Rewarding Learning

ADVANCED
General Certificate of Education
January 2014

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

[AMM21]

AMM21

TUESDAY 28 JANUARY, 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.

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

1 At time $t = 0$ seconds, a particle of mass 2 kg is at rest at the origin.
A constant force **F** of magnitude 27 N acts on the particle in the direction of the vector $\mathbf{d} = 4\mathbf{i} + 7\mathbf{j} - 4\mathbf{k}$

(i) Find the magnitude of **d** [2]

(ii) Find **F** [1]

(iii) Find the speed of the particle when $t = 4$ [6]

2 A particle moves in a plane so that its position vector **r** metres at time t seconds ($t \geqslant 0$) is given by

$$\mathbf{r} = \begin{pmatrix} 4t^2 - 6t + 1 \\ 3t^2 + 4 \end{pmatrix}$$

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

(ii) Find t when the particle is moving parallel to the vector $\begin{pmatrix} 1 \\ 2 \end{pmatrix}$ [4]

(iii) Show that the acceleration of the particle is constant, and find its magnitude. [3]

3 A car of mass 1800 kg is travelling along a straight horizontal road.
When the car is travelling at a speed of v m s^{-1}, it experiences a resistance of $42v$ newtons.

(i) Find the power produced by the car's engine when the car is travelling at its maximum speed of 45 m s^{-1} [4]

(ii) With the engine working at the same rate, find the acceleration of the car when its speed is 35 m s^{-1} [4]

4 **Fig. 1** below shows the cross section of a baggage chute composed of three sections, AB, BC and CD.
AB is vertical and of length x metres.
BC is a quarter circle of radius $2x$ metres.
CD is horizontal and of length d metres.
AB and BC are smooth.
CD is rough.

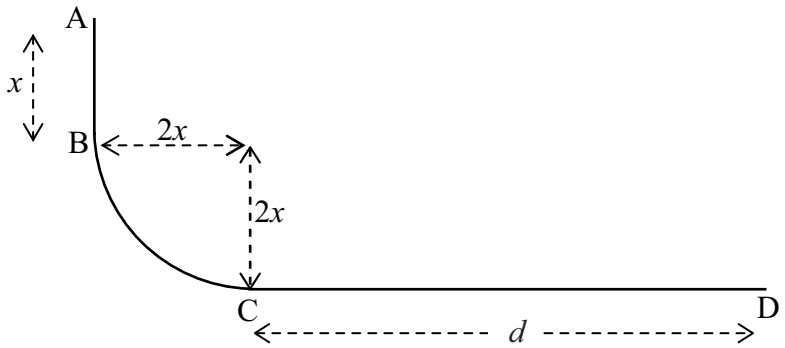

Fig. 1

A bag of mass m kg is released from rest at the point A and slides down the chute.
Assume gravitational potential energy to be zero at C.

(i) Find, in terms of g, m and x, an expression for the potential energy of the bag at A. [2]

The coefficient of friction between the bag and CD is μ.
The bag comes to rest at the point D.

(ii) Using the work–energy principle, or otherwise, find d in terms of μ and x. [5]

(iii) Find, in terms of g and x, the speed v m s^{-1} of the bag when it is halfway along CD. [5]

5 A racing car of mass 1200 kg moves along a straight horizontal road.
The engine of the car develops a constant power of 80 kW.
The constant resistances to the motion of the car total 1600 N.

(i) Show that the acceleration of the car can be modelled by

$$\frac{200 - 4v}{3v}$$

where v m s^{-1} is the velocity of the car at time t seconds. [4]

At $t = 0$ seconds, the car is travelling at a speed of 20 m s^{-1}

(ii) Find the time taken for the car to accelerate from 20 m s^{-1} to 30 m s^{-1} [11]

6 At time $t = 0$ seconds, a missile is fired from a point O on horizontal ground with a velocity of u m s^{-1} at an angle of θ above the horizontal.
When the missile is at a point P which is 200 m vertically above the ground, it has a velocity of 50 m s^{-1} at an angle of 30° above the horizontal, as shown in **Fig. 2** below.

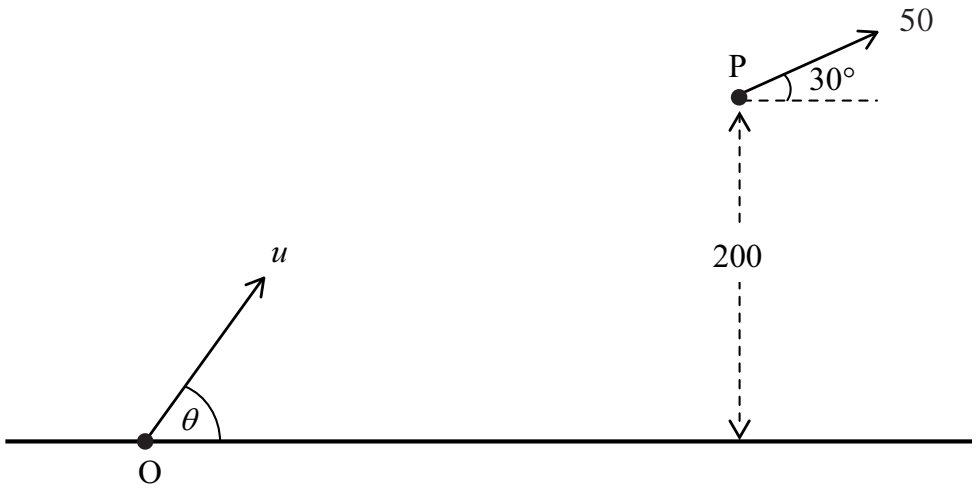

Fig. 2

(i) Find u and θ. [7]

(ii) Hence, find the value of t at which the missile is 200 m vertically above the ground for the second time. [4]

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

7 **[Take g = 10 m s^{-2} in this question]**

One end of a light inextensible string of length 0.5 m is attached to the vertex, V, of a smooth right circular cone.
A particle P of mass 2 kg is attached to the other end.
P rotates as a conical pendulum in a horizontal circle of diameter 0.6 m on the smooth outer surface of the cone, as shown in **Fig. 3** below.
The string remains parallel to the surface of the cone and P remains in contact with the cone at all times.

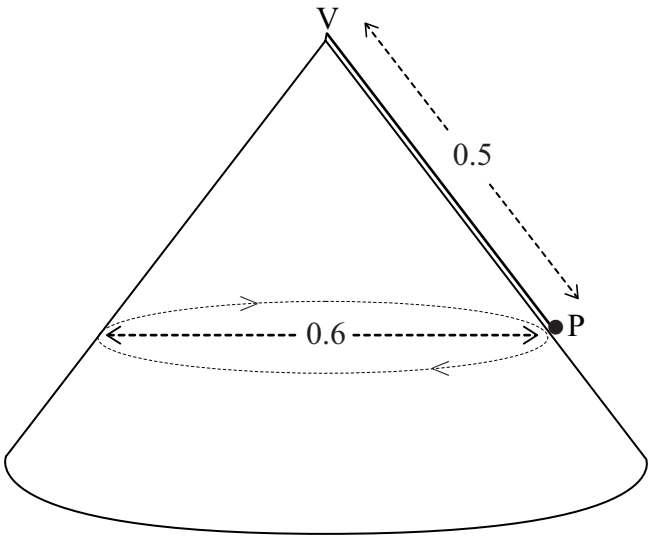

Fig. 3

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

P travels with an angular velocity of 3 rad s^{-1}

(ii) Find the tension in the string. [7]

THIS IS THE END OF THE QUESTION PAPER