Rewarding Learning

ADVANCED
General Certificate of Education
2010

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

[AMM21]

AMM21

FRIDAY 11 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.

Answer should be given to three significant figures unless otherwise stated.

1 Two forces

$$\mathbf{F}_1 = (2\mathbf{i} - 2\mathbf{j} + \mathbf{k})\ \text{N}$$

$$\text{and } \mathbf{F}_2 = (\mathbf{i} + 3\mathbf{j} - 2\mathbf{k})\ \text{N}$$

act on a particle, P, of mass 2 kg.

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

(ii) Find the angle between the resultant force acting on P and $\mathbf{F}_1$ [6]

2 A stone of mass 0.05 kg falls vertically into a tank of still water.
As it enters the water, the stone has a velocity of $10\,\text{m s}^{-1}$
After it has fallen 2 m vertically through the water, its velocity has been reduced to $4\,\text{m s}^{-1}$

(i) Find the change in the kinetic energy of the stone. [4]

(ii) Find the work done by gravity on the stone. [2]

(iii) Using the work–energy principle, find the resistance to motion, assumed constant. [5]

3 At time $t = 0$ seconds, a ball is thrown with a speed of $u\ \text{m s}^{-1}$ at an angle $\theta°$ above the horizontal.

(i) Find, in terms of g, u and θ, an expression for the greatest height reached by the ball. [3]

(ii) Find an expression for the time at which the ball is travelling horizontally. [3]

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

The maximum angular speed at which a car of mass m kg can travel around a horizontal circular bend without skidding is 0.15 rad s^{-1}
The bend has a radius of 100 m.

(i) Find the coefficient of friction between the wheels of the car and the road. [5]

(ii) Find, in terms of m, the kinetic energy of the car as it negotiates the bend with maximum angular speed. [4]

5 A train of mass 120 tonnes is ascending a hill inclined at $\sin^{-1}\left(\frac{1}{120}\right)$ to the horizontal as shown in **Fig. 1** below.

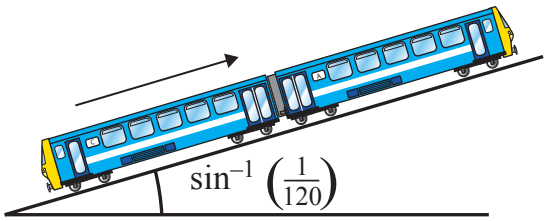

Fig. 1

When the engine is working at a rate of 240 kW, the train is moving at a constant speed of 12 m s^{-1}

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

(ii) Find the resistance to the motion of the train. [6]

In order to increase its speed, the engine is now made to work at a rate of 480 kW.

(iii) Given that the resistance remains constant, find the initial acceleration of the train up the hill. [4]

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

$$\mathbf{v} = (t^3 - 3t^2)\,\mathbf{i} + (t^2 - 4t)\,\mathbf{j}$$

(i) Find an expression for $\mathbf{a}$, the acceleration of the particle at any time t. [3]

(ii) Hence find the time at which $\mathbf{a}$ is zero. [3]

Initially Q is $3\mathbf{j}$ m from a fixed point O.

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

(iv) Find the distance that Q is from O when $t = 2$ [3]

(v) Find the direction in which Q is travelling when $t = 2$ [4]

7 An experimental motorised buggy starts from rest at a point A and moves in a straight line towards a point B, 600 m away.

The buggy's acceleration can be modelled by

$$a = \frac{1}{(s - 600)^2} \text{ m s}^{-2}$$

where s metres is the distance of the buggy from A.

(i) Find the speed, v, of the buggy in terms of s. [9]

(ii) Explain briefly why this is not a good model. [2]