WJEC
CBAC

GCE AS/A level

980/01

MATHEMATICS M1
Mechanics 1

P.M. MONDAY, 19 January 2009

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 train travels along a straight horizontal track with constant acceleration. Points *A, B* and *C* are on the track with *B* between *A* and *C*. The distance *AB* is 1200 m and the distance *BC* is 2500 m. As the train passes *B,* its speed is $26\,\text{ms}^{-1}$. The train takes 60 s to travel from *A* to *B*.

(a) Find the speed of the train as it passes *A*. [3]

(b) Determine the acceleration of the train. [3]

(c) Calculate the speed of the train as it passes *C*, giving your answer correct to one decimal place. [3]

2. A paratrooper jumps out of a stationary helicopter so that his initial velocity is $2\,\text{ms}^{-1}$ vertically downwards. He falls freely under gravity for 1·5 s, then his parachute opens and he descends vertically with uniform retardation for a further 22·5 s. His speed is zero as he reaches the ground.

(a) Calculate the speed of the paratrooper just before his parachute opens. [3]

(b) Draw a sketch of the velocity-time graph for the paratrooper's descent. [3]

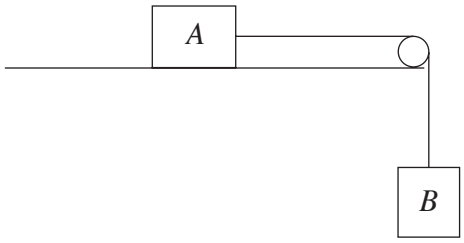
(c) Calculate the height of the paratrooper above the ground when he jumped out of the helicopter. [3]

3. A crate, of mass 15 kg, is placed on the floor of a lift. Calculate, in newtons, the magnitude of the reaction of the floor on the crate,

(a) when the lift is descending with a retardation of $2\,\text{ms}^{-2}$, [3]

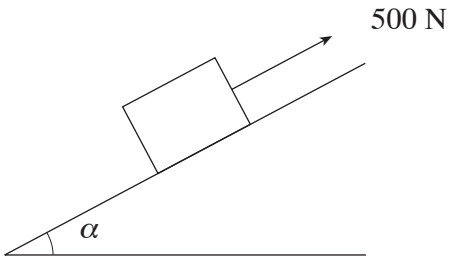
(b) when the lift is ascending at a constant speed of $3\,\text{ms}^{-1}$, [1]

4. The diagram shows an object *A*, of mass of 4 kg, on a **rough** horizontal table connected by a light inextensible string passing over a smooth light pulley, fixed at the edge of the table, to an object *B,* of mass 6 kg, hanging freely. The coefficient of friction between the object and the table is 0·3.



Initially, the system is held at rest with the string taut. It is then released. Find the magnitude of the acceleration of *A* and the tension in the string. [9]

5. The diagram shows a force, of magnitude 500 N, acting on an object, of mass 52 kg, on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{5}{12}$. The direction of the force is up the plane and parallel to a line of greatest slope. The coefficient of friction between the object and the plane is 0·4.



Calculate the acceleration of the object up the plane. [6]

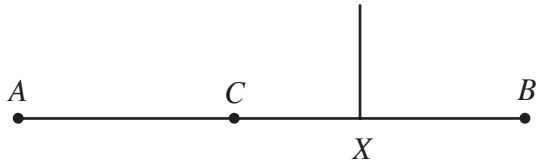
6. A sphere *A*, of mass 3 kg, is moving on a smooth horizontal floor with speed 4 ms^{-1} in a direction which is at right-angles to a smooth vertical wall. The sphere strikes the wall and rebounds with a speed of 2·8 ms^{-1}.

(a) Find the coefficient of restitution between the sphere and the wall. [2]

(b) Determine the magnitude of the impulse exerted by the wall on the sphere during the impact. [2]

(c) After *A* has rebounded from the wall, it catches up and collides directly with another sphere *B*, of mass 5 kg, which is travelling with speed 1·5 ms^{-1} in the same direction as *A*. The coefficient of restitution between spheres *A* and *B* is 0·6. Calculate the speed of *A* and the speed of *B* after the collision. [7]

7. The diagram shows a uniform rod *AB*, of mass 0·3 kg and length 2·0 m, with three particles, of masses 0·2 kg, 0·4 kg and 0·5 kg, attached to the points *A*, *C* and *B* respectively, where *AC* = 0·6 m. When the rod is suspended by a string attached to the point *X* of the rod, it rests horizontally in equilibrium.

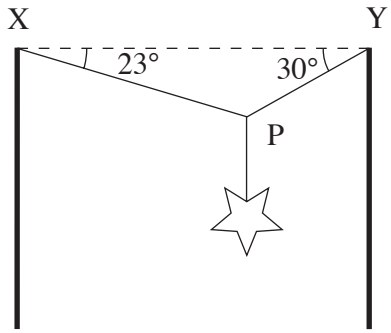


(a) Calculate the tension in the string. [3]

(b) Determine the distance *AX*. [4]

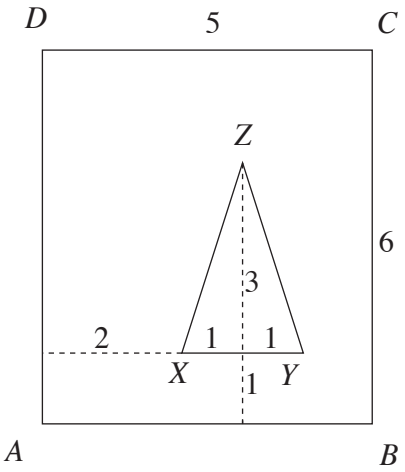
TURN OVER

8. The diagram shows a Christmas decoration supported by two cables *XP* and *YP*, inclined at angles 23° and 30° to the horizontal respectively. The mass of the decoration is 12 kg.



By modelling the cables as light inextensible strings, calculate the tension in cable *XP* and the tension in the cable *YP*. [7]

9. The diagram shows a uniform lamina formed by removing a triangular section *XYZ* from a rectangular plate *ABCD*. The triangle *XYZ* is isosceles with *XZ* = *YZ* and *XY* is parallel to *AB*. The dimensions (in cm) are shown in the diagram.



(a) Find the distance of the centre of mass of the lamina from

(i) *AD*,

(ii) *AB*. [9]

(b) When the lamina is freely suspended from *B*, it hangs in equilibrium. Calculate the angle that *BC* makes with the vertical. [3]

(c) When the lamina is freely suspended from a point *P* on *DC*, it hangs in equilibrium with *AD* vertical. Write down the distance of *P* from *D*. [1]