Rewarding Learning

ADVANCED

General Certificate of Education

2018

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

AMM21

[AMM21]

WEDNESDAY 13 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number on the Answer Booklet provided.
Answer **all six** 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 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 six questions.

Show clearly the full development of your answers.

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

1 A particle of mass 0.5 kg moves so that its position vector at time t seconds is given by

$$\mathbf{r} = (3 + t^2)\mathbf{i} + (4 - 2t^3)\mathbf{j} \text{ metres}$$

(i) Find the speed of the particle when $t = 2$ [5]

(ii) Find the exact magnitude and the direction of the resultant force acting on the particle when $t = 3$ [8]

2 A skydiver of mass 63 kg exits the door of an aeroplane.
Model the skydiver as a particle moving vertically downwards with an initial speed of $0\,\text{m s}^{-1}$
After falling a distance D metres, she has a velocity of $70\,\text{m s}^{-1}$

(i) Show that her kinetic energy is now 154 350 J. [2]

(ii) If there is no resistance to her motion, using Conservation of Mechanical Energy, find D. [5]

If instead there is a constant air resistance, the skydiver has to fall 700 m to reach a velocity of $70\,\text{m s}^{-1}$

(iii) Using the Work–Energy Principle, find the work done against air resistance. [5]

3 Take g to be 10 m s^{-2} in this question

A car of mass 1200 kg travels up a hill inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{20}$. The car experiences a constant resistance to motion of R newtons. The car's engine works at a constant rate of H watts. The maximum speed of the car when it is travelling up the hill is 24 m s^{-1}.

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

(ii) Find an equation connecting H and R. [5]

The car has a maximum speed of 30 m s^{-1} when it is travelling down the hill.

(iii) Find a second equation connecting H and R. [2]

(iv) Hence find H and R. [3]

The car now travels along level ground. The resistance to motion remains the same.

(v) Find the acceleration of the car when it is travelling with a speed of 18 m s^{-1} [4]

4 An object of mass m kg is projected vertically upwards in a resisting medium. The resistance, in newtons, produced by the medium is kmv^2, where k is a constant and $v\,\mathrm{m\,s^{-1}}$ is the velocity of the object at any time t seconds.

(i) Show that

$$\frac{\mathrm{d}v}{\mathrm{d}s} = \frac{(-kv^2 - \mathrm{g})}{v}$$ [4]

(ii) If the initial speed of the object is $u\,\mathrm{m\,s^{-1}}$, find an expression for the greatest height, above the point of projection, reached by the object. [8]

5 A cyclist is travelling on a bend in a track which is in the form of an arc of a circle of radius 80 m. The bend is banked at 30° to the horizontal as shown in **Fig. 1** below.

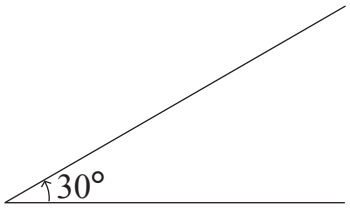

Fig. 1

The coefficient of friction between the tyres and the track is 0.6
Model the cyclist and his bike as a single particle.
The maximum speed at which the cyclist can travel round the bend without slipping is V.

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

(ii) Find V. [10]

6 Take g to be 10 m s^{-2} in this question

A ball B is thrown from a point O with an initial velocity of 20 m s^{-1} at an angle of elevation θ, where $\theta = \sin^{-1}\frac{4}{5}$

Two seconds later a second ball C is thrown from the same point O with an initial velocity of v m s^{-1} at an angle of elevation α.
B and C collide one second after C is projected.

Find α. [10]

THIS IS THE END OF THE QUESTION PAPER