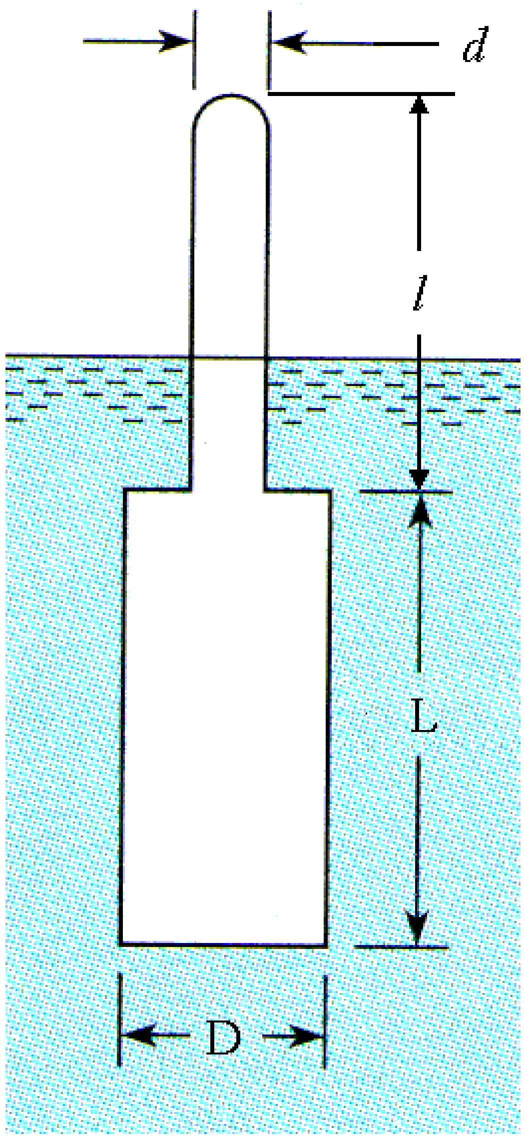
**HYDROSTATICS**

***<u>Example Problem: Buoyancy / Hydrometers.</u>***

What is the range of specific gravities that can be measured with the hydrometer shown in the figure?




<u>Given:</u>

| | |
|---|---|
| bulb diameter: | D = 2 cm. |
| bulb length: | L = 8 cm. |
| stem diameter: | d = 1 cm. |
| stem length: | l = 8 cm. |
| hydrometer mass: | m = 35 gr. |

Solution:

Liquid levels will range between the bottom and the top of the stem. For the thinnest liquid the stem will be fully submerged, while for the thickest liquid the stem will be entirely out of the liquid (i.e., only the bulb will be submerged.

When only the bulb is submerged (very thick liquid, high specific weight), the equilibrium of forces on the combination of the bulb and the stem gives:

$$B = W = mg \qquad (1)$$

where B is the buoyancy force and W is the weight of the bulb and the stem.

$$B = g_{high} \forall_{bulb} = g_{high}\left[\frac{p}{4}(0.02)^2(0.08)\right]$$

$$W = 0.035(9.81)$$

going back to eq.(1) we get $g_{high} = 13{,}661.46\, N/m^3$

or $S_{high} = \frac{13{,}661.46}{9{,}810} \Rightarrow S_{high} = 1.393$

When only the full stem is submerged (very thin liquid, low specific weight) the equilibrium of forces on the combination of the bulb and the stem gives again eq.(1). The weight of the bulb and the stem is still the same. However, the buoyancy force now is:

$$B = g_{low}(\forall_{bulb} + \forall_{stem}) = g_{low}\left(\frac{p}{4}0.02^2(0.08) + \frac{p}{4}0.01^2(0.08)\right)$$

equating the weight and the buoyancy force we now get

$$g_{low} = 10{,}929.17\, N/m^3$$

$$S_{low} = \frac{10{,}929.17}{9{,}810} \Rightarrow S_{low} = 1.114$$

So, the range of specific gravities that can be measured with this hydrometer is:

$$1.114 \le S \le 1.393$$