GCE AS/A level

980/01

MATHEMATICS M1
Mechanics 1

A.M. FRIDAY, 11 June 2010

1½ hours

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 $^{-2}$.

Sufficient working must be shown to demonstrate the **mathematical** method employed.

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 pebble is projected vertically downwards with speed $2{\cdot}1\ \text{ms}^{-1}$ from the top of a well, which is $15{\cdot}4$ m deep.

(a) Calculate the speed of the pebble when it hits the bottom of the well. [3]

(b) Find the time taken by the pebble to reach the bottom of the well. [3]

2. An express lift in a skyscraper travels non-stop from the ground floor to the top floor. For the first 15 s of its journey, the lift accelerates uniformly from rest. It then travels at a constant speed of $2{\cdot}7\ \text{ms}^{-1}$ for 90 s before finally decelerating uniformly to rest. The total time for the journey is 2 minutes.

(a) Sketch a velocity-time graph for the motion of the lift. [3]

(b) Calculate the distance travelled by the lift. [3]

A woman, of mass 75 kg, is standing on the floor of the lift during its journey.

(c) Calculate the reaction exerted by the floor of the lift on the woman when the lift is accelerating. [4]

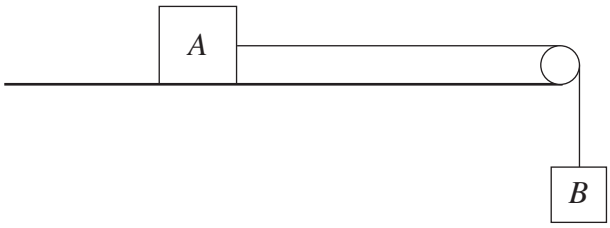
3. A boy sits on his toboggan and rides it down a straight line path on a snow-covered hill. The path may be modelled as a line of greatest slope of a plane inclined at an angle α to the horizontal, where $\sin \alpha = \frac{5}{13}$. The coefficient of friction between the toboggan and the slope is $0{\cdot}2$. The combined mass of the boy and the toboggan is 52 kg. Find the magnitude of their acceleration. [6]

4. A particle A, of mass 2 kg, moving with speed $12\ \text{ms}^{-1}$ on a smooth horizontal surface collides directly with a particle B, of mass 3 kg, moving with speed $7\ \text{ms}^{-1}$ in the same direction as A. The coefficient of restitution between the particles is $0{\cdot}6$.

(a) Find the speeds of A and B after the collision. [7]

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

5. The diagram shows an object A, of mass 6 kg, lying on a rough horizontal table. The object A is connected by means of a light inextensible string passing over a smooth pulley at the edge of the table to another object B, of mass 4 kg, hanging freely.

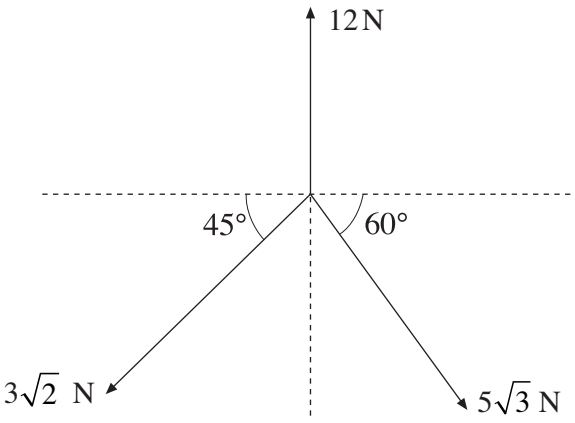


The coefficient of friction between object A and the table is 0·4. Initially, the system is held at rest with the string just taut. The system is then released.

(a) Find the magnitude of the acceleration of object A and the tension in the string. [9]

(b) What assumption did the word 'light' underlined above enable you to make in your solution? [1]

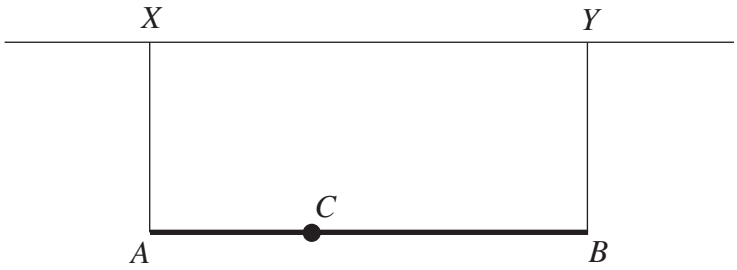
6. Three horizontal forces of magnitudes 12 N, $5\sqrt{3}$ N and $3\sqrt{2}$ N act in the directions shown in the diagram below.



Find the magnitude and direction of the resultant of the three forces. [8]

TURN OVER

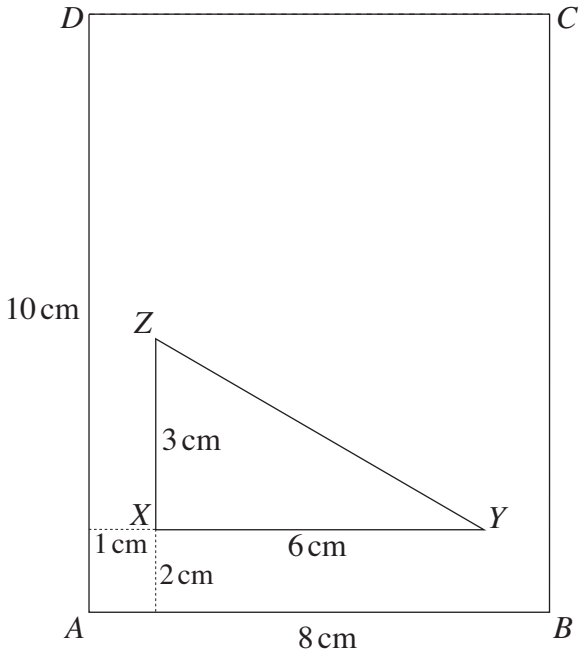
7. A uniform rod AB is suspended horizontally from the ceiling by means of two vertical light inextensible strings XA and YB of equal length.



The rod AB has mass 6 kg and length 1·4 m. A particle, of mass 10 kg, is attached to the rod at point C, where $AC = 0{\cdot}3$ m. Calculate the tension in **each** of the strings XA and YB. [7]

8. A car is travelling along a straight road ABC with uniform acceleration $a\,\text{ms}^{-2}$. The distance AB is 95 m. The time taken by the car to travel from A to B is 5 s and the time taken to travel from B to C is 2 s. At A the speed of the car is $u\,\text{ms}^{-1}$ and at C, its speed is $29{\cdot}8\,\text{ms}^{-1}$. Find the value of a and the value of u. [7]

9. The diagram below shows a decoration made from a uniform material. The rectangle $ABCD$ has $AB = 8$ cm and $AD = 10$ cm. An extra triangular piece XYZ, of the same material, with $XY = 6$ cm, $XZ = 3$ cm and $\hat{ZXY} = 90°$ is glued onto $ABCD$ such that XZ is 1 cm from AD and XY is 2 cm from AB.



(a) Find, correct to two decimal places, the distances of the centre of mass of the decoration from AD and AB. [9]

(b) The decoration is suspended freely from the point D. Calculate the angle AD makes with the vertical. [3]