Problems

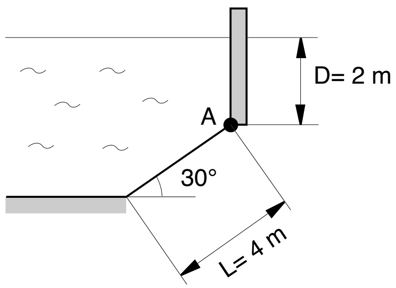
4.1 The density ρ of sea water increases as a function of the gage pressure p according to

$$\rho = \rho_0(1 + Kp)$$

The density at sea level ρ_0 (where $p = 0$) is 1 000 kg/m^3 and the compressibility coefficient is $K = 5 \times 10^{-10}$ Pa^{-1}. Calculate the pressure at a depth of 5 000 m in the following cases:

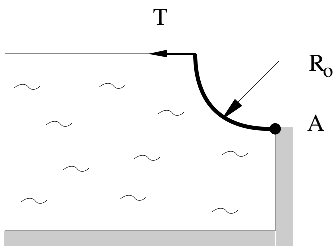
(a) Assuming that sea water is incompressible, i.e. $K = 0$.
(b) Assuming that the density varies weakly with pressure according to the above expression.

4.2 The inclined gate of the Figure has a hinge at A and is 5 m wide. Determine the net force acting on the inclined surface.



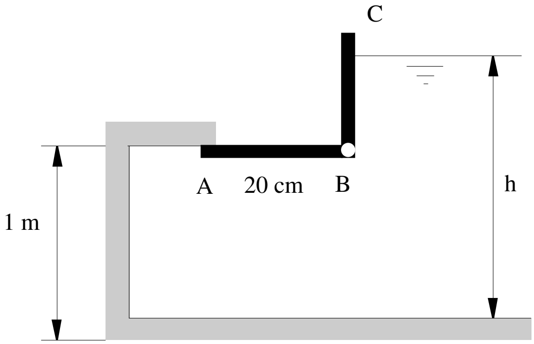
Problem 4.2. Force on a plane gate.

4.3 The gate of a tank articulated at A is shaped as a quarter of a circle. Determine the force per unit width T necessary to keep the gate in the depicted position.



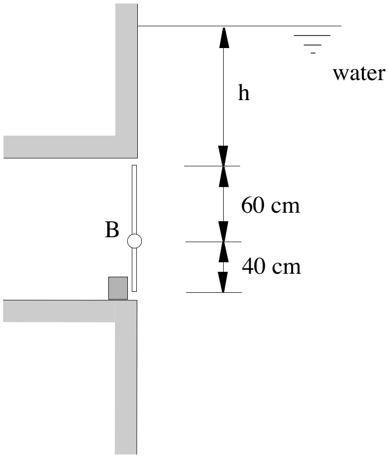
Problem 4.3. Force acting on a circular gate.

4.4 The gate ABC of the Figure has the shape of an L and it is articulated at B. Its width perpendicular to the paper is 2 m. When the water level is sufficiently high, the gate opens at A, allowing the liquid to flow. Calculate the water level h at which this happens.



Problem 4.4. Automatic gate.

4.5 The square gate of the Figure has a side of 1 m and is articulated in B. It automatically opens if the water level h is high enough. Calculate the minimum level for opening. Does the result depend on the liquid density?



Problem 4.5. Plane automatic gate.

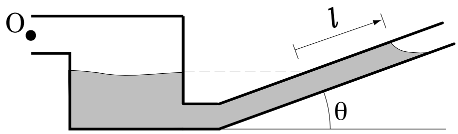
4.6 Before launching a weather balloon, it is filled with 100 kg of helium at atmospheric pressure and temperature (1.033×10^5 Pa and 288.15 K, respectively).

(a) Calculate the maximum load (balloon plus scientific load) that can be carried by the above amount of helium.
(b) The balloon rises with the load of item (a) up to an altitude of 11 km, where the atmospheric conditions are 2.263×10^4 Pa and 216.65 K. If the helium pressure and temperature are equal to the atmospheric conditions, calculate the net force acting upon the balloon and scientific load at this altitude.
Gas constants: $R_{\text{He}} = 2\,077$ J/(kg K), $R_{\text{air}} = 287$ J/(kg K)

4.7 Prove the result (4.28) for plane surfaces. Use that

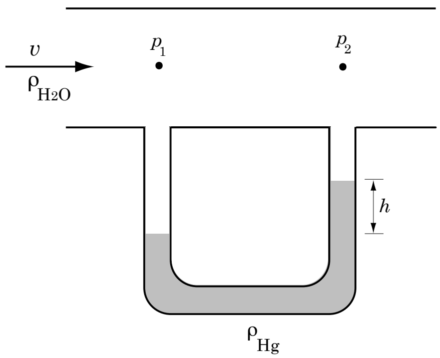
$$\xi_{cp} = \frac{\sin\theta I_{\eta\eta}}{h_{cg} A}$$

4.8 Relate the reading of the inclined manometer of the Figure with the pressure at O.



Problem 4.8. Inclined manometer.

4.9 The pressure loss $\Delta p = p_1 - p_2$ in the duct of the Figure is due to friction losses. Assuming fully developed flow, calculate the pressure loss as a function of the fluid densities and h.



Problem 4.9. Pressure loss in a horizontal duct.