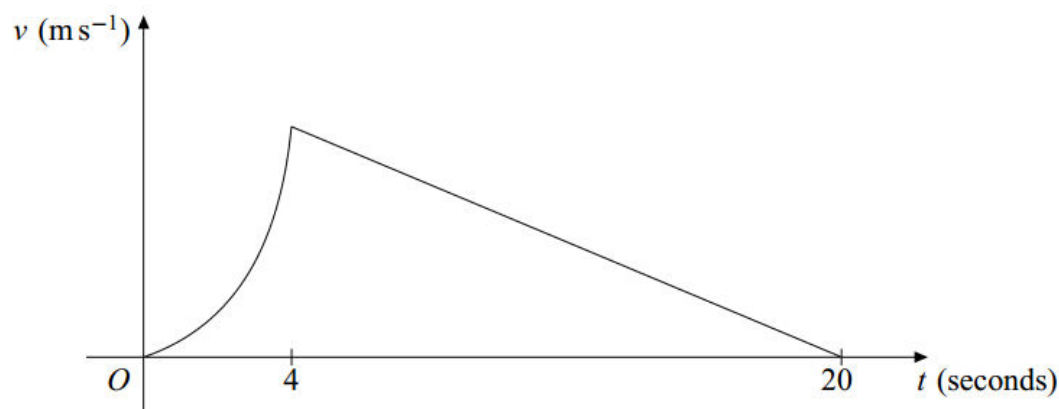


M2 Newton's Laws Challenge

Challenge 1



The velocity-time graph shows the velocity, $v \text{ m s}^{-1}$, at time t seconds, of a particle P which moves in a straight line. The motion of P has two separate stages.

In the first stage, P moves with velocity $v = 2t^2$ for 4 seconds.

In the second stage, P moves with a constant retardation for a further 16 seconds until coming to rest.

- (a) Find the value of v when $t = 4$. (1 mark)
- (b) Find the total distance travelled by P during the **two** stages of the motion. (6 marks)
- (c) The particle has mass 0.2 kg. Find the magnitude of the force acting on P when:
- (i) $t = 2$; (4 marks)
- (ii) $t = 10$. (3 marks)



Challenge 2

A particle moves so that, at time t , its acceleration is $3e^{-2t}\mathbf{i} + 2\mathbf{j}$. Its initial velocity is $5\mathbf{i}$. The unit vectors \mathbf{i} and \mathbf{j} are perpendicular.

Show that the velocity \mathbf{v} of the particle at time t is given by

$$\mathbf{v} = \left(\frac{13 - 3e^{-2t}}{2} \right) \mathbf{i} + 2t\mathbf{j} \quad (7 \text{ marks})$$



Challenge 3

A particle has mass 2000 kg. A single force, $\mathbf{F} = 1000\mathbf{i} - 5000\mathbf{j}$ newtons, acts on the particle, at time t seconds. The unit vectors \mathbf{i} and \mathbf{j} are perpendicular. No other forces act on the particle.

- (a) Find an expression for the acceleration of the particle. (2 marks)
- (b) At time $t = 0$, the velocity of the particle is $6\mathbf{j} \text{ m s}^{-1}$. Show that at time t the velocity, $\mathbf{v} \text{ m s}^{-1}$, of the particle is given by

$$\mathbf{v} = \frac{t^2}{4}\mathbf{i} + \left(6 - \frac{5t}{2}\right)\mathbf{j} \quad (4 \text{ marks})$$

- (c) The particle is initially at the origin. Find an expression for the position vector, \mathbf{r} metres, of the particle at time t seconds. (4 marks)



Final Challenge

A particle P moves so that at time t seconds its position vector, \mathbf{r} metres, is

$$\mathbf{r} = \begin{bmatrix} 2t^2 + 6 \\ 5t \end{bmatrix}, \quad 0 \leq t \leq 5.$$

- (a) Find the velocity of P at time t . (2 marks)
- (b) The force acting on P is $\begin{bmatrix} 2 \\ 0 \end{bmatrix}$ newtons. Find the mass of P . (3 marks)
- (c) At the instant when $t = 5$, an additional force, $\begin{bmatrix} 0 \\ t \end{bmatrix}$ newtons, begins to act on P .
- (i) Find the resultant acceleration of P . (3 marks)
- (ii) Find the velocity of P when $t = 10$. (5 marks)

