10 **(b)** A train of mass 200 tonnes moves along a straight level track against a resistance of $400v^2$, where v m/s is the speed of the train.
The engine exerts a constant power of P kW.

The acceleration of the train is $\dfrac{8000 - v^3}{500v}$.

(i) Find the value of P.
(ii) The train travels a distance 69.07 m while its speed increases from 10 m/s to v_1 m/s. Find the value of v_1.

(*i*)

$$T = \frac{1000P}{v}$$

$$\text{Force} = \text{Mass} \times \text{Acceleration}$$

$$\frac{1000P}{v} - 400v^2 = 200\,000\left(\frac{8000 - v^3}{500v}\right)$$

$$1000P - 400v^3 = 3200\,000 - 400v^3$$

$$P = 3200 \qquad 5$$

(*ii*)

$$v\frac{dv}{ds} = \frac{8000 - v^3}{500v} \qquad 5$$

$$\int_{10}^{v_1} \frac{500v^2}{8000 - v^3}\,dv = \int_0^{69.07} dx \qquad 5$$

$$\left[-\frac{500}{3}\ln\left(8000 - v^3\right)\right]_{10}^{v_1} = [x]_0^{69.07} \qquad 5$$

$$-\frac{500}{3}\ln\left(8000 - v_1^{\,3}\right) + \frac{500}{3}\ln(7000) = 69.07 \qquad 5$$

$$\frac{500}{3}\ln\left(\frac{7000}{8000 - v_1^{\,3}}\right) = 69.07$$

$$v_1^{\,3} = 3374.936276$$

$$v_1 = 15.0 \text{ m/s} \qquad 5$$

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