



Rewarding Learning

ADVANCED
General Certificate of Education
2014

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

[AMM21]



THURSDAY 12 JUNE, AFTERNOON

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 $g = 9.8 \text{ m s}^{-2}$, 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 \mathbf{F}_1 and \mathbf{F}_2 act on a particle of mass 6 kg, where $\mathbf{F}_1 = (2\mathbf{i} - 8\mathbf{j} - \mathbf{k})\text{N}$.
The resultant of these two forces gives the particle an acceleration of $(2\mathbf{i} - 5\mathbf{j} + 2\mathbf{k})\text{ms}^{-2}$

(i) Find \mathbf{F}_2 [4]

A third force \mathbf{F}_3 now acts on the particle together with \mathbf{F}_1 and \mathbf{F}_2
The resultant of these three forces causes the particle to move with a constant velocity.

(ii) Find \mathbf{F}_3 [2]

- 2** **Fig. 1** below shows a projectile fired with an initial velocity of $u\text{ms}^{-1}$ at an angle θ above the horizontal.
The horizontal range of the projectile is R metres.

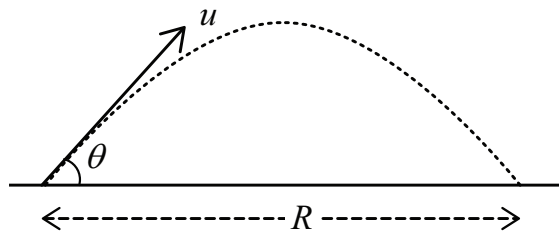


Fig. 1

(i) Show that the total time of flight, T seconds, of the projectile is given by

$$T = \frac{2u \sin \theta}{g} \quad [3]$$

(ii) Hence, show that

$$R = \frac{u^2 \sin 2\theta}{g} \quad [4]$$

(iii) For $u = 20\text{ms}^{-1}$, find the **maximum** value of R . [2]

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

- 3 A stunt rider, Rodney, is travelling on a smooth bend in a track which is in the form of an arc of a circle of radius 200 m.
The combined mass of Rodney and his motorcycle is 180 kg.
The bend in the track is banked at an angle of 35° to the horizontal, as shown in **Fig. 2** below.

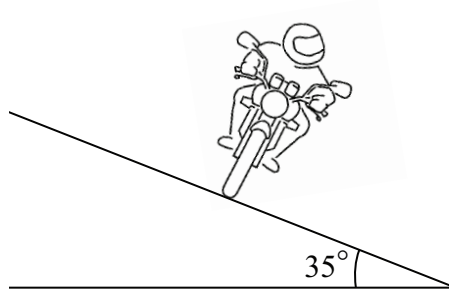


Fig. 2

Model Rodney and his motorcycle as a single particle.
(You may assume there are no sideways frictional forces between the tyres of the motorcycle and the track.)

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

While negotiating the bend, he travels at a constant speed of $v \text{ ms}^{-1}$

- (ii) Find the normal reaction between the road and the tyres of the motorcycle. [3]

- (iii) Find v . [5]

- 4 A car of mass 1400 kg is travelling on a straight horizontal road.
The engine of the car is working at a constant rate of 80 kW and the resistive forces opposing the motion of the car are constant and total 1600 N.

- (i) Find the acceleration of the car when it is travelling at 25 ms^{-1} [4]

- (ii) Find, in kJ, the kinetic energy of the car when it is travelling at maximum speed. [6]

The car now ascends a hill which is straight and inclined at θ° to the horizontal.
The power output and resistive forces remain the same as before.
When the car is travelling at 20 ms^{-1} up the hill, it has a retardation of 0.3 ms^{-2}

- (iii) Find θ . [5]

5 [In this question, take g to be 10 m s^{-2}]

An emergency parcel is to be dropped from a hovering helicopter to stranded hillwalkers. The parcel of mass m kg is dropped from rest and falls vertically under gravity.

The parcel is subject to air resistance of magnitude $\frac{mv^2}{60}$ newtons, where $v \text{ m s}^{-1}$ is the speed of the parcel, when it has dropped x metres.

- (i) Show that the equation of motion of the parcel can be modelled by the differential equation

$$60v \frac{dv}{dx} = 600 - v^2 \quad [4]$$

If the parcel is to land intact, its speed of impact with the ground below must be no more than 14 m s^{-1}

- (ii) Find the maximum height from which the parcel can be dropped if it is to land intact. [8]

- 6** A particle, P, is moving in the \mathbf{i} - \mathbf{j} plane so that its velocity, $\mathbf{v} \text{ m s}^{-1}$, at any time t seconds is given by

$$\mathbf{v} = (4 \cos t)\mathbf{i} + (3 + 2 \sin t)\mathbf{j}$$

- (i) Find the acceleration of P when $t = \pi$ [5]

When $t = 0$, the displacement of P from the origin O is $(2\mathbf{i} - 3\mathbf{j})\text{m}$.

- (ii) Find an expression for \mathbf{s} , the displacement of the particle from O, at any time t . [5]

- (iii) Find t when the particle first crosses the \mathbf{j} -axis. [2]

- 7 **Fig. 3** below shows two balls A and B of masses m kg and $3m$ kg respectively connected by a light inextensible string which passes over a smooth fixed pulley. Ball A is on a smooth plane inclined at 30° to the horizontal, and ball B hangs freely.

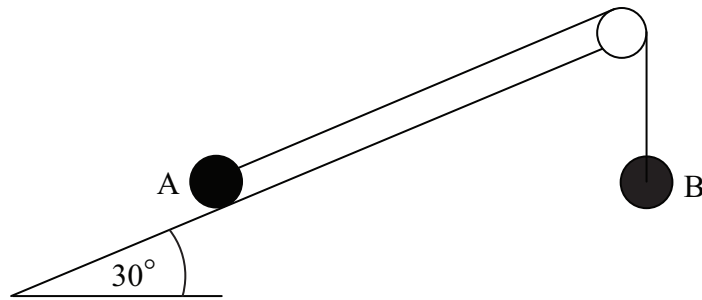


Fig. 3

Initially, A and B are held at the **same** horizontal level with the string taut. They are released from rest.

- (i) By using the Law of Conservation of Mechanical Energy, find in terms of g and l , the velocity v m s^{-1} of B when it has fallen l metres. (Assume A does not reach the pulley.) [8]
- (ii) Explain why the work done by the normal reaction between the plane and A is 0 J. [1]
- (iii) Explain why the work done by the tension in the string does not have to be considered. [1]

THIS IS THE END OF THE QUESTION PAPER
