Announcements

1. Exam 1 scores now available via class website. CHECK YOUR SCORE!
   a. Some of you are getting zeroes because you had a typo when you entered in your BYU ID back when you were assigned a CID.
2. Exam 2 upcoming!
   a. It will cover chapters 4 and 5—Newton's Laws, forces, work energy, power.
   b. It covers HW 5-10.
   c. Exam will start on Friday Oct 19.

Where are we now?

Course Objectives (from syllabus):
"This course will help you
- develop a new understanding of the physics of motion
- give you a greater ability to predict and control
  - mechanical and
  - thermodynamic systems.

You will learn and apply
- mathematical methods
- reasoning
- general problem solving skills

These new concepts and skills should
- enhance your experience of the physical world
- prepare you to use
  - physical concepts
  - devices
  - instruments

We hope your appreciation for the order, simplicity and complexity of God's creations will increase."

Where are we now?

Topics (from class schedule)

Kinematics
Forces & Newton's Laws
Work & Energy
Momentum
Circular Motion
Torque
Pressure
Fluids & Solids
Temperature
Gases
Thermodynamics
Waves

Collisions

Newton's third law says the forces in the collision are…

Draw the forces.

$\Delta v_1 = a_1 t$ $\Delta v_2 = a_2 t$

$m_1 \Delta v_1 =$ $m_2 \Delta v_2 =$

$m_1 \Delta v_1 + m_2 \Delta v_2 =$

If we define $\boxed{p = mv}$ then $\Delta p_{total} =$

Total momentum is conserved in any collision!
(if forces external to the group can be neglected)

Demo: airtrack, two gliders, bullet and gun

Momentum and collisions

$$\Sigma\vec{p}_{bef} = \Sigma\vec{p}_{aft}$$

Include momentums of <u>all</u> objects on both sides of eqn

→ if and only if no external forces

Conservation laws:
- when only "before" and "after" matter
- details of what goes on in-between are unimportant

If collision is quick enough, external forces can be ignored

Elastic collisions: <u>energy is conserved</u>
"Little-known true fact": *Relative* velocities reverse
$(v_1 - v_2)_{bef} = (v_2 - v_1)_{aft}$

Inelastic: everything else

Perfectly inelastic:

Demo: elastic and inelastic gliders
two similar balls

Strategies for momentum problems

1-D problems

1. Draw initial and final pictures separately
2. Choose a positive direction for velocities
3. Draw all velocity vectors and label masses
4. Use $\Sigma\vec{p}_{bef} = \Sigma\vec{p}_{aft}$ first and see if it gives you enough information to solve for the unknowns. Make the **sign** of v's used match their **direction**.
5. If it's truly "elastic", you can also use $KE_{total,initial} = KE_{total,final}$ (<u>or</u> use concept that *relative* velocities are *reversed*)

2-D problems

1. Draw a sketch of the motion before and after, including m's and v's.
2. Draw vector diagrams representing vectors of total momentum $\mathbf{p}_i$ and $\mathbf{p}_f$
3. Use $\mathbf{p}_i = \mathbf{p}_f$ or $p_{xi} = p_{xf}$ and $p_{yi} = p_{yf}$

Problem: A 100 kg defensive end running north at 4 m/s tackles a 75 kg quarterback running south at 7 m/s.
a) What is their velocity right after the tackle?

b) How much kinetic energy was gained or lost in the collision?

Demo: 2-d collision

Problem: A 100 kg defensive end running north at 4 m/s tackles a 75 kg quarterback running *east* at 7 m/s. What is their velocity right after the tackle?

An artillery shell of mass 20 kg is moving east at 100 m/s. It explodes into two pieces. One piece (mass 12 kg) is seen moving north at 50 m/s. What is the velocity (magnitude and direction) of the other piece?

Before: After:

Q4. General direction of the other piece?

a. NE c. SE
b.NW d. SW

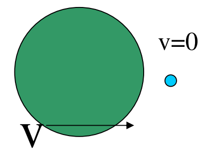
Q5. Magnitude of the other piece's momentum?

a. 0-200 kg m/s d. 600-800
b. 200-400 e. more than 800 kg m/s
c. 400-600

Then its velocity = ___________

Elastic collision very large and very small mass

Bowling ball and a marble! Marble is at rest.



Bowling ball won't slow down much, so its v will be almost *unchanged*.

Use the *relative velocity reversal* to find the final speed of the marble in terms of the bowling ball's velocity v!

"Velocity multiplier" Demo

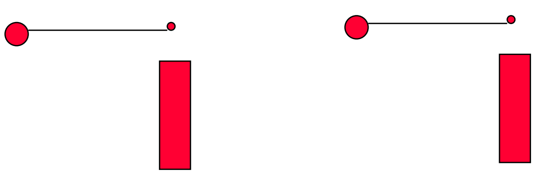
Elastic collision of two *equal* masses, head-on

What if masses are equal?

Demo: Newton's cradle, and airtrack

Which "hits harder"?

The board falls in one case. Hint: In which case does the momentum of the ball change the most?



Elastic collision, bounces off

Very **inelastic** collision, no bounce

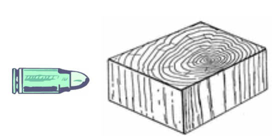
Demo: inelastic pendulum collision

Problems that involve p and E conservation at *different times*

1. Collision part: p is conserved but KE usually is not.
2. Motion part: Use conservation of energy.

A girl of mass m hangs on a rope. A boy of mass M runs at speed v horizontally and jumps on the rope, too. How high do they swing off the ground?

A bullet of mass m and speed v embeds in a block of wood of mass M at rest on the floor. If the frictional force on the block is f, how far does the block slide?



Momentum and the center of mass

Center of mass:

Finding the CM

Velocity of the center of mass:

Center of mass motion:

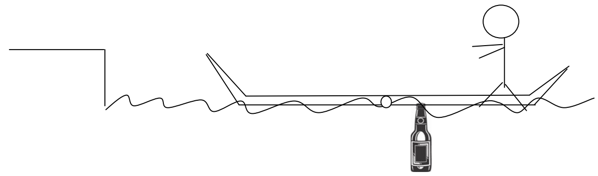
Only forces <u>outside</u> *a closed system can change the motion of the center of mass.*

Fireworks, explosions

Rocket motion in space

Video: fire extinguisher rocket

Fernando is at the end of the boat away from the shore. He has lost his paddles. If he runs to the left end of the boat and then stops, what will happen? (Assume **frictionless water**)



Imagine a bottle floating in the water to mark the original CM position.

Q6. While he's running, the center of mass (CM) of the Fernando-boat system is (viewed from the shore)
- a. moving to the left
- b. holding still
- c. moving to the right

Q7. While he's running the boat will be ____
- a. moving to the left
- b. holding still
- c. moving to the right

Q8. He will be ____ from shore, compared to his first position.
- a. closer
- b. the same
- c. farther