8.5 Inelastic Collisions

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What is an Inelastic Collision?

- The internal energy changes
- Energy is not conserved
- Things stick together rather than bounce against each other

More on Inelastic Collisions

- Lack of conservation means that the forces between colliding objects may remove or add internal kinetic energy

- Work done by internal forces may change the forms of energy within a system
  - For inelastic collisions, the internal work may transform some internal kinetic energy into heat transfer
  - May convert the stored internal energy into internal kinetic energy
    - Ex) when exploding bolts separate a satellite from its launch vehicle

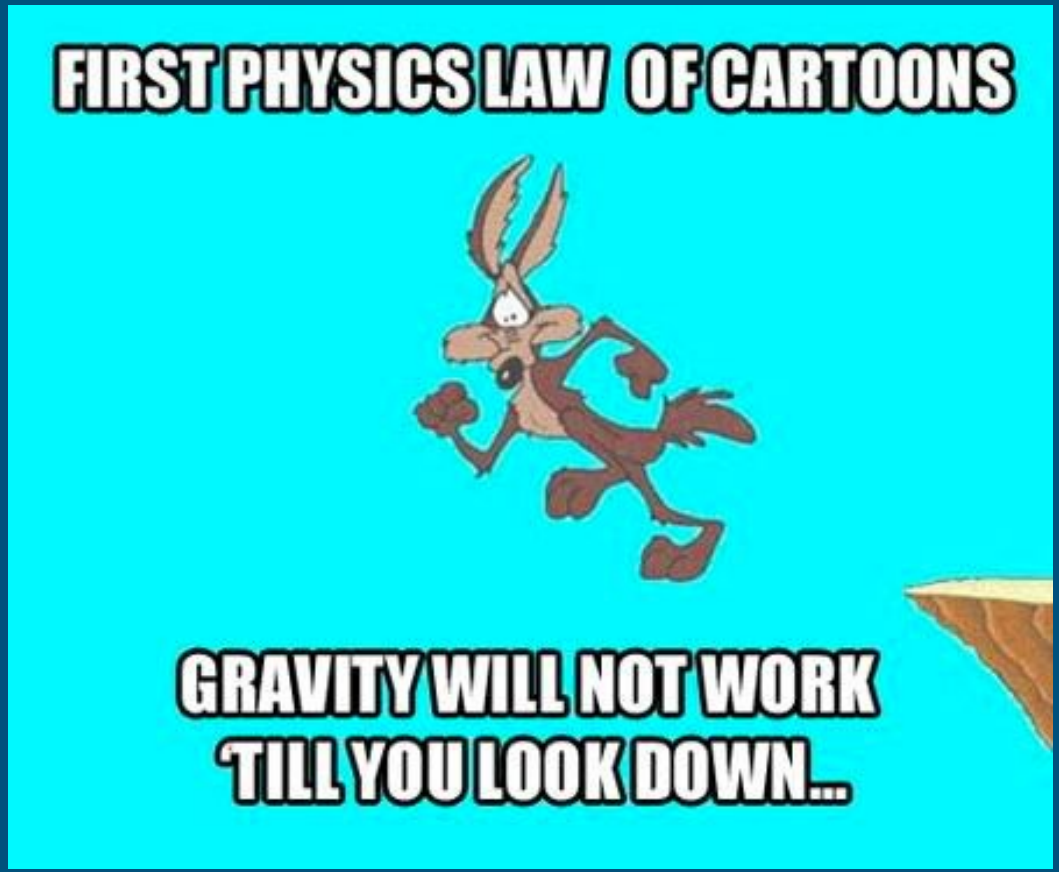
Equations

Total Kinetic Energy: $\frac{1}{2}mv^2+\frac{1}{2}mv^2=mv^2$

Conservation of Momentum: $m_1v_1=(m_1+m_2)v'$

Recoil: $v'=(m_1/m_1+m_2)v_1$

Energy in a collision: $\frac{1}{2}(m+M)v^2$

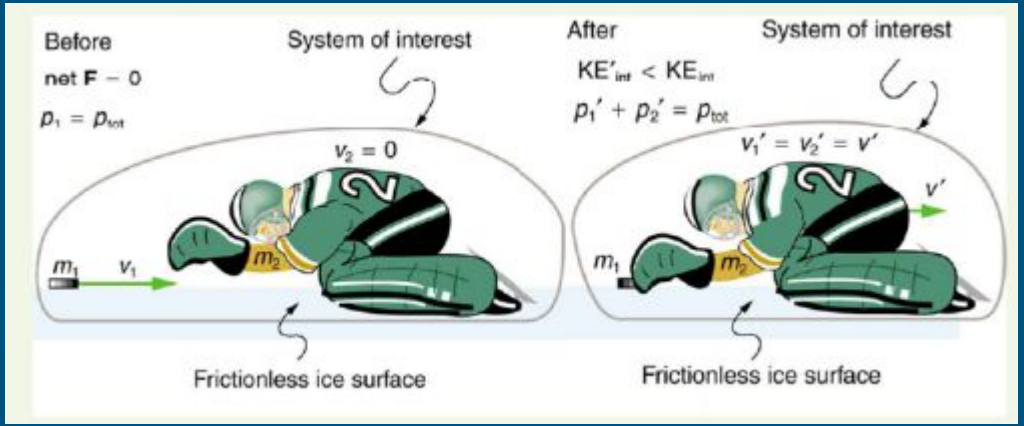

FIRST PHYSICS LAW OF CARTOONS
GRAVITY WILL NOT WORK
'TILL YOU LOOK DOWN...

Homer Simpson wrecking ball inelastic collisions

Example Problem

a. Find the recoil velocity of a 70.0 kg ice hockey goalie, originally at rest, who carries a 0.150 kg hockey puck slapped at him at a velocity of 35.0 m/s
b. How much kinetic energy is lost during the collision? Assume friction between the ice and the puck goalie system is negligible

Info on Problem



- The goalie catching the puck is pushed backwards
- When caught, the kinetic energy of the puck is converted into sound and thermal energy in the inelastic collision
- No external force on the goalie
- Conservation of momentum can be used to find the final velocity of the puck
- Once the final velocity is found, kinetic energy can be calculated before and after the collision

Steps to completing problem

- Conservation of momentum formula: $P_1 + P_2 = P'_1 + P'_2$ or $m_1v_1+m_2v_2=m'_1v'_1+m'_2v'_2$
- Since $v'_1=v'_2=v'$, The equation is simplified to $m_1v_1=(m_1+m_2)v'$ Which will become $v'=(m_1/m_1+m_2)v_1$ $v'=(0.150kg/(0.150kg+70.0kg)(35.0m/s)^2$ $v'=0.0748m/s$
- As a result, it is shown that the recoil velocity will be extremely small
- In the example of a perfect elastic collision, there is nearly zero recoil

$$\begin{aligned} \mathrm{KE}_{\mathrm{int}} &= \tfrac{1}{2}mv^2 = \tfrac{1}{2}(0.150\ \mathrm{kg})(35.0\ \mathrm{m/s})^2 \\ &= 91.9\ \mathrm{J}. \end{aligned}$$

After the collision, the internal kinetic energy is

$$\begin{aligned} \mathrm{KE}'_{\mathrm{int}} &= \tfrac{1}{2}(m+M)v^2 = \tfrac{1}{2}(70.15\ \mathrm{kg})(7.48\times 10^{-2}\ \mathrm{m/s})^2 \\ &= 0.196\ \mathrm{J}. \end{aligned}$$

The change in internal kinetic energy is thus

$$\begin{aligned} \mathrm{KE}'_{\mathrm{int}} - \mathrm{KE}_{\mathrm{int}} &= 0.196\ \mathrm{J} - 91.9\ \mathrm{J} \\ &= -91.7\ \mathrm{J} \end{aligned}$$

Inelastic Collisions in Everyday Life

- Collisions constantly occur in sports
  - In tennis a heavier tennis racket has a larger advantage over a lighter one.
  - Location of contact is also important since a smooth motion and contact will maximize velocity and therefore distance
    - Maximizing the velocity also helps in reducing certain injuries such as tennis elbow
  - All sports use some type of momentum, rotational motion, and vibrations


OH, YOU'RE A FAN OF COLLISION?
EISENSTEIN WOULD BE PROUD.

Lab

- Two gliders on a hover track
- Meant to show how inelastic collisions work
- They stick together which is what happens in inelastic collisions

Lab- Your Turn

Find the recoil of the glider that is moving when it hits the other glider:

Mass of glider hitting: 189.8g

Mass of glider being hit: 189.7g

Velocity: 0.0485 cm/s

Lab Answer

Recoil is .0243 cm/s

Conceptual Questions #16

16. What is an inelastic collision? What is a perfectly inelastic collision?

An inelastic collision is one in which the kinetic energy is turned into other forms of energy such as heat or sound.

A perfect inelastic collision will result in all of the kinetic energy being lost in other forms of energy(Ex: Temp, sound, etc.)

Homework Problems #31

31. A 0.240-kg billiard ball that is moving at 3.00 m/s strikes the bumper of a pool table and bounces straight back at 2.40 m/s (80% of its original speed). The collision lasts 0.0150 s. (a) Calculate the average force exerted on the ball by the bumper. (b) How much kinetic energy in joules is lost during the collision? (c) What percent of the original energy is left?

Answers

a. -86.4N
b. 0.3888 J is lost
c. 64%

Homework Problem #34

34. A battleship that is 6.00×10^7 kg and is originally at rest fires a 1100-kg artillery shell horizontally with a velocity of 575 m/s. (a) If the shell is fired straight aft (toward the rear of the ship), there will be negligible friction opposing the ship's recoil. Calculate its recoil velocity. (b) Calculate the increase in internal kinetic energy (that is, for the ship and the shell). This energy is less than the energy released by the gun powder—significant heat transfer occurs.

Answers:

a. 0.0105 m/s
b. KEint=181843750J KE'int=3307.56 KEint=-181840442.4

Homework Problem # 37

37. Professional Application

Space probes may be separated from their launchers by exploding bolts. (They bolt away from one another.) Suppose a 4800-kg satellite uses this method to separate from the 1500-kg remains of its launcher, and that 5000 J of kinetic energy is supplied to the two parts. What are their subsequent velocities using the frame of reference in which they were at rest before separation?

Answer: 0.7043 m/s and -2.25 m/s

Homework #40

40. Professional Application

The Moon's craters are remnants of meteorite collisions. Suppose a fairly large asteroid that has a mass of 5.00×10^{12} kg (about a kilometer across) strikes the Moon at a speed of 15.0 km/s. (a) At what speed does the Moon recoil after the perfectly inelastic collision (the mass of the Moon is 7.36×10^{22} kg) ? (b) How much kinetic energy is lost in the collision? Such an event may have been observed by medieval English monks who reported observing a red glow and subsequent haze about the Moon. (c) In October 2009, NASA crashed a rocket into the Moon, and analyzed the plume produced by the impact. (Significant amounts of water were detected.) Answer part (a) and (b) for this real-life experiment. The mass of the rocket was 2000 kg and its speed upon impact was 9000 km/h. How does the plume produced alter these results?

a. 1.019E-9
b. KE=5.625E14 KE=2.59E-6 KElost=-5.625E14

Homework#43

43. During a circus act, an elderly performer thrills the crowd by catching a cannon ball shot at him. The cannon ball has a mass of 10.0 kg and the horizontal component of its velocity is 8.00 m/s when the 65.0-kg performer catches it. If the performer is on nearly frictionless roller skates, what is his recoil velocity?

Answer:

1.067 m/s

Thanks for listening!!