



Rewarding Learning

ADVANCED
General Certificate of Education
January 2010

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

[AMM21]



MONDAY 1 FEBRUARY, AFTERNOON

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 a 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 $t = 0$ seconds a body, P, has a velocity of $2\mathbf{i} \text{ m s}^{-1}$ and is at a fixed point O. P has a constant acceleration of $(5\mathbf{i} - \mathbf{j}) \text{ m s}^{-2}$
- (i) Find the velocity of P when $t = 2$ [3]
- (ii) Find the direction in which P is travelling at this time. [4]
- 2** A body of mass $M \text{ kg}$ is projected vertically downwards at $u \text{ m s}^{-1}$. When it has fallen a distance x metres, its speed is $3u \text{ m s}^{-1}$. Use the principle of conservation of mechanical energy to find x in terms of u and g . [7]
- 3** The displacement of a particle from a fixed point O at any time t seconds is given by
- $$\mathbf{r} = (t^3\mathbf{i} + t^2\mathbf{j} + t\mathbf{k}) \text{ m}$$
- (i) Find the velocity of the particle when $t = 3$ [3]
- (ii) Find the speed of the particle when $t = 3$ [2]
- (iii) Find an expression for the acceleration of the particle at time t . [2]
- (iv) Explain why the acceleration of the particle is not constant. [1]

4 Take g to be 10 m s^{-2} in this question.

A car of mass 800 kg can **ascend** a hill inclined at an angle $\sin^{-1} \left(\frac{1}{64} \right)$ to the horizontal at a steady speed of 15 m s^{-1}
The resistance to motion is 275 N .

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

(ii) Show that the power developed by the car's engine is 6 kW . [6]

The car now travels **down** the same hill with the engine working at the same rate and against the same resistance.

(iii) Find the maximum speed of the car **down** the hill. [4]

- 5** A smooth ring of mass 0.1 kg is threaded onto a light inelastic string.
The ends of the string are attached to two fixed points A and B, where A is 0.4 m vertically above B.
The ring is made to move in horizontal circles with centre B.
The angle between the string and AB is 30° as shown in **Fig. 1** below.

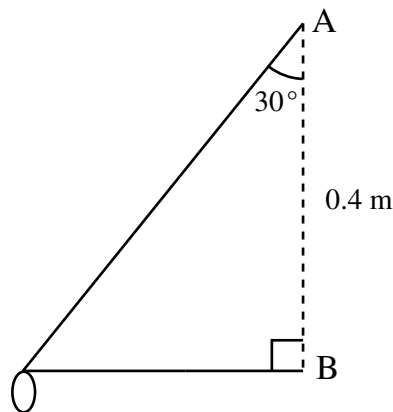


Fig. 1

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

(ii) Find the tension in the string. [2]

(iii) Find the angular velocity at which the ring is moving. [7]

(iv) Find the time taken for the ring to complete one circle. [2]

6 A particle, P, is projected from horizontal ground with speed $u \text{ m s}^{-1}$ and at an angle θ to the horizontal.

(i) Show that the horizontal range of P is

$$\frac{u^2 \sin 2\theta}{g} \quad [6]$$

A golfer strikes a ball so that its initial velocity $u \text{ m s}^{-1}$ makes an angle of 27° with the horizontal. The range of the ball on the horizontal plane is 176.4 m.

(ii) Find u . [3]

(iii) Find the greatest height of the ball above the horizontal. [3]

7 A toy truck of mass 3 kg is travelling along a horizontal surface.

The truck's engine produces a forward force of 0.6 N.

The resistance to the motion of the truck is $9v \text{ N}$, where $v \text{ m s}^{-1}$ is the speed of the truck at any time t seconds.

(i) Show that the motion of the truck can be modelled by the differential equation.

$$\frac{dv}{dt} = 0.2 - 3v \quad [4]$$

The truck starts from rest.

(ii) Show that

$$t = \frac{1}{3} \ln \left| \frac{0.2}{0.2 - 3v} \right| \quad [8]$$

(iii) Find v when $t = 1$ [3]

(iv) State **one** further modelling assumption that you have made. [1]

THIS IS THE END OF THE QUESTION PAPER
