INTRO TO BUOYANCY & BUOYANT FORCE

● Objects immersed in liquids are pushed UP by a force called Buoyant Force **(F_B).**

- This happens due to a pressure difference between the Top & Bottom →
- ARCHIMEDES' PRINCIPLE**:** The magnitude of Buoyant Force is **"**the same as the weight of the liquid displaced**"**
    - → **F_B = ____________________**   - Remember: **$\rho_{,OBJ}$ = __________________**
    - The density that matters**:** density of **________________**, NOT of object**.**
    - The volume that matters**:** volume **_____________________________**, not necessarily the entire volume**.**
- MOST Buoyancy problems are FORCE problems **(**$\sum F = ma$**).** Most the time, objects are at rest AND equilibrium**.**

EXAMPLE**:** When an object of unknown mass and volume is fully immersed in a large water tank and released from rest, it accelerates up. Once the object reaches equilibrium, 30% of its volume is above water. Calculate the density of this object**.**

EXAMPLE: BUOYANCY / COMPARE BUOYANT FORCES

EXAMPLE**:** A 50 cm^3 piece of wood and a 50 cm^3 piece of metal are placed in a large water tank. The wood floats above the water line, while the metal sinks to the bottom of the tank. Which has greater buoyant force acting on it**?**

a) Wood
b) Metal
c) Same buoyant force
d) Not enough info to determine

PRACTICE: BUOYANCY / DENSITY OF AN OBJECT FLOATING UNDER WATER

PRACTICE**:** When an object of unknown mass and volume is fully immersed in large oil (800 kg/m^3) container and released from rest, it stays at rest. Calculate the density of this object**.**

BUOYANCY / THE THREE COMMON CASES

● An object floats or sinks depending on its DENSITY when compared to the density of the LIQUID. Three common cases:

(1) OBJECT FLOATS ABOVE

V_{UNDER} _____ V_{TOTAL}

F_B _____ mg

ρ_{OBJ} _____ ρ_{LIQ}

(2) OBJECT FLOATS UNDER

V_{UNDER} _____ V_{TOTAL}

F_B _____ mg

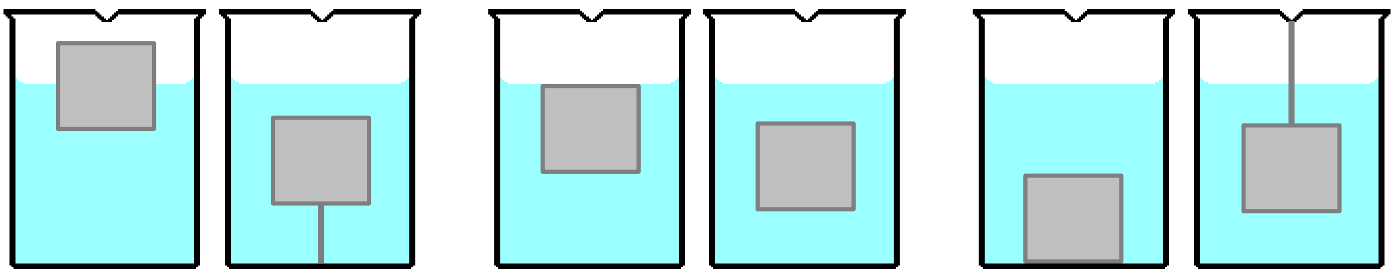
ρ_{OBJ} _____ ρ_{LIQ}

(3) OBJECT SINKS

V_{UNDER} _____ V_{TOTAL}

F_B _____ mg

ρ_{OBJ} _____ ρ_{LIQ}



→ If object floats freely (no strings), there's a shortcut:

EXAMPLE 1: A block of unknown material floats with 80% of its total volume under water. What is its density?

EXAMPLE 2: An aluminum (2,700 kg/m³) block with dimensions 1.0 x 1.0 x 1.0 m sits on a scale at the bottom of a 2.0 x 2.0 x 2.0 m tank that is filled with water to its top. How much does the scale read?

PRACTICE: BUOYANCY / DENSITY OF LIQUID WITH UNKNOWN BLOCK

PRACTICE**:** A block floats with 40% of its volume above water. When you place it on an unknown liquid, it floats with 30% of its volume above. What is the density of the unknown liquid**?**

EXAMPLE: BUOYANCY / IS CROWN MADE OF GOLD?

EXAMPLE**:** You want to verify if a 100-g crown is in fact made of pure gold **(**19.32 g/cm^3**),** so you lower it by a string into a deep bucket of water. When the crown is completely submerged, you measure the tension on the string to be 0.88 N. Is the crown made of pure gold**?**

PRACTICE: BUOYANCY / DENSITY OF SUBMERGED BLOCK ON STRING

PRACTICE: An 8,000 cm^3 block of wood is fully immersed in a deep water tank, then tied to the bottom. When the block is released and reaches equilibrium, you measure the tension on the string to be 12 N. What is the density of the wood**?**

EXAMPLE: BUOYANCY / MAXIMUM LOAD ON A FLOATING BOARD

EXAMPLE**:** A wooden board (700 kg/m^3) has 1m^2 in area, 10 cm in thickness, and floats on a salt-water lake. What is the maximum amount of mass you can place on top of the board such that this load does not get wet**?**

PRACTICE: BUOYANCY / HEIGHT OF SIDES ON A FLOATING CONTAINER

PRACTICE**:** You want to build a large storage container, with outer walls and an open top, as shown, so that you can load things into it, while it floats on fresh water, without any water getting inside. If the bottom face of the container measures 3.0 m by 8.0 m, how high should the side walls be, such that the combined mass of container and inside load is 100,000 kg?