

980/01

MATHEMATICS M1

Mechanics 1

A.M. FRIDAY, 14 January 2005

(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

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 $AC = 0.5$ 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]

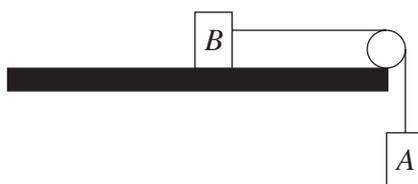
(c) Find the distance between signal A and destination B . [3]

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]

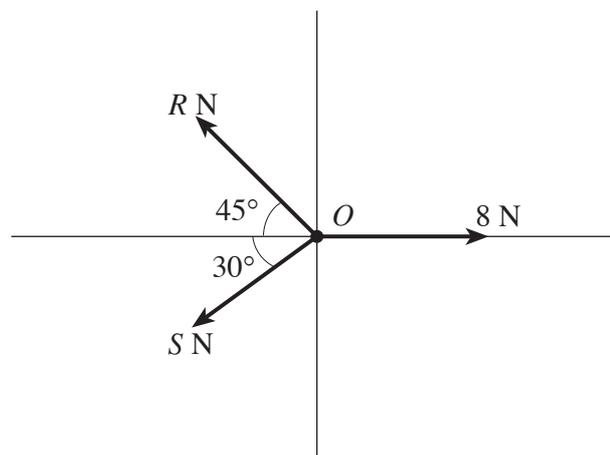
(b) Modelling the child as a particle, find the reaction between the child and the floor of the lift. [3]

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.



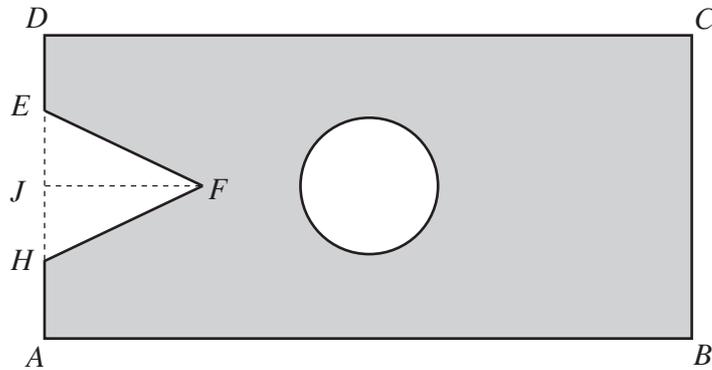
Initially, A is supported so that the system is at rest with the string taut. When A is released, it descends with uniform acceleration a ms^{-2} , and a frictional force of magnitude 13.2 N acts upon B . Calculate the value of a and the tension in the string. [7]

5. A ball is thrown vertically **downwards** with initial speed 3.2 ms^{-1} from a point A which is 8.1 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 3.25 ms^{-1} . [5]
- (b) Find the time that elapses between the first bounce and the instant when the ball is next 0.4 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 $\mu = 0.4$, 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 $\mu = 0.6$, 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 ms^{-1} , collides directly with another sphere B of mass 5 kg moving in the **opposite** direction with speed 2 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 , $S \text{ N}$ and $R \text{ N}$.



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

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 isosceles 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]