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ADVANCED
General Certificate of Education
2011

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

[AMM21]

AMM21

THURSDAY 16 JUNE, AFTERNOON

***** Please note amendment to Question **4(i)** on page 3.

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 Two forces $(2\mathbf{i} - 11\mathbf{j})$ N and $(6\mathbf{i} + 7\mathbf{j})$ N act on a body of mass 4 kg.

(i) Find the acceleration of the body. [3]

The body starts from rest.

(ii) Find the **speed** of the body after 4 s. [5]

2 A smooth bend in a track is banked at 20° to the horizontal. A car of mass 1000 kg travels round the bend at a speed of 15 m s^{-1} on an arc of a horizontal circle, of radius r metres, as shown in **Fig. 1** below.

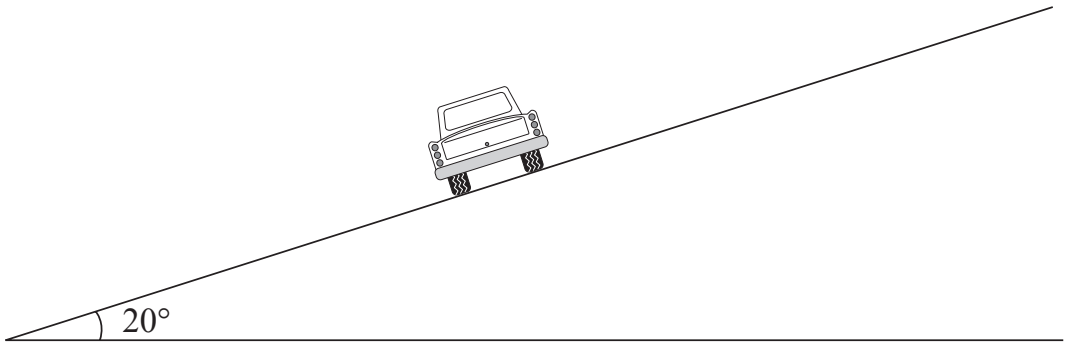

Fig. 1

Model the car as a particle.

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

(ii) Find the normal reaction between the car and the road. [3]

(iii) Find r. [5]

3 A pair of scale pans, A and B, each of mass m kg, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. They are held at the same level as shown in **Fig. 2** below.

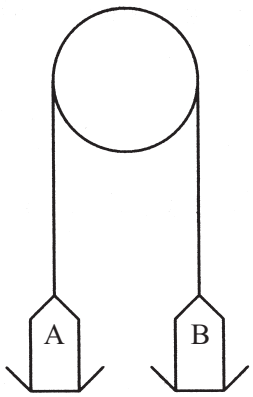

Fig. 2

A mass of $2m$ kg is now placed on A.
The system is released from rest.

(i) Calculate, in terms of m, the kinetic energy of B when it is moving at $4\,\text{m}\,\text{s}^{-1}$ [2]

(ii) Using the principle of conservation of energy, find how far B has risen when it has a speed of $4\,\text{m}\,\text{s}^{-1}$ [7]

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

***** In the light of further quality assurance, you should attempt this question with part **(i)** revised as shown below.

4 A fire engine's pump raises 100 litres of water through a vertical distance of 10 m.
The water issues from the end of a hose at $25\,\text{m}\,\text{s}^{-1}$
1 litre of water has a mass of 1 kg.

(i) If the cross-sectional area of the end of the hose is $0.01\,\text{m}^2$, find the time taken for the 100 litres to issue from the end of the hose. [2]

(ii) Find the power developed by the fire engine's pump. [5]

5 A lorry of mass 2000 kg is travelling along a straight horizontal test track.
When its velocity is $30\,\text{m s}^{-1}$ its engine is switched off.
During its subsequent motion a horizontal resistance of magnitude $100v^2$ N opposes its motion, where $v\,\text{m s}^{-1}$ is the lorry's speed at any time t seconds.
Model the lorry as a particle.

(i) Show that the lorry's equation of motion can be modelled by

$$\frac{\mathrm{d}v}{\mathrm{d}t} = -\frac{v^2}{20}$$ [3]

(ii) Find the value of t when $v = 0.5$ [8]

6 A ball is projected at an angle θ above the horizontal with an initial velocity of $u\,\text{m s}^{-1}$

(i) Prove that the greatest height, h metres, of the ball above the horizontal is given by

$$h = \frac{u^2 \sin^2 \theta}{2g}$$

[4]

A ball bounces off a roof with an initial velocity of $3\,\text{m s}^{-1}$ at an angle of 30° above the horizontal.

The roof is 4 m vertically above horizontal ground as illustrated in **Fig. 3** below.

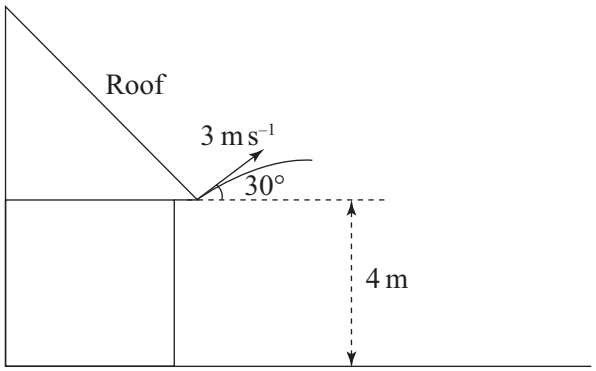

Fig. 3

(ii) Find the greatest height above the ground reached by the ball. [4]

(iii) Show that the ball will reach the ground after 1.07 s [4]

(iv) Find the horizontal distance travelled by the ball before it reaches the ground. [2]

7 The velocity $v\,\mathrm{m\,s^{-1}}$ of a particle R at any time t seconds is given by

$$v = (t^2 - 4t)\mathbf{i} + \left(\frac{t^3}{3} - t^2\right)\mathbf{j} + \mathbf{k}$$

(i) Find an expression for the acceleration of R at any time t. [3]

(ii) Find t when the acceleration is zero. [4]

R passes through a fixed point O when $t = 0$

(iii) Find an expression for the displacement of R from O at any time t. [4]

(iv) Find the **distance** of R from O when $t = 3$ [4]

THIS IS THE END OF THE QUESTION PAPER