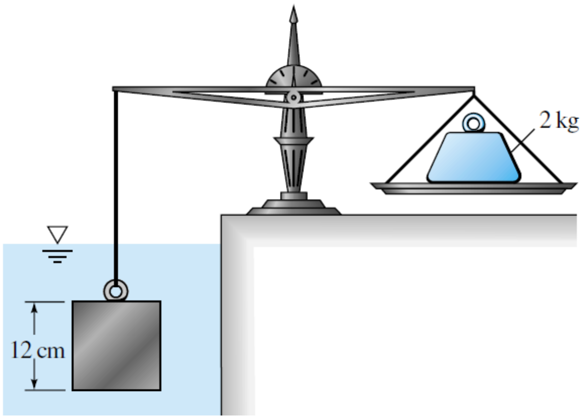
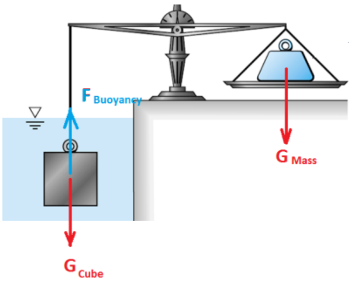
FLUID MECHANICS

PROBLEM SOLVING

1. **The homogeneous 12 cm cube in Fig. is balanced by a 2 kg mass on the beam scale when the cube is immersed in 20 ^{0}C ethanol. What is the specific gravity of the cube? (The ethanol specific gravity is 789 kg/m^3 at 20 ^{0}C)**



Answer:



$G_{cube} - F_{buoyancy} = G_{mass}$

$\rho_{cube}\ g\ V_{cube} - \rho_{ethanol}\ g\ V_{cube} = m\ g$

$\rho_{cube}\ 0{,}12^3 m^3 - 789\ kg/m^3\ 0{,}12^3 m^3 = 2\ kg$

$\rho_{cube} = 2\ kg/0{,}001728\ m^3 + 789\ kg\ /m3$

$\rho_{cube} = 1946{,}4\ kg/m^3$

2. **An average size balloon with an envelope volume of 2800 m3. We wish to determine the net upward buoyant force generated by the envelope. The air inside the envelope is typically heated to an average temperature of about 100 degrees.**

Answer:

The heated air inside the envelope is at roughly the same pressure as the outside air. With this in mind we can calculate the density of the heated air at a given temperature, using the Ideal gas law, as follows:

$P = \rho RT$

Where:

-P is the absolute pressure of the gas, in Pa

-ρ is the density of the gas, in kg/m3

-R is the gas constant, in Joules/kg.K

-T is the absolute temperature of the gas, in Kelvins (K)

Now,

Normal atmospheric pressure is approximately 101,300 Pa

The gas constant for dry air is 287 Joules/kg.K

The air inside the envelope is typically heated to an average temperature of about 100 degrees Celsius, which is 373 K

$P = \rho RT \Rightarrow \rho = P/RT = 101300\ N/m^2 / (287\ Nm/kgK\ 373\ K) = 0{,}946\ kg/m^3$

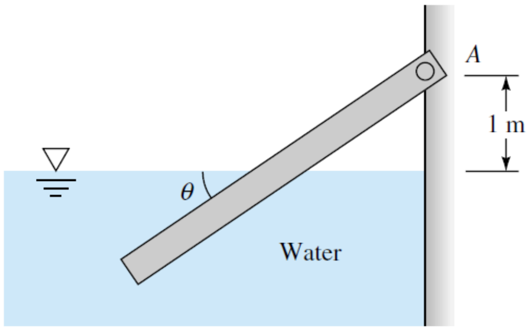
Substituting the above three values into the Ideal gas law equation and solving for ρ we get ρ = 0.946 kg/m3. This is the density of the heated air inside the envelope. Compare this to normal (ambient) air density which is approximately 1.2 kg/m3. Next, for an average size balloon with an envelope volume of 2800 m3 we wish to determine the net upward buoyant force generated by the envelope.

The net buoyant force is defined here as the difference in density between the surrounding air and the heated air, multiplied by the envelope volume. Thus,

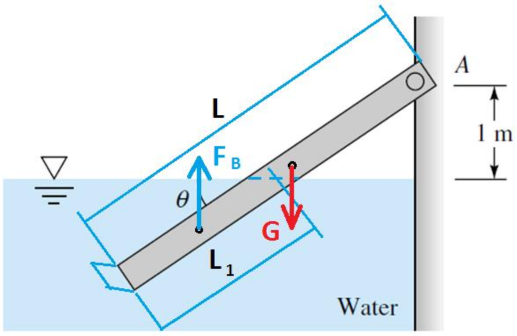
$F_{B,net} = (1.2—0.946)x2800 = 711$ kgf

This is the net buoyant force pushing upwards on the heated air inside the envelope. The hot air balloon components (such as envelope, gondola, burner, fuel tanks, and passengers) can at most weigh 711 kg in order for the buoyant force to be able to completely lift the hot air balloon off the ground.

3. A uniform wooden beam (specific gravity = 0,65) is 10 cm by 10 cm by 3 m and is hinged at A, as in Fig. At what angle θ will the beam float in the 20 ^{0}C water?



Answer:



The momet is taken by A point;

F_B $(L_1/2 + L/2)$ Cos θ = G L/2 Cos θ F_B =g ρ_{water} V_{sub} , G =g ρ_{wooden} V_{wooden}

g ρ_{water} V_{sub} $(L_1/2 + L/2)$ Cos θ =g ρ_{wooden} V_{wooden} L/2 Cos θ   as simplified

ρ_{water} V_{sub} $(L_1/2 + L/2) = \rho_{wooden}$ V_{wooden} L/2

1000 kg/m^3 (0,1^2 L_1)m^3(L_1/2 + 1,5)m = 650 kg/m^3 (0,1^2 3)m^3 1,5 m

10 L_1(L_1/2 + 1,5) = 29,25

10 L_1(L_1 + 3) = 58,5   Both sides are multiplied by 2

$L_1^2 + 3 L_1 - 5,85 = 0$ ERROR!

By the second degree equation solution method

$(L_1)_{1,2} = -b \pm \sqrt{(b^2 - 4ac)} / 2a$

$(L_1)_{1,2} = -3 \pm \sqrt{(3^2 - 4\ 1\ (-5.85)}) / 2*1$

$(L_1)_1$ = 1,34 This true answer

$(L_1)_2$ = -4,345

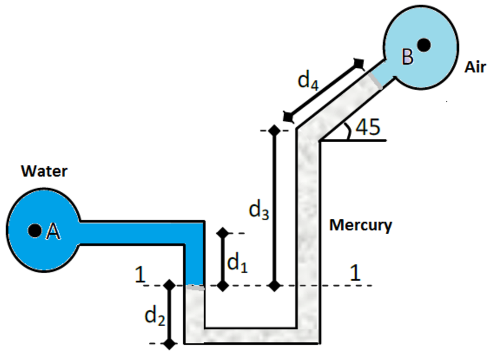
Sin θ =1m / (L- L_1) = 1/(3-1,34) =0,60

θ = 37 ^{0}

Not

34.3° (book answer is different-?)

4. Find the pressure difference between points A and B shown in the Figure (d_1 = 30 cm and d_3 = 45 cm, d_4 = 20 cm).



Let's write the changes in pressure moves from A to B, step by step.

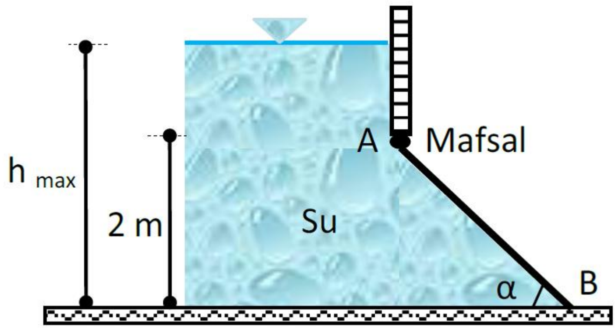
$P_A + \rho_{water}$ g d_1 +(d_2 distances neutrals each other) - $\rho_{mercury}$ g d_3 - $\rho_{mercury}$ g d_4 Sin 45 - P_B =0

$P_A - P_B = \rho_{mercury}$ g d_3 + $\rho_{mercury}$ g d_4 Sin 45 - ρ_{water} g d_1

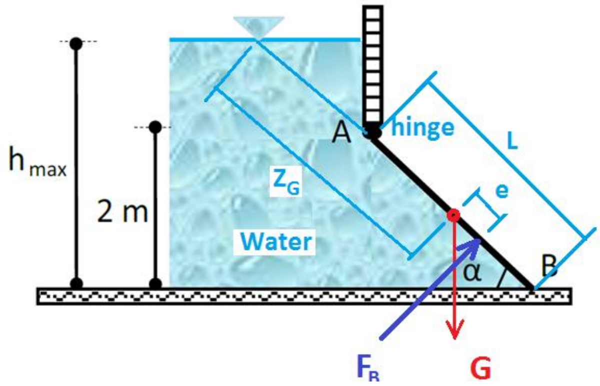
$P_A - P_B$ = 13600 kg/m^3 9,81 m/s^2 0,45 m + 13600 kg/m^3 9,81 m/s^2 0,20 m Sin 45 – 1000 kg/m^3 9.81 m/s^2 0,30m

$P_A - P_B$ = 75962 Pa { If you multiply an expression by the acceleration of gravity, the result is always Newton. Other kgf}

5. The width of the AB cover in the figure is 4 m, the weight is 392.4 kN and the angle is 45^0. What is the maximum height of the water for the cover not to be opened self-automatically.



Answer;



The water does not change anything to be on the left and right of cover. Both the water at the side of the cover shows the same effect. Only directions different.

The main formula for plane surfaces

$e = \frac{I_G}{h_G A}$ for oblique cover like this is $e = \frac{I_G}{Z_G A}$. Both is the same formula.

e = 7,47 /[(h_{max}-1m) Sin45*11,28] I_G =$wL^3/12$ = 4 x $2,82^3$ /12 = 7,47 m^4 Z_G =(h_{max}-1m) Sin45

A=4m 2.82m =11,28 m^2

If we take a moment to the point A