momentum, impulse, conservation of momentum, and elastic/inelastic collisions

Sources:
https://openstax.org/books/physics/pages/8-1-linear-momentum-force-and-impulse

linear: $\vec{p} = m\vec{v}$ (momentum, mass, velocity)

angular: $\vec{L} = I\vec{\omega}$ (angular momentum, moment of inertia, angular velocity)

back to newton's second law: $F = ma = \frac{\Delta p}{\Delta t}$

$\boxed{\Delta p = F_{net}\Delta t}$ - impulse-momentum theorem

**Grasp Check**

You may have heard the advice to bend your knees when jumping. In this example, a friend dares you to jump off of a park bench onto the ground without bending your knees. You, of course, refuse. Explain to your friend why this would be a foolish thing. Show it using the impulse-momentum theorem.

a. Bending your knees increases the time of the impact, thus decreasing the force.
b. Bending your knees decreases the time of the impact, thus decreasing the force.
c. Bending your knees increases the time of the impact, thus increasing the force.
d. Bending your knees decreases the time of the impact, thus increasing the force.

(answer is d)

## Conservation of momentum

- If there are no outside forces acting on the system, then momentum is conserved; $\sum m v_1 = \sum m v_2$

discussion question: in a spacecraft with a centrifuge to generate artificial gravity. say you're doing <something> - is momentum conserved? what if the centrifuge itself is considered part of the system?

Momentum is NOT conserved in the (non-inertial) reference frame of someone inside the centrifuge, since there would appear to be an outside force acting on the system.

If centrifuge is part of system, then YES. "Gravity" (centrifugal force) is now internal to the system.

- Similarly, if net external torque ($\tau$) is 0, then angular momentum is conserved; $\sum \vec{L}_1 = \sum \vec{L}_2$

## Elastic & inelastic collisions

elastic collision: objects separate after impact and kinetic energy is conserved (velocity is also reversed - problem 9.16 in 3000 Solved Problems in Physics)

inelastic collision: objects stick together after impact, kinetic energy is NOT conserved

coefficient of restitution: $e = \frac{|v_{2f} - v_{1f}|}{|v_{2i} - v_{1i}|} = \frac{\text{relative speed after impact}}{\text{relative speed before impact}}$

elastic: $e = 1$ (never happens - but can approximate)

normal: $0 < e < 1$

purely inelastic: $e = 0$

final velocities for head-on elastic collisions:

$$v_{1f} = m_1 - m_2$$