KEY

Impulse and Momentum

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.

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

$p_i = 0\ kg\,m/s$ (rest)

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

$v_f = \frac{\vec{J}}{m} = \frac{150}{45} = 3.3\ m/s$ [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?

$v_i = 22\ m/s$

$v_f = 0\ m/s$

$m = 1000\ kg$

$t = 1.5s$

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

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

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

$= 1.5 \times 10^4\ N$ [against motion]

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

$\vec{p} = m\vec{v}$

$= (75)(10)$

$= 750\ kg\,m/s$ [left]

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]?

$\vec{v}_i = 15\ m/s$ [R]

$\vec{v}_f = 0\ m/s$

$m = 1500\ kg$

$t = 0.30s$

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

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

$= 75000\ N$

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

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

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

$m = 0.2\ kg$

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

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

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

$= (0.2)(70-30)$

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

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

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

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

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

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.

$m = 0.06\ kg$

$F = 250\ N$

$\Delta t = 0.05\ s$

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

$= (250)(0.05)$

$= 12.5\ N \cdot s$

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

b) Find the final velocity of the object.

$v_i = 0\ m/s$

$v_f = ?\ [m/s]$

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

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

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

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

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

$= 208.\overline{3}\ m/s$

$\therefore \vec{v}_f = 2.1 \times 10^2\ m/s$ [direction of the force]