

Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

8 Momentum

Exercise A, Question 11

Question:

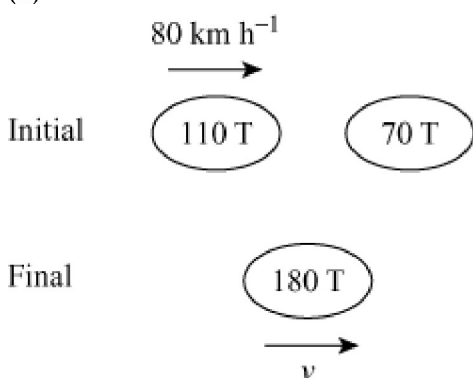
A train of total mass 110 tonnes and velocity 80 km h^{-1} crashes into a stationary locomotive of mass 70 tonnes.

(a) Calculate the velocity of the combined system immediately after impact.
The trains plough on for a further 40 m.

(b) Calculate the average deceleration and the resistance to motion.

Solution:

(a)



Using conservation of momentum (with the same units as the question)

$$\begin{aligned} 80 \times 110 &= v \times 180 \\ v &= \frac{880}{18} \\ &= 48.88 \text{ km h}^{-1} \end{aligned}$$

Velocity after the impact is 48.9 km h^{-1}

$$\begin{aligned} 48.9 \text{ km h}^{-1} \text{ is } & \frac{48.9 \times 1000}{60 \times 60} \text{ m s}^{-1} \\ &= 13.58 \text{ m s}^{-1} \end{aligned}$$

(b) To find the acceleration, use $v^2 = u^2 + 2as$,

$$\begin{aligned} 0 &= 13.58^2 - 2a \times 40 \\ a &= \frac{13.58^2}{2 \times 40} \\ &= 2.3052 \text{ m s}^{-2} \end{aligned}$$

\therefore Average deceleration is 2.31 m s^{-2}
Using $F = ma$,

$$\begin{aligned}\text{resistance to motion is } & 180\,000 \times 2.305 \\ & = 414\,900 \text{ N}\end{aligned}$$

∴ Resistance is 415 000 N.

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