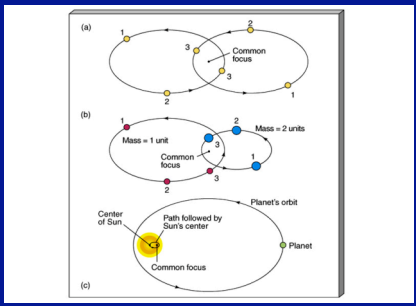
Newton's Correction to Kepler's First Law

The orbit of a planet around the Sun has the common center of mass (instead of the Sun) at one focus.



Clicker Question:

A flaw in Copernicus's model for the solar system was:

A: It didn't explain retrograde motion.

B: He used circular orbits.

C: The Earth was still at the center.

D: He used the same mass for all the planets.

E: All of the above

Clicker Question:

How long does it take the space shuttle to orbit the Earth once?

A: 10 minutes

B: 90 minutes

C: 1 day

D: 1 week

Clicker Question:

Suppose Matt weighs 120 lbs on his bathroom scale on Earth, how much will his scale read if he standing on a platform 6400 km high (1 Earth radius above sea-level)?

A: 12 lbs

B: 30 lbs

C: 60 lbs

D: 120 lbs

E: 240 lbs

Phases of Matter and Fluid Mechanics

- What are the different phases of matter and some of the properties of each?

Phases of Matter

- What are the different phases of matter and some of the properties of each?
  - Solid: Fixed shape
  - Liquid: Takes shape of container, incompressible
  - Gas: Takes shape of container, easily compressible
    - Gas and liquids both flow => both are "fluids"
  - Plasma: A gas that is electrified or "ionized"

Density

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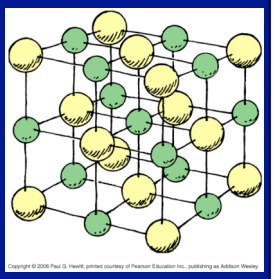
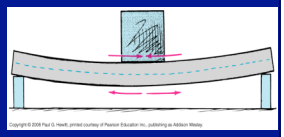
  - How is density related to atomic structure?
    - The more closely packed the atoms, the greater the density of an object.
  - What can we say about the atoms in a solid to account for its fixed shape?
    - Interatomic forces hold the molecules of a solid in fixed locations

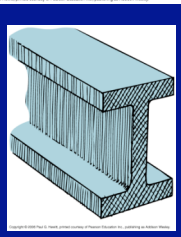


The density of an object is a measure of its compactness.

Tension and Compression

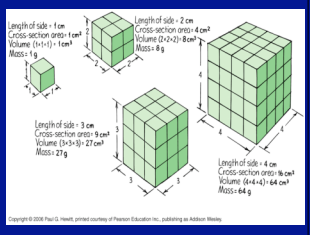
- Tension – stretching
  - Atoms pulled apart
- Compression – squeezing
  - Atoms pushed together
- Which part of the beam is
  - under tension?
  - under compression?
  - under no stress at all?
- So, what is the benefit of an I-beam vs. a solid beam?





Scaling

- An ant can lift several times its own body weight
  - Why can't an elephant do the same thing?
    - Objects grow heavier at a faster rate than they grow stronger
      - Strength related to 2-d cross-sectional area
      - Weight is related to volume
  - What happens to the area to volume ratio of an object as its size increases?



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- Why can a lady bug fall out of a tree unharmed, but a person cannot?
  - Air resistance more effective for larger surface area to volume ratio (crushed vs. uncrushed feather)
    - Bug acts as its own parachute!

Liquids

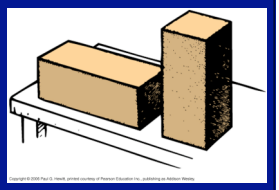
- Molecules are not confined to fixed positions
  - Can flow by sliding over one another
- Very difficult to compress
  - What does this imply about the spacing between molecules in a liquid?
  - How do you think this compares to the spacing between molecules in a gas?

Pressure

- Pressure is a force divided by the area over which the force is exerted

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

- Which block feels the greatest gravitational force?
- Which block exerts the greatest pressure on the table?

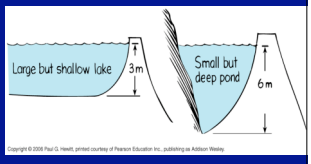


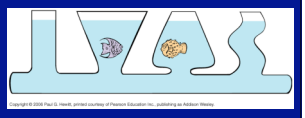
Pressure in a Liquid

- Pressure in a liquid increases with depth
  - Felt in your ears at the bottom of a swimming pool

Pressure = Weight density * depth

  - Weight density = weight per unit volume
- Which body of water exerts the greatest pressure on the dam?
- Which fish feels the greatest pressure?





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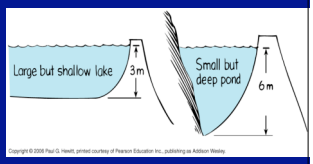
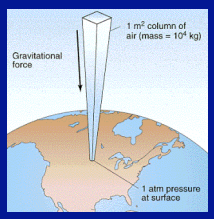
  - Pressure only depends on depth



DEMO : Pascal Tubes, Water Traj.

Atmospheric Pressure

- We are at the bottom of the atmosphere
  - At sea level 1 m^3 of air weighs 1.2 kg
  - Pressure is 101 kPa (aka 1 atmosphere or 14.7 psi)
  - kPa = kiloPascals
  - psi = pounds per square inch



DEMO : Crush the Can

Clicker Question:

Which material is most resistent (doesn't break apart) under tension?

A: a concrete block

B: a strand of spaghetti

C: a steel bar

D: a strong man

Clicker Question:

A car has tires at 40 psi measured warm at sea level. Suppose the car is driven up a mountain to 10,000 feet elevation. What will happen to the tire pressure?

A: increase

B: decrease

C: stay the same

D: can't say

Clicker Question:

To measure the density of an object we need to know what?

A: mass and circumference

B: volume and width

C: mass and volume

D: weight and height

Buoyancy

- The apparent loss of weight of a submerged object
  - Objects under water are much easier to lift
- In what direction does the buoyant force point?
- What is the source of this force?

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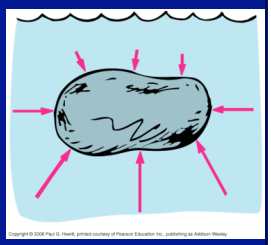
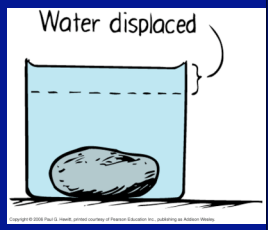
- The apparent loss of weight of a submerged object
  - Objects under water are much easier to lift
- In what direction does the buoyant force point?
  - Up (in direction of least pressure)
- What is the source of this force?
  - The pressure *difference acting on the top and bottom of the object*



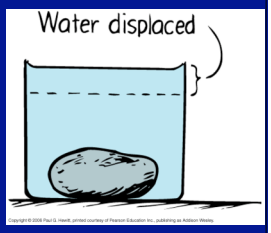
Archimedes' Principle

- An immersed object is buoyed up by a force equal to the weight of the fluid it displaces
  - What property of an object determines how much fluid a completely submerged object will displace?



Archimedes' Principle

- An immersed object is buoyed up by a force equal to the weight of the fluid it displaces
  - What property of an object determines how much fluid a completely submerged object will displace?
    - The volume of the object
      - Regardless of shape, mass
    - For partially submerged object, it is the volume of the submerged part
      - Boat



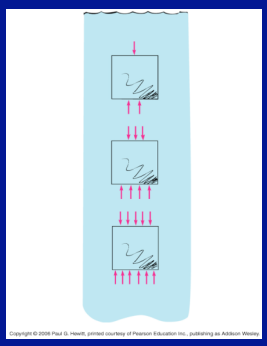
DEMO : Archimedes Principle

Archimedes' Principle (Cont.)

- Does Archimedes' principle depend on depth?

Archimedes' Principle (Cont.)

- Does Archimedes' principle depend on depth?
  - No. Volume of fluid displaced by submerged object is the same at any depth.
  - Buoyant force only depends on pressure differences
    - Same at any depth



Sink or Float

- An object more (less) dense than the fluid in which it is immersed will sink (float).
  - What must you do to increase your buoyancy in water?

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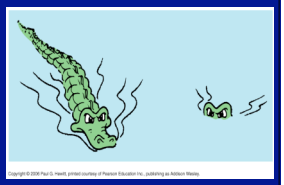
- An object more (less) dense than the fluid in which it is immersed will sink (float).
  - What must you do to increase your buoyancy in water?
    - Decrease your density
      - Life jacket increases volume while adding very little weight
- An object with a density equal to the surrounding fluid will neither sink nor float.
  - Fish (air sac) and submarines (ballast) can vary their densities



Crocodiles increase their density by swallowing stones.

DEMO : Cartesian Diver

The Principle of Flotation

- How is it that an iron ship will float in water?
- How much water must be displaced for an object to float?

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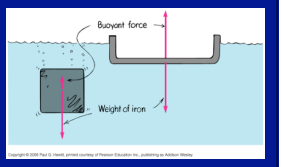
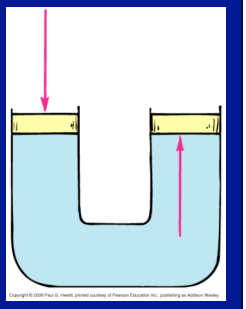
- How is it that an iron ship will float in water?
- How much water must be displaced for an object to float?
- Principle of flotation
  - A floating object displaces a volume of fluid with a weight equal to its own weight.



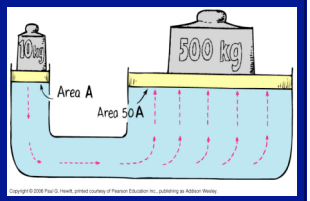
Pascal's Principle

- A change in pressure at any point in an enclosed fluid at rest is transmitted undiminished to all points in the fluid.
  - Direct consequence of incompressibility
- How can we use this fact to lift a very heavy load by applying a force that is only a small fraction of the weight of the object?



The Hydraulic Press

- Force = Pressure * Area
  - Area at right is 50 times area at left, and so is the force!
- Pascal's Principle enables us to multiply forces
- Why doesn't this violate conservation of Energy?



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- Why doesn't this violate conservation of Energy?
  - Load is raised only 1/50th of the distance that the light load descends!
    - Work = Force * Distance