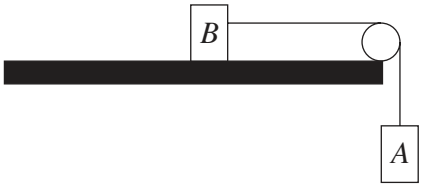
(c) Find the distance between signal A and destination B. [3]

3. A child, of mass 30 kg, is standing in a lift, which is of mass 720 kg. When the lift is accelerating upwards at a constant rate of a ms^{-2}, the tension in the lift cable is 9000 N.

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

(b) Modelling the child as a particle, find the reaction between the child and the floor of the lift. [3]

4. The diagram shows two bodies A and B, of mass 6 kg and 2 kg respectively, connected by a light inextensible string passing over a smooth light pulley fixed at the edge of a **rough** horizontal table. Body A hangs freely below the pulley, and body B is on the table.



Initially, A is supported so that the system is at rest with the string taut. When A is released, it descends with uniform acceleration a ms^{-2}, and a frictional force of magnitude 13·2 N acts upon B. Calculate the value of a and the tension in the string. [7]

5. A ball is thrown vertically **downwards** with initial speed $3{\cdot}2\,\text{ms}^{-1}$ from a point A which is $8{\cdot}1$ m above the horizontal ground. The coefficient of restitution between the ball and the ground is $\frac{1}{4}$.

(a) Show that the speed of the ball immediately after it first rebounds from the ground is $3{\cdot}25\,\text{ms}^{-1}$. [5]

(b) Find the time that elapses between the first bounce and the instant when the ball is next $0{\cdot}4$ m above the ground. [4]

6. An object of mass 80 kg is on a rough ramp inclined at an angle of 30° to the horizontal. The coefficient of friction between the ramp and the object is denoted by μ. Initially, the object is held at rest. It is then released.

(a) Given that $\mu = 0{\cdot}4$, find the magnitude of the acceleration of the object as it slides down the ramp. Give your answer correct to two decimal places. [6]

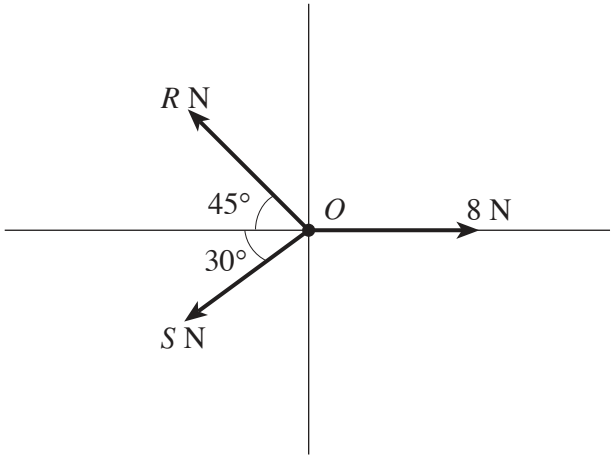
(b) Given that $\mu = 0{\cdot}6$, describe what happens next when the object is released. Give a reason for your answer. [3]

7. A sphere A, of mass 3 kg moving with speed $6\,\text{ms}^{-1}$, collides directly with another sphere B of mass 5 kg moving in the **opposite** direction with speed $2\,\text{ms}^{-1}$. The coefficient of restitution between the spheres is $\frac{1}{3}$.

(a) Find the speed of each sphere after the collision. [7]

(b) Find the magnitude of the impulse exerted by A on B during the collision. [2]

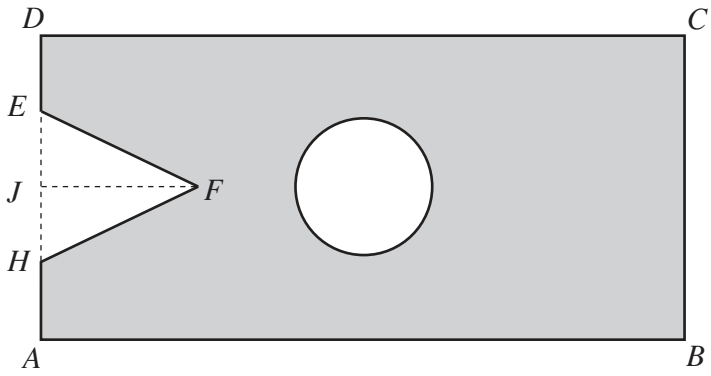
8. The diagram shows a particle lying in equilibrium at the origin O under the action of three horizontal forces of magnitudes 8 N, S N and R N.



Find the values of R and S, giving your answers correct to two decimal places. [8]

Turn over.

9. The diagram shows a rectangular uniform sheet of metal $ABCD$ with $AB = 10$ cm, $BC = 4$ cm. A circular piece of radius 1 cm is removed, the centre of the circle being the centre of the rectangle. A piece EFH is also removed, where EFH is an isoceles triangle with height $FJ = 3$ cm and $EF = FH$. Also $AH = DE = 1$ cm.



(a) Find the distance of the centre of mass of the remaining lamina $ABCDEFH$ from

(i) AB,
(ii) AD, giving your answer correct to two decimal places. [8]

(b) The remaining lamina $ABCDEFH$ is freely suspended from the point B. Find the angle AB makes with the vertical. [3]