Momentum & Impulse

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Newton's second law

$$F = ma$$

$$F = m\frac{v-u}{t}$$

$$F = m\frac{\Delta v}{t}$$

$m \times \Delta v$

Changes in momentum

$F \times t = m \times \Delta v$

Impulse

$m \times v$

Momentum

Conservation of momentum:
when 2 or more objects act on each other, their total momentum remains constant.
(collision problems)
Momentum before = momentum after

Momentum (Cont'd)

- **Any moving object will have momentum.**
- **Momentum** is a vector quantity.

$$Momentum\ (kg{\cdot}m/s) = Mass\ (kg) \times Velocity\ (m/s)$$

$$p = m \times v$$

- Momentum is always conserved:
  - Consider a collision between object 1 & 2
  - **Total momentum before = total momentum after**

Momentum (Cont’d)

Study question:

1. Two skaters (Ed: 80 kg, 2 m/s to the right; and Sue: 60 Kg, 1.5 m/s to the left) approach each other, collide and move off together. At what velocity do they move after the collision?

Momentum (Cont'd)

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Assume the direction to the right as positive

Total momentum before collision:

$$\text{Ed's momentum} + \text{Sue's momentum} = 80 \times 2 + 60 \times (-1.5) = 70 \text{ kg m/s}$$

Total momentum after collision:

$$\text{Momentum of Ed \& Sue} = 140 \times v$$

$$140 \times v = 70$$

$$v = 0.5 \text{ m/s to the right}$$

Impulse

- A change in momentum is **impulse**

- Forces cause **changes in momentum**

$$impluse = change\ in\ momentum$$

$$force\ (N) = \frac{change\ in\ momentum\ (kg\frac{m}{s})}{time\ (s)}$$

$$F = \frac{mv - mu}{t}$$

Impulse

How to derive impulse?

$$f = m \cdot a$$

$$f = m \cdot \frac{\Delta v}{\Delta t}$$

$$f \cdot \Delta t = m \cdot \Delta v$$

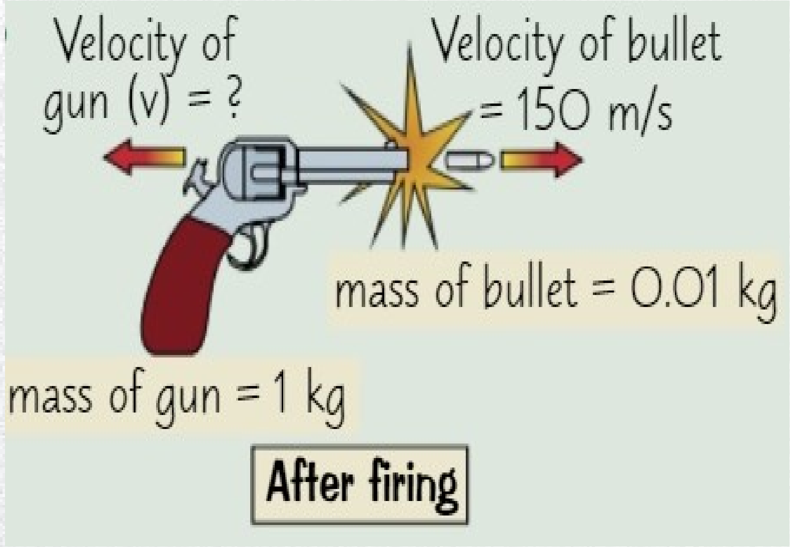
$$\therefore \quad f \cdot \Delta t = \Delta p$$

Momentum & Impulse

Study question:

2. A gun fires a bullet as shown. At what speed does the gun move backwards?

Find the force exerted on the gun if it is accelerated for 0.1 seconds.



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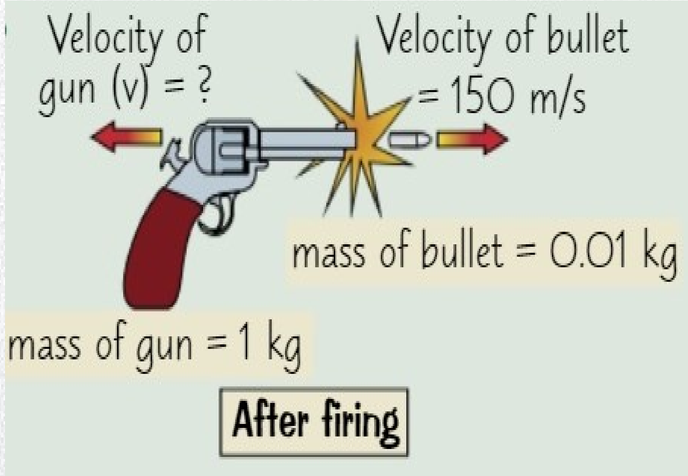

Assume forward as positive

Total momentum before firing: 0 kg·m/s

Total momentum after firing:

Momentum of the bullet + momentum of the gun = (0.01 kg × 150 m/s) + 1 kg × v = 1.5 + v

$\Longrightarrow$ 1.5 + v = 0 $\Longrightarrow$ v =-1.5 m/s (moves backwards)

Force exerted on the gun: $F = \frac{\mathrm{mv} - \mathrm{mu}}{t} = \frac{1 \times -1.5 - 1 \times 0}{0.1}$ = *-15 N*

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Momentum & Impulse

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Given:

m = 58 g = 0.058 kg, v = 34 m/s, u = 0 m/s, t = 11.6 ms = 0.0116 s

Find: *F*

$$F = \frac{\mathrm{mv} - \mathrm{mu}}{t} = \frac{0.058 \times -34 - 0.058 \times 0}{0.0116} = 170\ N$$