GCE AS/A level

980/01

MATHEMATICS M1
Mechanics 1

A.M. MONDAY, 25 January 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 boy throws a ball vertically upwards from a point A with an initial speed of $18{\cdot}2\,\text{ms}^{-1}$.

(a) Find the greatest height above A reached by the ball. [3]

(b) Calculate the time taken for the ball to return to point A. [3]

(c) Find the speed of the ball $2{\cdot}5$ s after it was thrown. State clearly the direction of motion of the ball at this time. [3]

2. A lift is pulled upwards by means of a vertical cable. Initially, the lift is at rest. It then accelerates until it reaches a maximum speed. The lift moves at this maximum speed before decelerating uniformly at $3\,\text{ms}^{-2}$ to rest. The total mass of the lift and its contents is 360 kg.

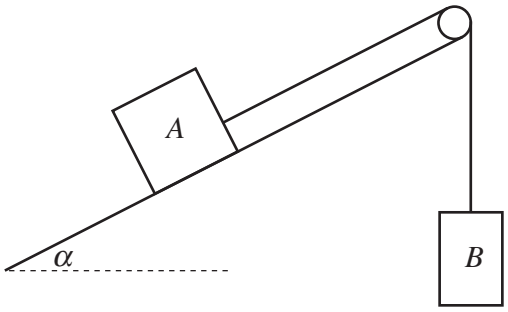
(a) Calculate the tension in the lift cable

(i) when the lift is decelerating,
(ii) when the lift is moving at its maximum speed. [4]

A crate on the floor of the lift has a mass of 25 kg. When the lift is accelerating the reaction between the crate and the floor of the lift is 280 N.

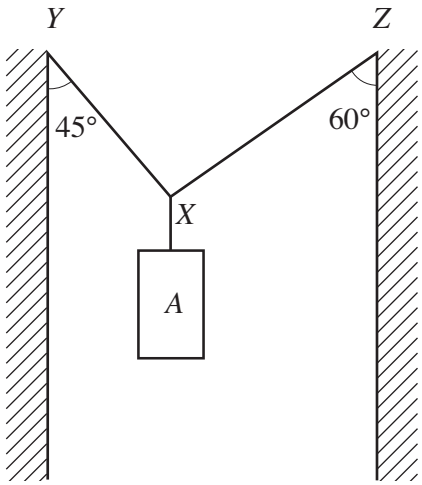
(b) Find the magnitude of the acceleration of the lift. [3]

3. The diagram shows an object A, on a fixed smooth inclined plane, joined by a light inextensible string passing over a smooth fixed pulley to an object B, which hangs freely. The plane is inclined at an angle α to the horizontal, where $\sin\alpha = 0{\cdot}4$. The masses of A and B are 11 kg and 9 kg respectively. The string is in the same vertical plane as a line of greatest slope of the plane.



Initially, the objects are held at rest with the string just taut. The system is released. Calculate the tension in the string and the magnitude of the acceleration of A. [7]

4. The diagram shows an object *A*, of mass 15 kg, suspended in equilibrium in a shaft with vertical walls by means of two ropes *XY* and *XZ*. The rope *XY* makes an angle of 45° with the vertical and the rope *XZ* makes an angle of 60° with the vertical.



Calculate the tension in each of the ropes *XY* and *XZ*. [7]

5. A car travels along a straight road. The car starts at rest from the point *A* and accelerates for 30 s at a constant rate until it reaches a speed of 25 ms^{-1}. The car continues at 25 ms^{-1} for *T* s until it approaches a built-up area when a constant retardation is applied for 10 s until the car slows to a speed of 15 ms^{-1} as it passes the point *B*. The distance *AB* is 8 km.

(a) Sketch a velocity-time graph for the journey between *A* and *B*. [4]

(b) Find the total time of the journey from *A* to *B*. [5]

6. An object, of mass 5 kg, lies on a rough horizontal surface. The coefficient of friction between the object and the surface is 0·6. A horizontal force of magnitude *T* N is applied to the object.

(a) Given that $T = 40$, calculate the magnitude of the frictional force and the acceleration of the object. [5]

(b) Given that $T = 20$, describes what happens, giving a reason for your answer. [2]

TURN OVER

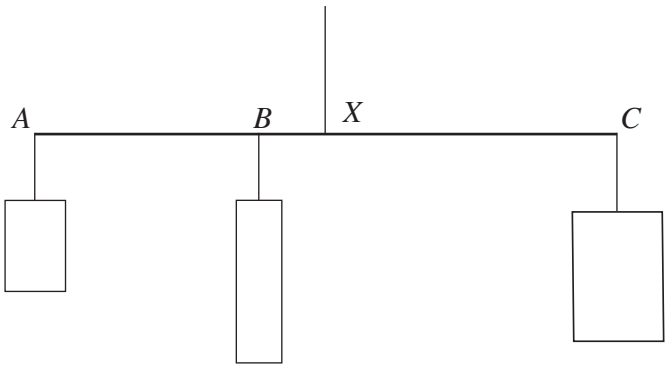
7. An object A, of mass 3 kg, moving with speed 7 ms^{-1} on a smooth horizontal plane collides directly with another object B, of mass 5 kg, moving with speed 3 ms^{-1} in the **opposite** direction. After the collision, the direction of motion of B is reversed and its speed is 2·4 ms^{-1}.

(a) Calculate the coefficient of restitution between A and B. [6]

After the collision between A and B, the object B collides with a wall which is perpendicular to its direction of motion. The coefficient of restitution between the wall and B is 0·6.

(b) Calculate the speed of B after the collision with the wall. [2]

8. The diagram shows a wind chime consisting of a horizontal uniform rod AC, suspended in equilibrium by means of a light string attached to the mid-point X of the rod, together with three objects hanging from the points A, B and C of the rod.

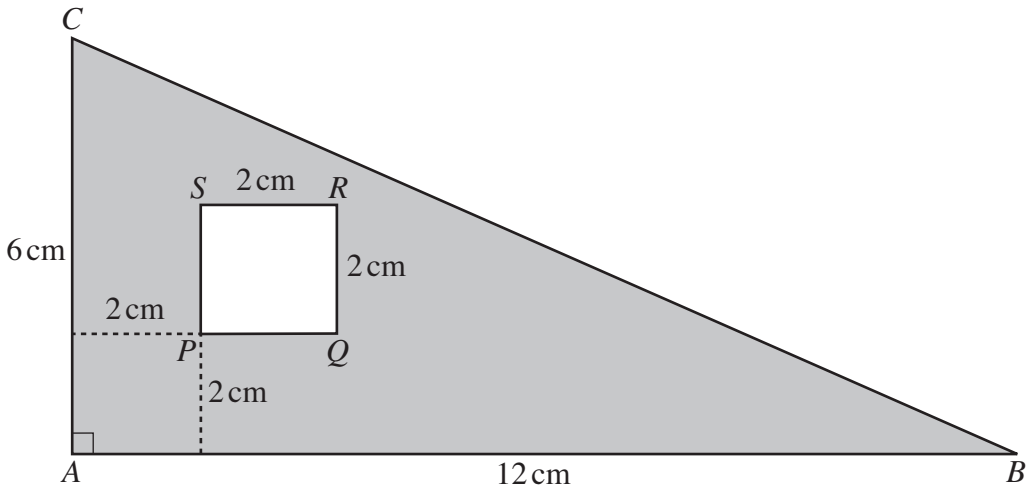


The length of the rod AC is 20 cm and the length of AB is 8 cm. The masses of the objects hanging from A, B, C are 0·1 kg, M kg, 0·4 kg respectively. The mass of the rod is 0·5 kg.

(a) Find the value of M. [4]

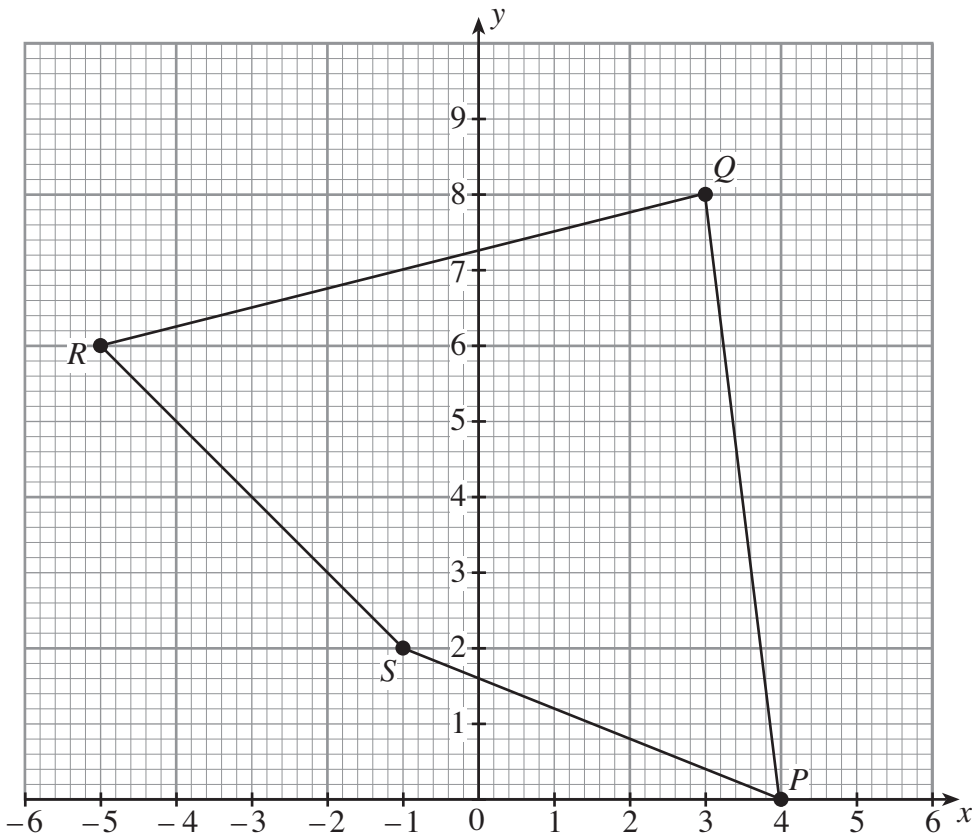
(b) Calculate the tension in the string. [3]

9. *(a)* The diagram shows a triangular lamina ABC made of uniform material with $AB = 12\,\text{cm}$, $AC = 6\,\text{cm}$ and $B\hat{A}C = 90°$. A square piece $PQRS$, of side 2 cm, is removed. The point P is 2 cm from AC and 2 cm from AB. The line PQ is parallel to AB.



Find the distances of the centre of mass of the remaining lamina from AC and AB. [9]

(b) The diagram shows four particles P, Q, R and S, of mass 10 kg, 5 kg, 2 kg and 3 kg respectively, attached to light rods which are rigidly joined together. The positions of the particles P, Q, R and S, on the x-y plane are $(4, 0)$, $(3, 8)$, $(-5, 6)$ and $(-1, 2)$.



Find the coordinates of the centre of mass of the system. [5]