Buoyancy

Chapter 15: Walker

Brainstorm

- Buoyancy in everyday life:

Buoyancy in physics has a much more specific definition

Density

First we need the concept of density

- Density:

$$\rho = M/V$$

  - ρ is the density ("rho")
  - M is the mass
  - V is the volume

- Units: kg/m^3

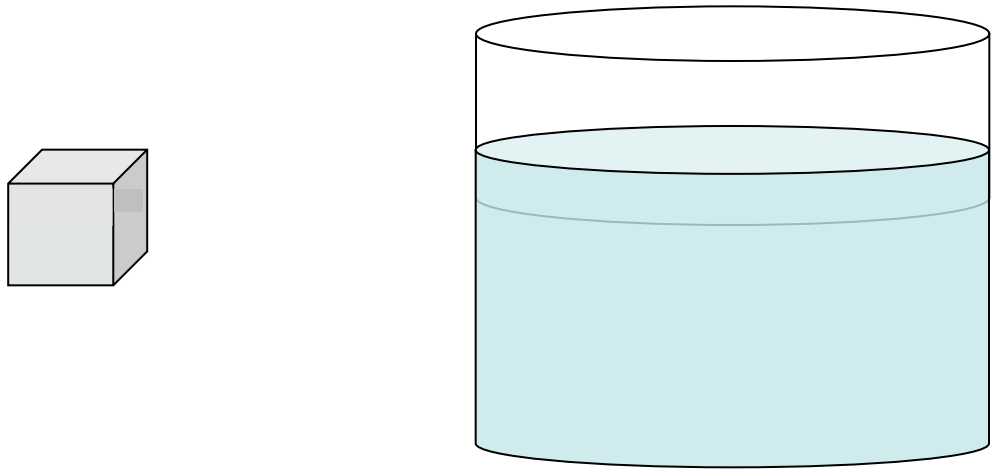
- e.g. density of water is 1000 kg/m^3.

Volume of Water Displaced

- Depends on only the *volume* of object *under water*, not the mass, weight, density, or shape of the object.

"Eureka"

- Method for measuring volume displaced



Buoyant Force

- Archimedes principle: an object completely or partially submerged in a fluid is buoyed up by a buoyant force (B) equal to the weight of the liquid displaced (W_{liq}):

$$B = W_{liq} = M_{liq}g = g\rho_{liq}V_{disp}$$

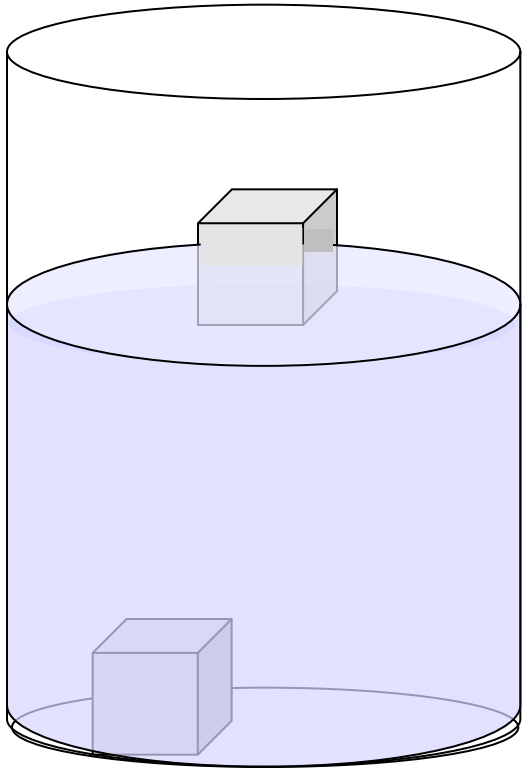
  - M_{liq} is the mass of the liquid
  - ρ_{liq} is the density of the liquid
  - V_{disp} is the volume of liquid displaced (the volume of the part of the object that's under water)

Discussion: Buoyant Force

- Two blocks with the same volume are dropped into a tank of water. The blocks are made of different materials. The first block floats with half the block below the surface of the water. The second block sinks and remains at the bottom of the tank.
- How does the buoyant force on block 1 compare to the buoyant force on block 2?

For floating object, the volume of fluid displaced is less than the volume of the object.

→ $B_{submerged} > B_{floating}$



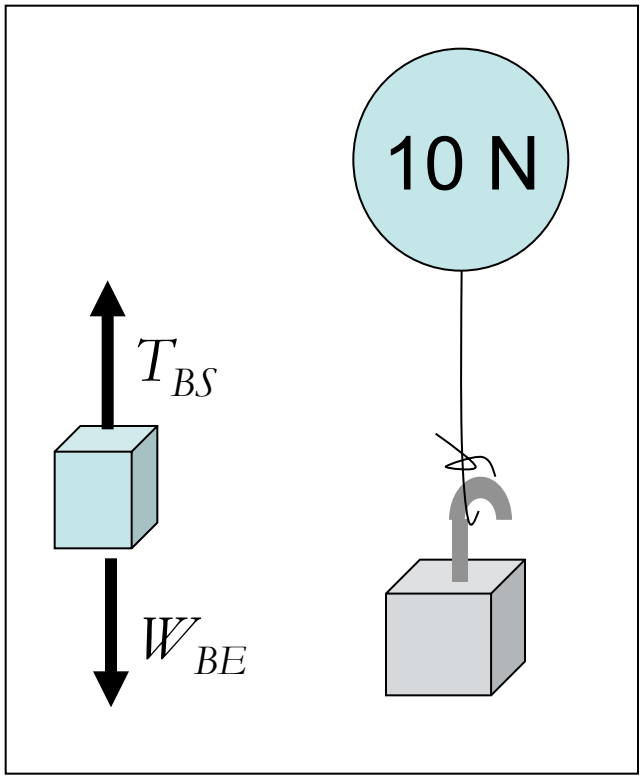
Evidence for the Buoyant Force

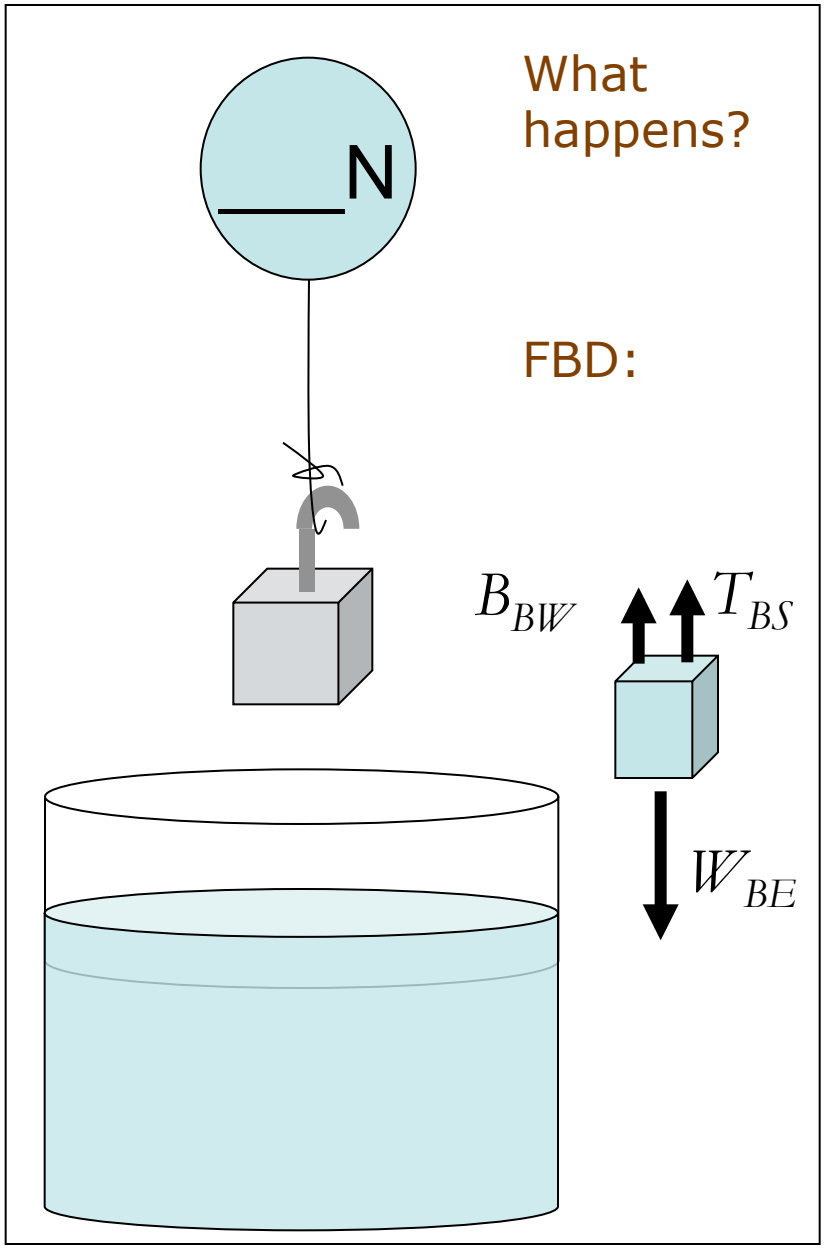
A 1 kg block is hung from a spring scale 10 N. Predict: if the block is placed in water the reading will

(A) Increase

(B) Decrease,

(C) Remain the same





Measuring Buoyant Force

Use your free-body diagram and Newton's second law for an object at rest to write an equation that relates the weight of the block to the other force or forces. (*Hint:* What is the net force acting on each block?)

This equation suggests a procedure for determining the magnitude of the buoyant force on a completely submerged object. How do you measure it?

Sink or Float? Use FBD

Case 1: Suppose an ice cube is floating in the water as shown.

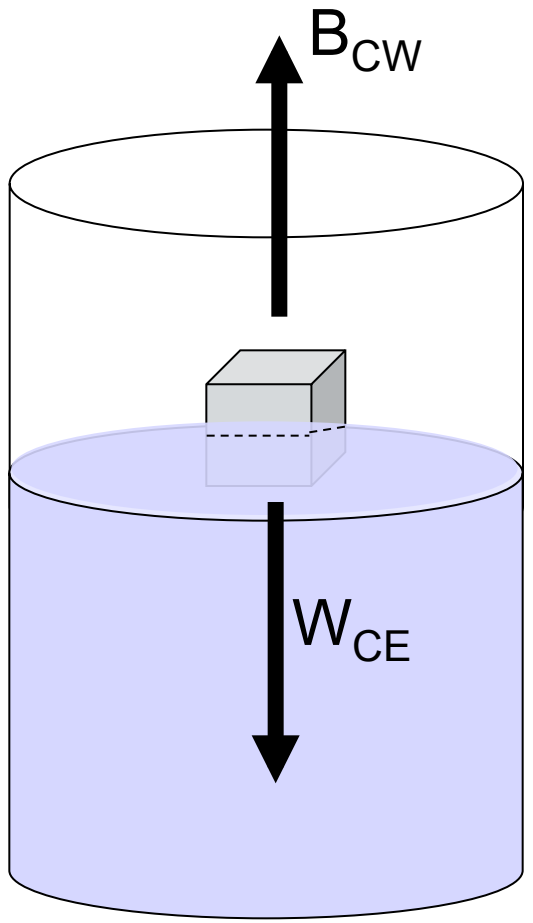
- Sketch the forces exerted on the ice cube.
- How does the magnitude of the buoyant force compare to the weight of the ice cube?

  $B_{CW} = W_{CE}$
- How does the volume of water displaced compare to the volume of the object?

  $V_{disp} < V_{obj}$
- How does the magnitude of the buoyant force compare to the weight of the water displaced?

  $B_{CW} = W_{WE}$

Compare weight of object and buoyant force



Use the Phet to compare weight of object and buoyant force

Case 2: an ice cube that is totally submerged

- Draw FBD (write down force values):

- Compare B to weight of object: $B_{CW} > W_{CE}$
- Compare V of object and of liquid displaced: $V_{disp} = V_{obj}$
- Compare B to weight of liquid displaced: $B_{CW} = W_{WE}$

Will it sink or float?

Case 3: cube of iron of the same size that is submerged

- Draw FBD (write down force values):

- Compare B to weight of object: $B_{CW} < W_{CE}$
- Compare V of object and of liquid displaced: $V_{disp} = V_{obj}$
- Compare B to weight of liquid displaced: $B_{CW} = W_{WE}$

Will it sink or float?

Lab: Buoyancy

- Volume displaced
- Buoyant force
- Whether an object will sink or float