Fluid Mechanics (ME 201)

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Tutorial 2 – Fluid Statics

(Problem numbers 5, 6, 9, 11, 12 are for self-practice)

1. The tube shown in the following figure is filled with mercury with $\rho = 13580$ kg/m^3. Calculate the force applied to the piston whose diameter is 50 mm (i) neglecting surface tension effects, and (ii) with surface tension $\sigma_{\text{mercury/air}}$=486.5 mN/m and contact angle 140^o.
   . [(i) 52.3 N (ii) 55.19 N]

2. A multitube manometer using water and mercury is used to measure the pressure of air in a vessel, as shown in the figure. Calculate the gage pressure in the vessel if h_1 =0.4 m, h_2 =0.5 m, h_3 =0.3 m, h_4 =0.7 m, h_5 =0.1 m and h_6 =0.5 m. [1.9 bar]

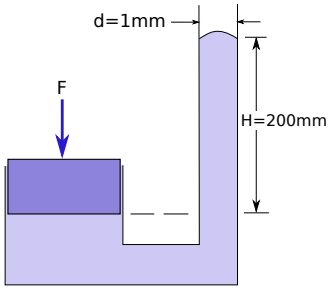

Figure for Problem 1

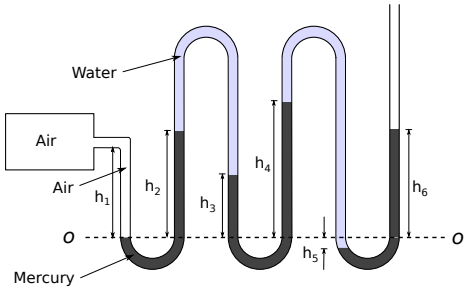

Figure for Problem 2

3. A hollow metal cube with sides 100 mm floats at the interface between a layer of water and a layer of an oil with specific gravity 0.6 such that 10% of the cube is exposed to the oil. What is the pressure difference between the upper and lower horizontal surfaces? What is the average density of the cube? [951.57 Pa; 9515.6 kg/m^3]

4. The semicircular plane gate AB is hinged along B and held by horizontal force F_A applied at A. The liquid to the left of the gate is water. Calculate the force F_A required for equilibrium.
   . [12.49 MN]

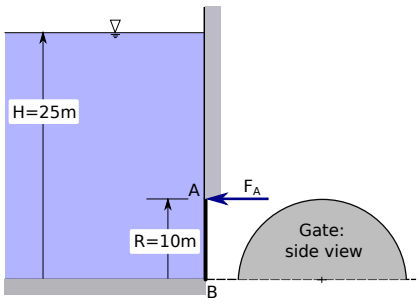

Figure for Problem 4

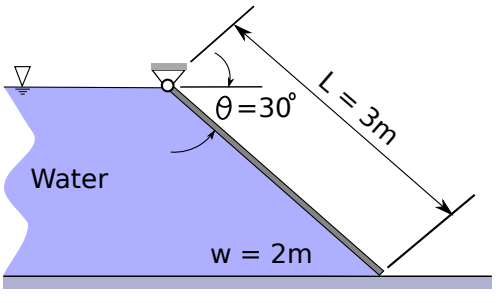

Figure for Problem 5

5. A plane gate of uniform thickness holds back a depth of water as shown. Find the minimum weight needed to keep the gate closed. [89.2 kN]

6. Surface AB is a circular arc with a radius of 2 m and a width of 1 m into the paper. The distance AE is 4 m. The fluid above surface AB is water, and atmospheric pressure prevails on the free surface of the water and on the bottom side of surface AB. Find the magnitude and line of action of the hydrostatic force acting on surface AB. [146.87 kN]

7. Liquid concrete of density 2400 kg/m^3 is poured into the form shown in figure, R=0.313 m. The form has a constant width of 4.25 m normal to the paper. Compute the magnitude of the vertical force exerted on the form by the concrete and specify its line of action. [2.104 kN]

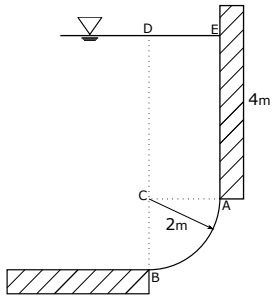

Figure for Problem 6

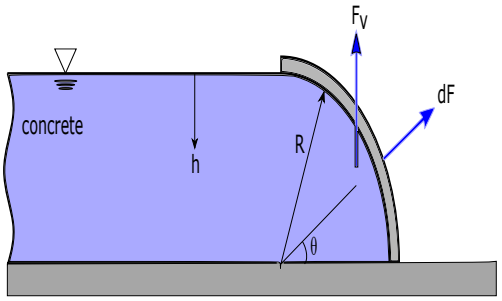

Figure for Problem 7

8. A hot air balloon (approximated as a sphere of diameter 15 m) is to lift a basket load of 2670 N. To what temperature must the air be heated in order to achieve liftoff? Assume pressure inside the balloon is atmospheric pressure. [292.6 K]

9. A block of steel (specific gravity 7.85) floats at a mercury-water interface as shown in the figure. What is the ratio of a and b for this condition? Specific gravity of mercury is 13.57. [0.835]

10. A metal sphere of volume $V_m = 0.1$ m^3, specific gravity 2 is fully immersed in water. It is attached by a flexible wire to a buoy of volume $V_B = 1$ m^3 and specific gravity 0.1. Calculate the tension in the wire and the volume of the buoy that is submerged. [981 N, 0.2 m^3]

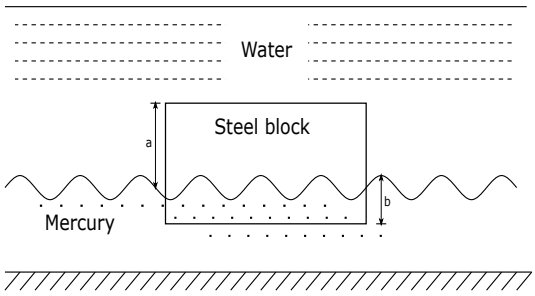

Figure for Problem 9

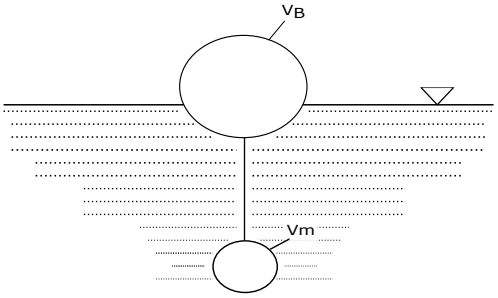

Figure for Problem 10

11. Derive hydrostatic pressure condition for a compressible ideal gas in isothermal conditions. . $\left[p = p_0 \; exp\left(\frac{g}{RT_0}(y - y_0)\right)\right]$

12. Mark the location of the centroid for rectangle, right angled triangle, circle, and semi-circle. Also write moments of inertia as well as product of inertia for all these shapes about centroid.