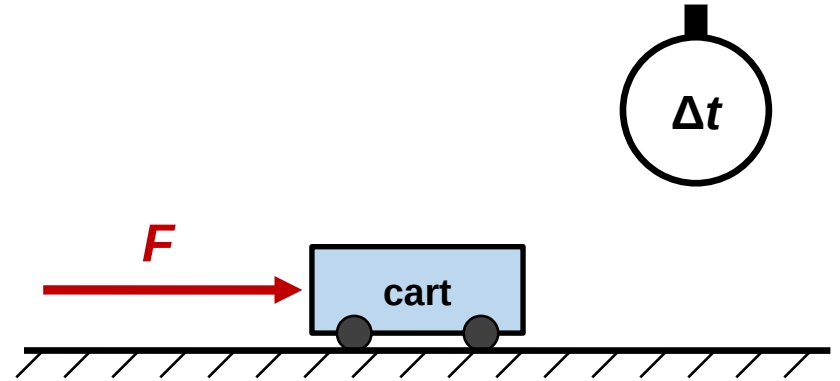


Essential Question

How does a force change an object's momentum?

What Is Impulse?

- A force acting over time
- Impulse = force $\times$ time
- Unit: newton-seconds (N·s)



$$\text{impulse} = \text{force} \times \text{time}$$

Impulse Changes Momentum

$$J = F\Delta t = \Delta p$$

 J

impulse (N·s)

 F

force (N)

 Δt

time (s)

 Δp change in momentum
(kg·m/s)

Where It Comes From

- Start with Newton's 2nd law
- Acceleration: $a = \Delta v / \Delta t$
- Multiply both sides by Δt
- So $\text{N} \cdot \text{s} = \text{kg} \cdot \text{m/s}$

$$F = ma$$

↓

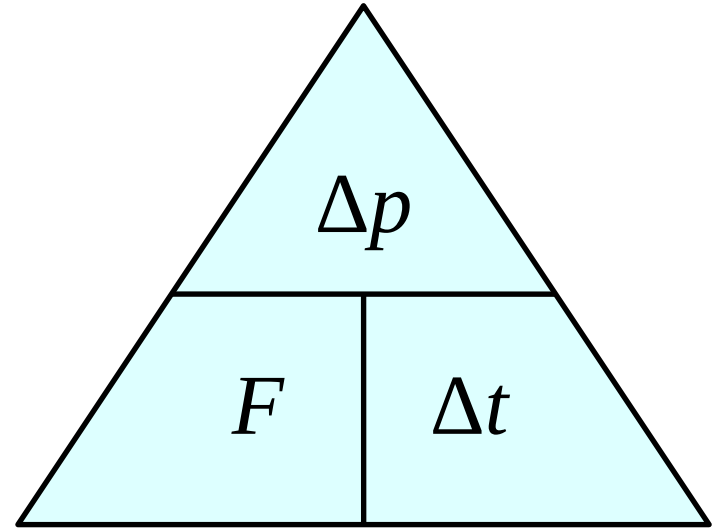
$$F = m\Delta v / \Delta t$$

↓

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

Solving for Any Variable

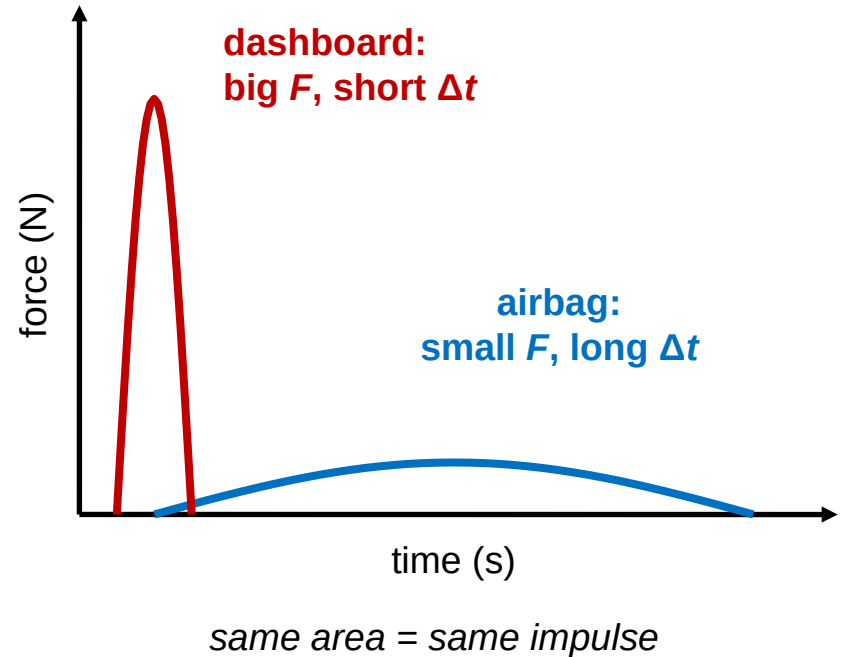
- Impulse: $J = F\Delta t$
- Force: $F = \Delta p / \Delta t$
- Time: $\Delta t = \Delta p / F$
- $\Delta p = m(v_f - v_i)$



cover the one you want

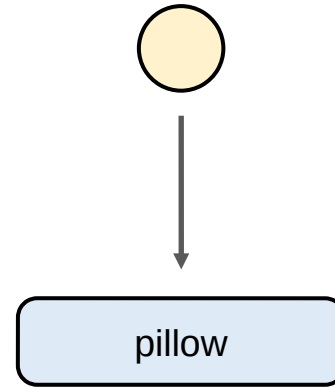
More Time, Less Force

- Stopping needs the same Δp
- Longer time: smaller force
- Shorter time: bigger force

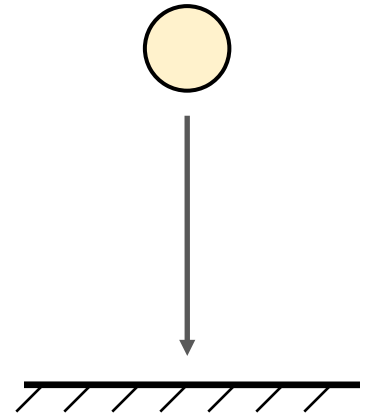


Stretching the Time

- Airbags and crumple zones
- Helmet foam
- Bend your knees when you land
- Catch an egg gently



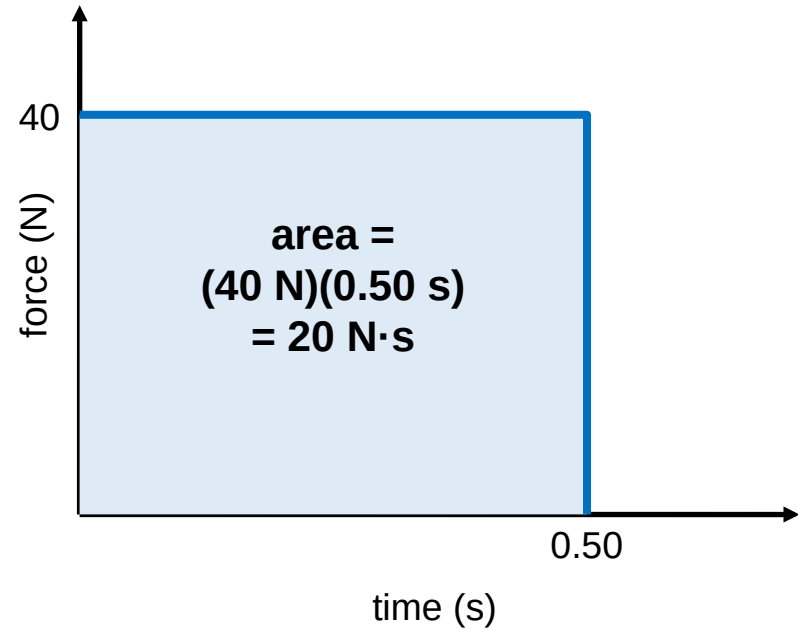
longer Δt
smaller F
egg survives



shorter Δt
bigger F
egg breaks

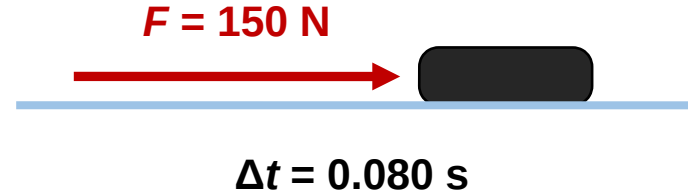
Force-Time Graphs

- Area under the curve = impulse
- Rectangle: $F \times \Delta t$
- Triangle: $\frac{1}{2} \times \text{base} \times \text{height}$



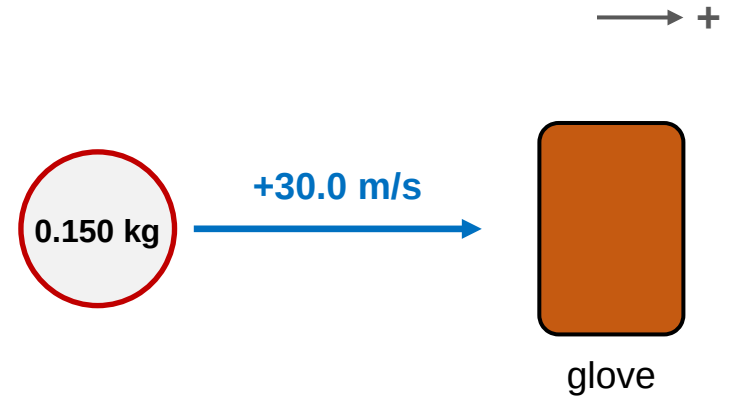
Example: Finding Impulse

A hockey stick pushes a puck with an average force of 150 N for 0.080 s. What impulse does the stick give the puck?



Example: Catching a Baseball

A 0.150 kg baseball moving right at 30.0 m/s is caught and stopped by a glove in 0.0500 s. What average force does the glove exert on the ball?



Example: Airbag vs. Dashboard

A 70.0 kg driver moving at 15.0 m/s is brought to a stop. Find the size of the average force on the driver if an airbag stops him in 0.300 s, and if the dashboard stops him in 0.0150 s.

Airbag

$$\Delta t = 0.300 \text{ s}$$

same Δp

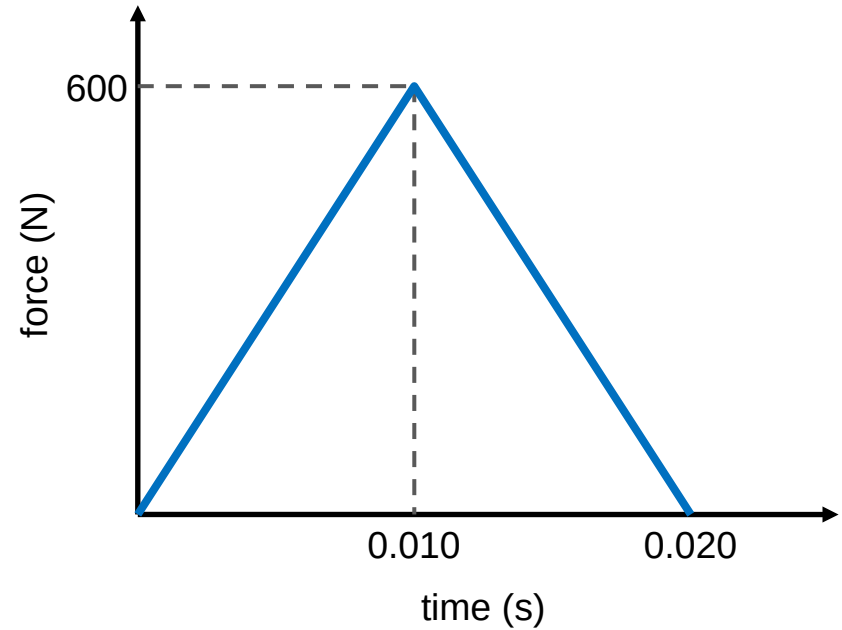
Dashboard

$$\Delta t = 0.0150 \text{ s}$$

same Δp

Example: Force-Time Graph

A 0.40 kg soccer ball at rest is kicked. The graph shows the force on the ball. Find the impulse and the ball's final speed.



Big Ideas

- Impulse = force $\times$ time, $J = F\Delta t$
- Impulse = change in momentum, Δp
- More time means less force
- Area under F - t graph = impulse