QQQ – Further Mechanics 2 – Chapter 5 – Dynamics (Version 1)

Total Marks: 26

(26 = Platinum, 23 = Gold, 21 = Silver, 18 = Bronze)

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1. A particle P of mass 0.5 kg moves on the positive x-axis under the action of a single force directed towards the origin O. At time t seconds the distance of P from O is x metres, the magnitude of the force is $0.375x^2$ N and the speed of P is v m s^{-1}.

When $t = 0, OP = 8$ m and P is moving towards O with speed 2 m s^{-1}.

(a) Show that $v^2 = 260 - \frac{1}{2}x^3$. **(4)**

(b) Find the distance of P from O at the instant when $v = 5$. **(2)**

(Total 6 marks)

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2. A particle P of mass m moves in a straight line away from the centre of the Earth. The Earth is modelled as a sphere of radius R. When P is at a distance $x, x \geqslant R$, from the centre of the Earth, the force exerted by the Earth on P is directed towards the centre of the Earth and has magnitude $\dfrac{mgR^2}{x^2}$. When P is at a distance $2R$ from the surface of the Earth, the speed of P is $\sqrt{\dfrac{gR}{3}}$.

Assuming that air resistance can be ignored, find the distance of P from the surface of the Earth when the speed of P is $2\sqrt{\dfrac{gR}{3}}$. **(7)**

(Total 7 marks)

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3. The points A and B lie on a smooth horizontal surface with $AB = 4.5$ m.

A light elastic string has natural length 1.5 m and modulus of elasticity 15 N. One end of the string is attached to A and the other end of the string is attached to B. A particle, P, of mass 0.2 kg, is attached to the stretched string so that APB is a straight line and $AP = 1.5$ m. The particle rests in equilibrium on the surface.

The particle is now moved directly towards A and is held on the surface so APB is a straight line with $AP = 1$ m.

The particle is released from rest.

(a) Prove that P moves with simple harmonic motion. **(5)**

(b) Find

(i) the maximum speed of P during the motion,

(ii) the maximum acceleration of P during the motion. **(3)**

(c) Find the total time, in each complete oscillation of P, for which the speed of P is greater than 5 m s^{-1}. **(5)**

(Total 13 marks)

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