

Impulse and Momentum

KEY

1. What velocity will a 40.0-kg child sitting in a 5.0-kg wagon move if pushed from rest by a 75 N force for 2.0s.

$$\vec{J} = \Delta \vec{p} = \vec{F} \Delta t = (75)(2.0) = 150 \text{ N}\cdot\text{s}$$

$$p_i = 0 \text{ kg}\cdot\text{m/s} \quad (\text{rest})$$

$$\Delta \vec{p} = \vec{p}_f - \vec{p}_i \Rightarrow \Delta \vec{p} = \vec{p}_f = \vec{J} = m \cdot v_f$$

$$v_f = \frac{\vec{J}}{m} = \frac{150}{45} = \underline{3.3 \text{ m/s}} \quad [\text{direction of motion}]$$

2. What average force will stop a 1000-kg car in 1.5 s if the car is initially moving at 22m/s?

$$v_i = 22 \text{ m/s}$$

$$v_f = 0 \text{ m/s}$$

$$m = 1000 \text{ kg}$$

$$t = 1.5 \text{ s}$$

$$\vec{J} = F \Delta t = \Delta \vec{p}$$

$$F = \frac{\vec{J}}{\Delta t} = \frac{\vec{p}_f - \vec{p}_i}{\Delta t}$$

$$= \frac{0 - (1000)(22)}{1.5}$$

$$= \underline{1.5 \times 10^4 \text{ N}} \quad [\text{against motion}]$$

3. What is the momentum of 75.0-kg object moving at the velocity of 10m/s [left]?

$$\begin{aligned} \vec{p} &= m \vec{v} \\ &= (75)(10) \\ &= \underline{750 \text{ kg}\cdot\text{m/s}} \quad [\text{left}] \end{aligned}$$

4. What force is required to stop a 1500-kg object over 0.30 s if the object initially moves at the velocity of 15m/s [right]?

$$v_i = 15 \text{ m/s [R]}$$

$$v_f = 0 \text{ m/s}$$

$$m = 1500 \text{ kg}$$

$$t = 0.30 \text{ s}$$

$$\vec{F} = \frac{\vec{J}}{\Delta t} = \frac{\Delta \vec{p}}{\Delta t} = \frac{\vec{p}_f - \vec{p}_i}{\Delta t}$$

$$= \frac{0 - (1500)(15)}{0.30}$$

$$= 75000 \text{ N}$$

$$\therefore \vec{F} = \underline{7.5 \times 10^4 \text{ N [L]}}$$

5. What is the impulse applied to 0.2-kg object moving at velocity 70m/s [right] that initially moved at velocity 30 m/s [right]?

$$\vec{v}_f = 70 \text{ m/s [R]}$$

$$\vec{v}_i = 30 \text{ m/s [R]}$$

$$m = 0.2 \text{ kg}$$

$$\vec{J} = \Delta \vec{p}$$

$$\Delta \vec{p} = \vec{p}_f - \vec{p}_i$$

$$= m (\vec{v}_f - \vec{v}_i)$$

$$= (0.2)(70 - 30)$$

$$\vec{J} = 8 \text{ N}\cdot\text{s [R]}$$

6. What force was needed to create the impulse in #5 provided the force was exerted for 4.5×10^{-3} s?

$$\vec{F} = \frac{\vec{J}}{\Delta t}$$

$$= \frac{8}{4.5 \times 10^{-3}}$$

$$\vec{F} = 1.8 \times 10^3 \text{ N [R]}$$

7. Consider a 0.06-kg object initially at rest. This object is acted upon by a force of 250N over 0.05s.

a) Find the impulse.

$$m = 0.06 \text{ kg}$$

$$F = 250 \text{ N}$$

$$\Delta t = 0.05 \text{ s}$$

$$\vec{J} = \vec{F} \Delta t$$

$$= (250)(0.05)$$

$$= 12.5 \text{ N}\cdot\text{s}$$

$$\therefore \vec{J} = 13 \text{ N}\cdot\text{s [direction of the force]}$$

b) Find the final velocity of the object.

$$v_i = 0 \text{ m/s}$$

$$v_f = ? \text{ [m/s]}$$

$$\vec{J} = \vec{p}_f - \vec{p}_i$$

$$= m (\vec{v}_f - \vec{v}_i)$$

$$\frac{\vec{J}}{m} = v_f - v_i$$

$$\frac{\vec{J}}{m} + \vec{v}_i = \vec{v}_f$$

$$\therefore \vec{v}_f = \frac{12.5}{0.06} + 0$$

$$\therefore \vec{v}_f = 208.3 \text{ m/s}$$

[direction of the force]