



Rewarding Learning

ADVANCED  
General Certificate of Education  
2018

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## Mathematics

Assessment Unit M2  
*assessing*  
Module M2: Mechanics 2

**MV18**

[AMM21]

WEDNESDAY 13 JUNE, MORNING

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### Time

1 hour 30 minutes, plus your additional time allowance.

### 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 at the end of each question indicate the marks awarded to each question or part question.

Answers should include diagrams where appropriate and marks may be awarded for them.

Take  $g = 9.8 \text{ m s}^{-2}$ , 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 marks]

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

**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 marks]

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

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 marks]

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

A car of mass  $1200 \text{ kg}$  travels up a hill inclined at an angle  $\theta$  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  $24 \text{ m s}^{-1}$

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

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

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

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

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

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  $18 \text{ m s}^{-1}$  [4 marks]

- 4 An object of mass  $m$  kg is projected vertically upwards in a resisting medium.

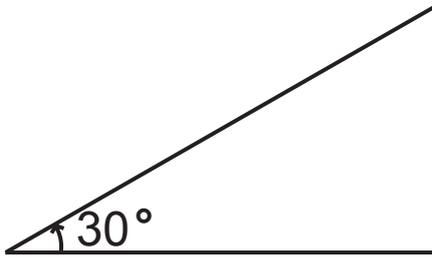
The resistance, in newtons, produced by the medium is  $kmv^2$ , where  $k$  is a constant and  $v \text{ m s}^{-1}$  is the velocity of the object at any time  $t$  seconds.

- (i) Show that [4 marks]

$$\frac{dv}{ds} = \frac{(-kv^2 - g)}{v}$$

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

- 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  $30^\circ$  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 marks]

- (ii) Find  $V$ . [10 marks]

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

A ball B is thrown from a point O with an initial velocity of  $20 \text{ m s}^{-1}$  at an angle of elevation  $\theta$ , 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  $v \text{ m s}^{-1}$  at an angle of elevation  $\alpha$ .

B and C collide one second after C is projected.

Find  $\alpha$ . [10 marks]

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**THIS IS THE END OF THE QUESTION PAPER**

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