



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 $g = 9.8 \text{ ms}^{-2}$, 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 ms^{-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 $\mathbf{v} \text{ ms}^{-1}$ 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.

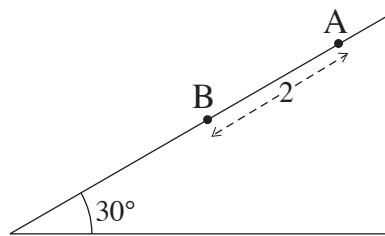


Fig. 1

- (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 ω rad s $^{-1}$. The string is taut and BP is horizontal as shown in **Fig. 2** below.

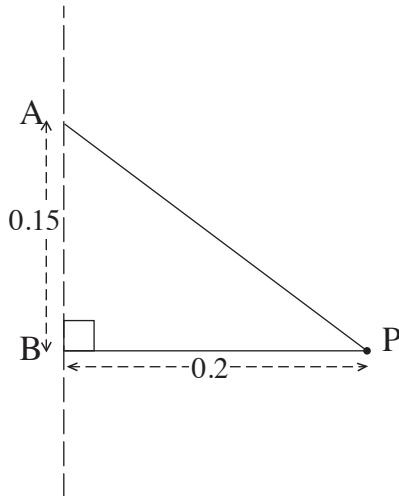


Fig. 2

- (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

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