Momentum

and Impulse

1

Which would be harder to stop?

Why ? The truck has more mass.

2

Which would be harder to stop?

Velocity = 5 m/s

Velocity = 30 m/s

Why ? The red car is traveling faster.

3

Momentum depends on

- **Mass (kg)**
- **Velocity (m/s)**

Specifically

Momentum = mass x velocity

or

p = m x v

4

Momentum

- **The strength of an object's motion**
- **A vector quantity**
- **Determined by both the object's mass and velocity**
- **Momentum (p) = mass (m) x velocity (v)**

5

Impulse

- **Defined as the change in momentum**
- **Impulse – momentum theorem:**
  - **The impulse exerted on a body is equal to the change in the object's momentum**

$$\text{Impulse} = \Delta p$$
$$F\Delta t = \Delta p$$
$$F\Delta t = mv_f - mv_i$$
$$\Delta p = mv_f - mv_i$$

6

Changing an Object's Momentum

- **How do we do it?**
  - Apply a force
- **What if we need to stop something quickly?**
  - Larger force
- **What if there is a force limitation? (ie. Pain)**
  - More time
- **How do we cause a large change in momentum?**
  - Large force over a large time

7

Airbags

- **How does an air bag use this concept of impulse to decrease the amount of force on your body?**

More time ⇒ less force

8

Momentum/Impulse Example

- **A 2250 kg car traveling to the west is slowed uniformly from 20.0 m/s with a force of 8437.5 N for 4.00 s.**
  - **What is the change in the car's momentum (or its impulse)?**
  - **What is the speed of the car after the brakes are applied?**

9

Given: **m = 2250 kg** **v_i = 20.0 m/s, West**

F = 8437.5 N, East **t = 4.00 s**

$\Delta P = mv_f - mv_i$

$\Delta P = F\Delta t$

$\rightarrow (8437.5\,N)(4\,s) = 33{,}750\ kg \cdot m/s$

$33{,}750\ kg\,m/s = (2250)v_f - (2250)(-20)$

$33{,}750\ kg\,m/s = 2250\,v_f + 45{,}000$

$-45{,}000 \quad -45{,}000$

$\frac{11250}{2250} = \frac{2250v_f}{2250}$

$-5\ m/s = v_f$

$5\ m/s\ West = v_f$

10

Momentum/Impulse Example 2

- **A 0.45 kg volleyball travels at 4.0 m/s over the net. You jump up and hit the ball back at a velocity of 7.0 m/s. If the contact time is 0.04 s,**
  - **What is the change in the ball's momentum?**
  - **What is force exerted on the ball?**

11

Given: $m = .45 kg$ $v_i = 4.0 m/s$

$t = .04 s$ $v_f = -7.0 m/s$

$\Delta P = mv_f - mv_i$

$\Delta P = F\Delta t$

$\Delta P = (45)(-7) - (.45)(-4)$

$= -4.95 kg \cdot m/s$

$\frac{-4.95}{.04} = \frac{F(.04)}{.04}$

$F = -123.75 N$

12