



Rewarding Learning

ADVANCED

General Certificate of Education

2017

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2



AMM21

[AMM21]

WEDNESDAY 14 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 $g = 9.8 \text{ m s}^{-2}$, 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 seconds, where $t \geq 0$, a particle P is moving in a horizontal plane with acceleration $\mathbf{a} \text{ m s}^{-2}$, where

$$\mathbf{a} = (3t^2 + 4t)\mathbf{i} + (6t - 5)\mathbf{j}$$

When $t = 3$, the velocity of P is $(48\mathbf{i} + 10\mathbf{j}) \text{ m s}^{-1}$

- (i)** Find the velocity of P at time t seconds. [5]

- (ii)** Find the speed of P when it is moving parallel to the vector \mathbf{i} [4]

- 2** A block of mass 10 kg is pulled along a rough, straight, horizontal road by a constant horizontal force of magnitude 70 N.

The block moves in a straight line passing through two points X and Y on the road, where $XY = 50 \text{ m}$.

The work done against friction in moving the block from X to Y is 2800 J.

Model the block as a particle.

- (i)** State why you can ignore the effect of air resistance in this model. [1]

- (ii)** Show that the coefficient of friction between the block and the road is $\frac{4}{7}$ [4]

The velocity of the block at Y is six times its velocity at X.

- (iii)** Using the work–energy principle, find the velocity of the block at X. [4]

- 3** A car of mass 1300 kg accelerates along a straight, horizontal road.
The power produced by the car's engine is 32.5 kW.
Model the car as a particle and the resistance to its motion as negligible.
- (i) Show that the acceleration of the car is $\frac{25}{v} \text{ m s}^{-2}$, where $v \text{ m s}^{-1}$ is the speed of the car at time t seconds. [4]
- (ii) Find the distance travelled by the car as it accelerates from 1 m s^{-1} to 5 m s^{-1} [6]
- 4** Ben and Rachel are walking through a field.
At time $t = 0$ seconds, Ben is at a fixed point O in the field and Rachel is at the point with position vector $(-3\mathbf{i} + 6\mathbf{j}) \text{ m}$ relative to O.
Ben is moving with a constant speed of 1.25 m s^{-1} towards the point with position vector $(6\mathbf{i} + 8\mathbf{j}) \text{ m}$ relative to O.
- (i) Find, in vector form, Ben's velocity. [4]
- Rachel is moving with a constant speed of $\sqrt{10} \text{ m s}^{-1}$ towards the point with position vector $(15\mathbf{i}) \text{ m}$ relative to O.
- (ii) Show that Rachel's velocity is $(3\mathbf{i} - \mathbf{j}) \text{ m s}^{-1}$ [4]
- At $t = 2$ seconds, Rachel is at the point P.
- (iii) Show that Ben will also pass through the point P. [4]

- 5** A particle P is projected from a point A on horizontal ground with speed $u \text{ m s}^{-1}$ at an angle of elevation α and moves freely under gravity.
P hits the ground at the point B.

(i) Show that $AB = \frac{u^2}{g} \sin 2\alpha$ [6]

An archer fires an arrow with an initial speed of 45 m s^{-1} to hit a target which is level with the point of projection.

The arrow travels a horizontal distance of 80 m to hit the target.

You may assume that air resistance is negligible.

(ii) Find the two possible angles of projection. [4]

(iii) Find the shortest possible time of flight of this arrow. [3]

(iv) State one modelling assumption you have made in answering this question. [1]

- 6 **Fig. 1** below shows a light inelastic string OP of length 0.5 m. The end O of the string is fixed to a point 0.3 m vertically above the point C which lies on a smooth horizontal surface. A particle of mass 5 kg is fastened to the end P. The particle rotates on the surface in horizontal circles about the point C.

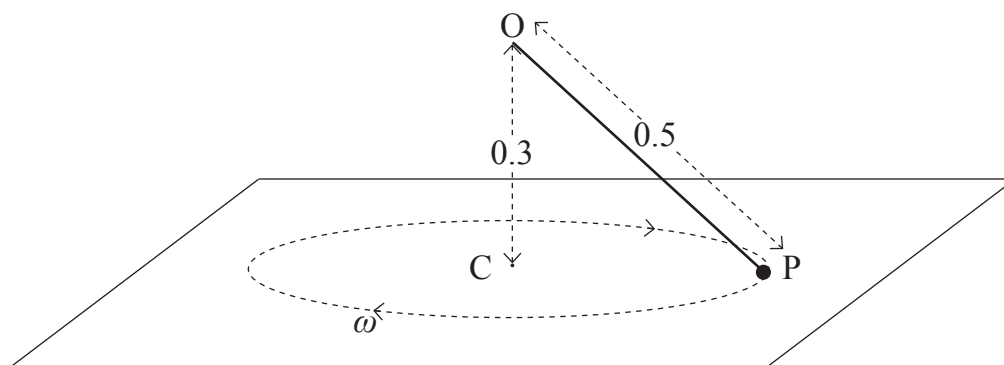


Fig. 1

The particle moves with angular speed $\omega \text{ rad s}^{-1}$

- (i) Draw a diagram showing the external forces acting on the particle. [2]
- (ii) Find, in terms of ω , an expression for the reaction between the particle and the surface. [7]
- (iii) Find the maximum value of ω at which the particle is on the point of leaving the surface. [2]

7 In this question take $g = 10 \text{ m s}^{-2}$

Fig. 2 below shows a smooth bead, B, of mass 0.05 kg threaded on to a smooth fixed vertical rod.

The bead is attached to one end of a light inextensible string of length 2 m .

The string passes over a smooth fixed peg P. A particle C, of mass of 0.1 kg , is attached to the other end of the string.

The horizontal distance between P and the rod is 0.4 m .

Initially, B is held at the same horizontal level as P.

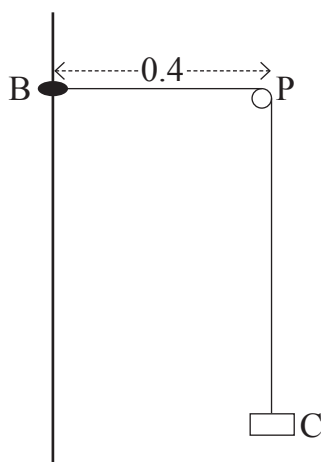


Fig. 2

Take the gravitational potential energy to be zero at the horizontal through P.

(i) Find the initial gravitational potential energy of the system.

[2]

B is then released from rest.

Fig. 3 below shows the system when B has fallen a distance of x metres from its original position.

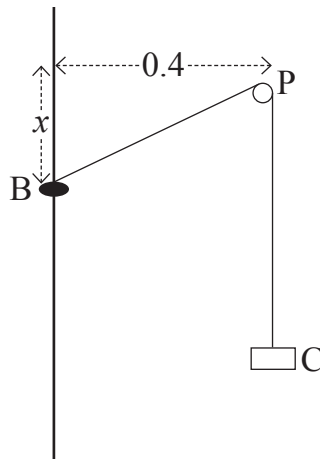


Fig. 3

(ii) Show that when B has fallen a distance of x metres, the distance PC is now

$$2 - \sqrt{x^2 + 0.16} \quad [1]$$

(iii) Find the gravitational potential energy of the system when B has fallen a distance of x metres. [4]

(iv) By using the principle of conservation of mechanical energy, find the value of x at which B momentarily comes to rest. [3]

THIS IS THE END OF THE QUESTION PAPER
