Further Dynamics and Kinematics – 2022 GCE Mechanics Further Math A Y543

1.

   A particle P of mass 2.5 kg is free to move along the x-axis. When its displacement from the origin is x m its velocity is v m s^{-1}.

   At time $t = 0$ seconds, P is at the point where $x = 1$ and is travelling in the negative x-direction with speed 5 m s^{-1}.

   At this time an impulse of I Ns is applied to P in the positive x-direction so that P moves in the positive x-direction with speed 18 m s^{-1}.

   (a) Find the value of I. [1]

   Subsequently, whenever P is in motion, two forces act on it. The first force acts in the positive x-direction and has magnitude $\dfrac{5v^2}{x}$ N. The second force acts in the negative x-direction and has magnitude $60v$ N.

   (b) Show that the motion of P can be modelled by the differential equation $\dfrac{dv}{dx} = \dfrac{av}{x} + b$ where a and b are constants whose values should be determined. [2]

   (c) By solving the differential equation derived in part **(b)** find an expression for v in terms of x. [4]

   You are given that $x = \dfrac{4}{3e^{-24t} + 1}$ when $t \geqslant 0$.

   (d) Describe in detail the motion of P when $t \geqslant 0$. [3]

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