Rewarding Learning

ADVANCED

General Certificate of Education

2019

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

AMM21

[AMM21]

WEDNESDAY 12 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number on the Answer Booklet provided.
Answer **all seven** questions.
Show clearly the full development of your answers.
Answers should be given to three significant figures unless otherwise stated.
You are permitted to use a graphic or scientific calculator in this paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
Answers should include diagrams where appropriate and marks may be awarded for them.
Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless specified otherwise.
A copy of the **Mathematical Formulae and Tables booklet** is provided.
Throughout the paper the logarithmic notation used is $\ln z$ where it is noted that $\ln z \equiv \log_e z$

Answer all seven questions.

Show clearly the full development of your answers.

Answers should be given to three significant figures unless otherwise stated.

1 At time $t = 0$ seconds a particle B is at the point O. Its velocity, $\mathbf{v}\,\text{m}\,\text{s}^{-1}$, at any time t can be modelled by

$$\mathbf{v} = 3t\mathbf{i} - t^2\mathbf{j} + 4\mathbf{k}$$

(i) Find the direction of B's acceleration when $t = 3$ [5]

(ii) Find the distance of B from O when $t = 1$ [6]

2 A particle of mass 0.2 kg moves from a point P to a point Q under the action of the constant force $(\mathbf{i} + 2\mathbf{j})$ N.
P has position vector $(\mathbf{i} - \mathbf{j})$ m relative to a fixed point O. The particle's velocity at P is zero. It takes 3 seconds to move from P to Q.

Find the position vector of Q relative to O. [6]

3 A light inextensible string has one end attached to a box A of mass $2m$ kilograms and the other end attached to a box B of mass $3m$ kilograms. The string passes over a smooth fixed pulley as shown in **Fig. 1** below.

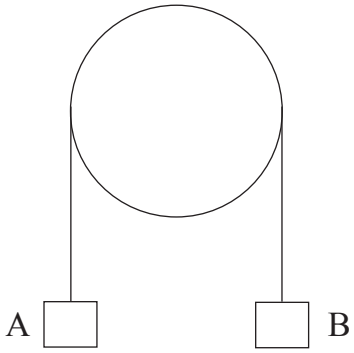

Fig. 1

Initially A and B are at rest at the same level.
Take the grativational potential energy to be zero at this starting level.
The boxes are released from rest.

(i) When A has risen a distance x, find, in terms of m, g and x, the total gravitational potential energy of A and B. [4]

(ii) Using the conservation of mechanical energy, find, in terms of g and x, the velocity of B, when A has risen a distance x. [5]

(iii) State one modelling assumption you have made about x. [1]

4 A car of mass 650 kg moves along a straight horizontal road. The car's engine produces a constant power of 13 kW.
Assume that any resistance to motion is negligible.

(i) Show that the motion of the car can be modelled by the equation

$$\frac{dv}{dt} = \frac{20}{v}$$

where v m s^{-1} is its speed at any time t seconds. [5]

Initially the car is travelling at 10 m s^{-1}

(ii) Find t when $v = 20$ [7]

(iii) As the car's velocity increases does the force produced by the car's engine increase or decrease? Briefly explain your answer. [2]

5 An empty sledge of mass 6 kg slides from rest down a rough slope inclined at 20° to the horizontal as shown in **Fig. 2** below.

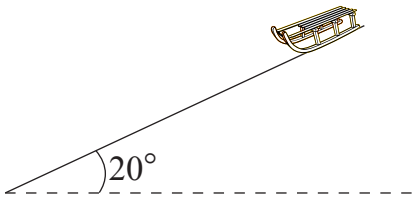

Fig. 2

The sledge starts from the top of the slope which is 15 m long.
At the bottom of the slope the sledge has a speed of 5 m s^{-1}

Model the sledge as a particle.

(i) Find the kinetic energy of the sledge at the bottom of the slope. [2]

(ii) Draw a diagram showing the external forces acting on the sledge. [2]

(iii) Find the work done by friction as the sledge moves to the bottom of the slope. [6]

6 Take $g = 10\,m\,s^{-2}$ in this question.

A ball is projected, at an angle of 30° above the horizontal, from the top of a vertical wall 4 m high as shown in **Fig. 3** below. The wall stands on horizontal ground.

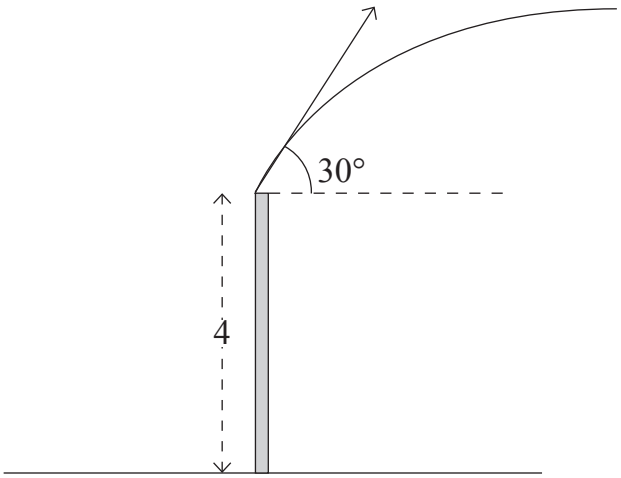

Fig. 3

The ball hits the ground after 3 s.

(i) Show that the initial speed of the ball is $27\frac{1}{3}\,m\,s^{-1}$ [3]

(ii) Find the horizontal distance travelled by the ball before it hits the ground. [2]

(iii) Find the speed and the direction in which the ball is travelling as it hits the ground. [7]

7 A block A of mass 1.5 kg rests on a rough horizontal table.
It is attached to one end of a light inextensible string of length 1.8 m.
The string passes through a small smooth hole in the table and carries a block B of mass 0.5 kg at its other end. B describes horizontal circles with uniform angular speed 4 rad s^{-1} as shown in **Fig. 4** below.

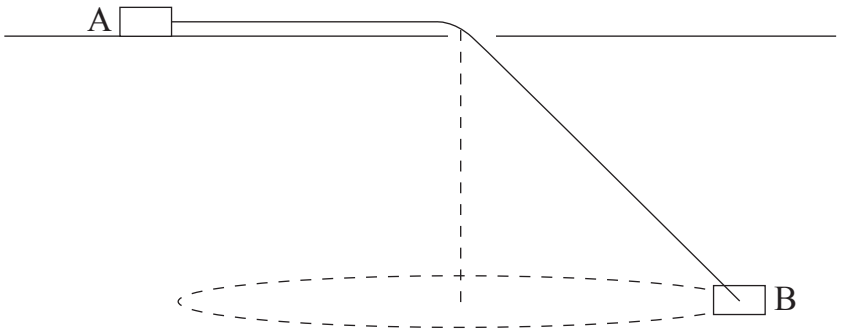

Fig. 4

(i) Draw a diagram showing the external forces acting on A and B. [2]

(ii) If A is 1 m from the hole and is on the point of slipping, find μ. [10]

THIS IS THE END OF THE QUESTION PAPER