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ADVANCED
General Certificate of Education
2012

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

[AMM21]

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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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 A box of mass 4 kg is in equilibrium under the action of three forces **P**, **Q** and **R** where

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

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 $(\mathbf{i} + 3\mathbf{j})$ m s^{-1}
Particle B has an initial velocity of $(\mathbf{i} - 3\mathbf{j})$ m s^{-1} and a constant acceleration of $(\mathbf{i} + \mathbf{j})$ 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 $\mathrm{m\,s^{-1}}$ 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 $\mathbf{v}\,\mathrm{m\,s^{-1}}$ 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.

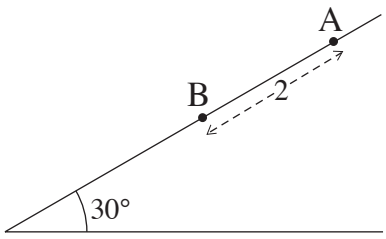

Fig. 1

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

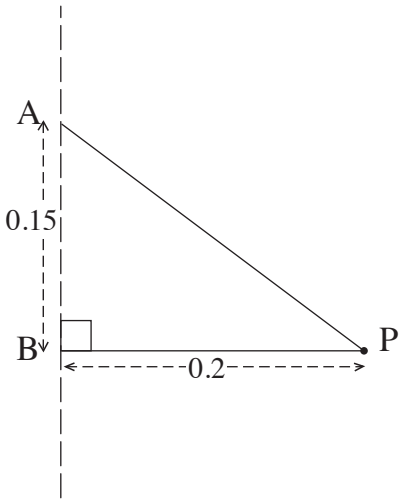

Fig. 2

(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

$$\frac{100 - v^2}{2v} = 100\frac{\mathrm{d}v}{\mathrm{d}t}$$ [3]

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

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

THIS IS THE END OF THE QUESTION PAPER