



ADVANCED
General Certificate of Education
2012

Mathematics

Assessment Unit M2
assessing
Module M2: Mechanics 2
[AMM21]



THURSDAY 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 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** A box of mass 4 kg is in equilibrium under the action of three forces **P**, **Q** and **R** where

$$\mathbf{P} = (3\mathbf{i} + 5\mathbf{j} + 4\mathbf{k}) \text{ N}$$

$$\text{and } \mathbf{Q} = (-2\mathbf{i} + 4\mathbf{j} - 4\mathbf{k}) \text{ N}$$

- (i) Find **R**. [3]
- (ii) If the direction of **R** is now reversed, find the acceleration given to the box. [4]

- 2** Two particles A and B start from a fixed point O at time $t = 0$ seconds.
Particle A moves with a constant velocity of $(\mathbf{i} + 3\mathbf{j}) \text{ m s}^{-1}$
Particle B has an initial velocity of $(\mathbf{i} - 3\mathbf{j}) \text{ m s}^{-1}$ and a constant acceleration of $(\mathbf{i} + \mathbf{j}) \text{ m s}^{-2}$
- (i) Find the velocity of B at any time t . [2]
- (ii) Find the time at which the velocities of A and B are perpendicular. [4]
- (iii) Find the **speed** of B when $t = 5$ [3]

- 3 At time $t = 0$ seconds a ball is thrown with an initial velocity of 14 m s^{-1} at an angle of 40° above the horizontal.

When $t = 2$ find:

- (i) the horizontal component of its velocity; [2]
- (ii) the vertical component of its velocity; [2]
- (iii) the direction in which the ball is travelling. [3]

- 4 A particle moves along a curve so that at any time t seconds its velocity $\mathbf{v} \text{ m s}^{-1}$ is given by

$$\mathbf{v} = 2\mathbf{i} + 3t\mathbf{j}$$

The displacement of the particle from a fixed point O at time $t = 0$ is

$$\mathbf{s} = \mathbf{j}$$

Find the **distance** of the particle from O when $t = 3$ [6]

- 5 A box of mass 5 kg slides down a plane inclined at an angle of 30° to the horizontal. Initially the box is at rest at a point A on the plane. B is a point 2 m down the plane from A as shown in **Fig. 1** below.

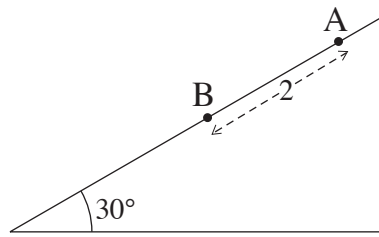


Fig. 1

- (i) If the plane is smooth, use the conservation of mechanical energy to find the velocity of the box at B. [8]
- (ii) If instead, the plane is rough, coefficient of friction 0.3:
- (a) find the work done by friction; [6]
- (b) use the work–energy principle to find the velocity of the box at B. [4]

- 6 A light inextensible string has its ends fastened to two fixed points A and B. A is 0.15 m vertically above B. A small smooth bead P of mass 0.3 kg has been threaded onto the string. P moves in a horizontal circle of radius 0.2 m about the line AB with constant angular speed $\omega \text{ rad s}^{-1}$. The string is taut and BP is horizontal as shown in **Fig. 2** below.

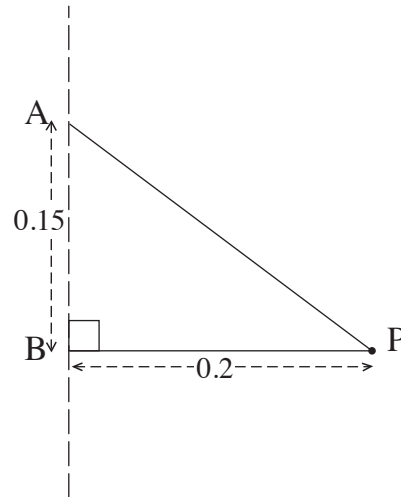


Fig. 2

- (i) Draw a diagram showing the external forces acting on P. [2]
- (ii) Show that the tension in the string is 4.9 N and hence find ω . [9]

- 7 A man on a bicycle, combined mass 100 kg, is travelling along a straight horizontal road against a variable resisting force of $\frac{v}{2}$ N.

The man is working at a constant rate of 50 W.

Model the man and his bicycle as a particle.

- (i) Find the maximum speed that the man might attain. [5]

- (ii) Show that the motion of the man can be modelled by the differential equation

$$\frac{100 - v^2}{2v} = 100 \frac{dv}{dt} \quad [3]$$

- (iii) Find the time taken for the man's speed to increase from 2 m s^{-1} to 4 m s^{-1} [8]

- (iv) Explain why the man will not attain the speed found in (i). [1]

THIS IS THE END OF THE QUESTION PAPER

Permission to reproduce all copyright material has been applied for.
In some cases, efforts to contact copyright holders may have been unsuccessful and CCEA
will be happy to rectify any omissions of acknowledgement in future if notified.