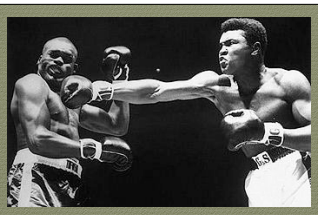


"It isn't the mountains ahead to climb that wear you out; it's the pebble in your shoe."
- Muhammad Ali

Pain and Collisions

Momentum, Impulse, and Pressure

Extra Practice Problems: 5.1, 5.7, 5.9, 5.11, 5.13, 5.15, 5.17, 9.3, Conceptual 9.1

Today

Momentum (p).
(mass times velocity)

Impulse (I).
(change in momentum)

Pressure (P).
(force over some area of space)

Momentum

Think of a time when you've heard this term.

(Linear) Momentum

Mass times Velocity.

$\vec{p} = m\vec{v}$ SI units: $\frac{\text{kg m}}{\text{s}}$

Direction of momentum is
same as direction of velocity!

(Linear) Momentum

Mass times Velocity.

$\vec{p} = m\vec{v}$ SI units: $\frac{\text{kg m}}{\text{s}}$

$|p|$ = 12 kg m/s

>

$|p|$ = 0 kg m/s

Let's try it

A pitcher claims he can throw a **0.145 kg baseball** with as much momentum as a **3.00 g bullet** moving with a speed of **1500 m/s!**

What must the baseball's speed be if the pitcher's claim is valid?

Which has greater kinetic energy?

$p = mv$

$KE = \frac{1}{2}mv^2$

A. the ball
B. the bullet
C. they are the same

Q51

Impulse

Change in Momentum.

$\vec{I} = \Delta\vec{p} = m\vec{v}_f - m\vec{v}_i$

SI units: $\frac{\text{kg m}}{\text{s}}$

Impulse

Are impulses bad if acted on too quickly?

(Usually…!)

Newton's Second Law Revisited

$$\boldsymbol{F}_{\text{net}} = m\boldsymbol{a}$$

$$\boldsymbol{F}_{\text{net}} = \frac{\Delta \boldsymbol{p}}{\Delta t}$$

This is the general form of Newton's 2nd Law.

Impulse

Can also be written as average/constant force (F) on an object times the duration of that force, Δt

$$\boldsymbol{F}_{\text{net}}\,\Delta t = m\boldsymbol{v}_f - m\boldsymbol{v}_i$$

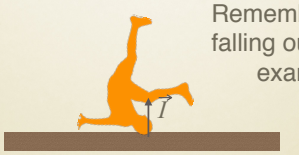
Time is the collision time (start to end of impact).

Direction of impulse is the same as the direction of the force acting on an object (note: impulse only happens if there's a force!).

Impulse

Impulses hurt if acted on too quickly!

$$\boldsymbol{F}_{\text{net}}\,\Delta t = m\boldsymbol{v}_f - m\boldsymbol{v}_i$$

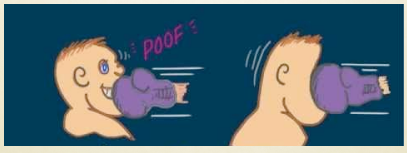


Remember "child falling out of bed" example!

Impulse

Impulses hurt if acted on too quickly!

$$\boldsymbol{F}_{\text{net}}\,\Delta t = m\boldsymbol{v}_f - m\boldsymbol{v}_i$$



$F\Delta t$ $F\Delta t$

"Rolling with the punches"
Boxers opt for more Δt rather than more force!

Food generates the lady's impulse.

The wall generates the car's impulse.

A 100-g lump of clay hits a wall at 70 cm/s and sticks. A 100-g rubber ball hits the same wall at 60 cm/s and rebounds with a speed of 30 cm/s.

Which object has a larger impulse magnitude delivered by the wall during the collision?

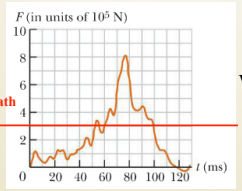
A. The clay
B. The ball
C. Both impulses are the same.
D. Cannot be determined.

Q52

Impulse and Average Force

What if the force isn't constant?

Force vs time in a car crash



Where is the biggest impulse?

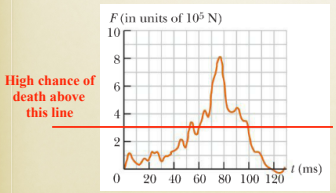
A. Between 70 and 80 ms
B. Between 10 and 20 ms
C. Between 100 and 110 ms
D. Before the collision

Q53

Impulse and Average Force

A car is **travelling at 27 m/s** (60 mph) and crashes into a pole, coming to **rest** in time **150ms**. What is the ***average*** force exerted on a **100kg person** strapped into the car in this collision?

$$\boldsymbol{F}_{\text{avg}}\,\Delta t = m\boldsymbol{v}_f - m\boldsymbol{v}_i$$



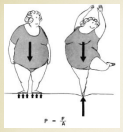
Always wear seatbelts!

Pressure

Force over Area.

Which hurts more?

Damage depends more on pressure than force!



Pressure

Force over Area.

Pressure or Stress = F / A

SI units: Pascal (Pa) $\frac{N}{m^2}$

Pressure (mainly for liquids and gases) or **Stress** (for solids) tells you over what area the force is spread.

Man on a Chair

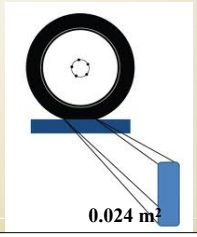
A man sits on a four-legged chair with his feet off the floor. The combined mass of the man and chair is 95 kg. If the chair legs are circular and have a radius of 0.50 cm at the bottom, what pressure does each leg exert on the floor?

What could you do to reduce pressure and chance of scratching?

Car Tires

The four tires of an automobile are inflated to a gauge pressure of **2.0×10^5 Pa**. Each tire has an area of **0.024 m²** in contact with the ground. Determine the weight of the automobile.

P = F / A



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