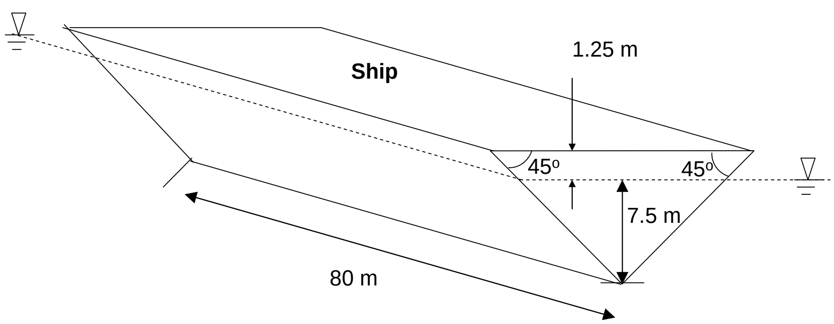
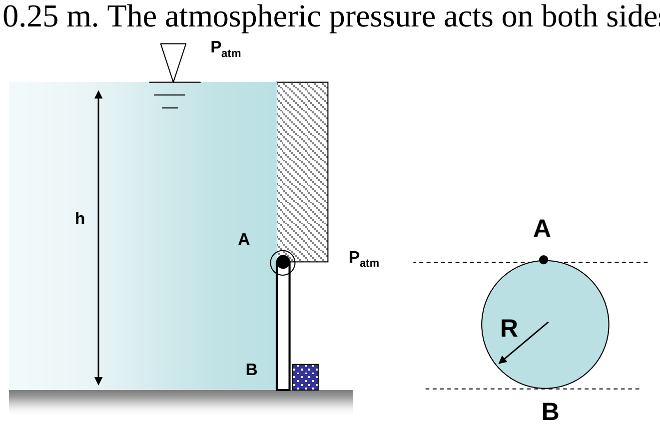
MECH 314 Intro Fluid Mechanics
Spring 2010 – Section 2 (Dr Oweis)
Quiz 1 – Closed Book and Notes

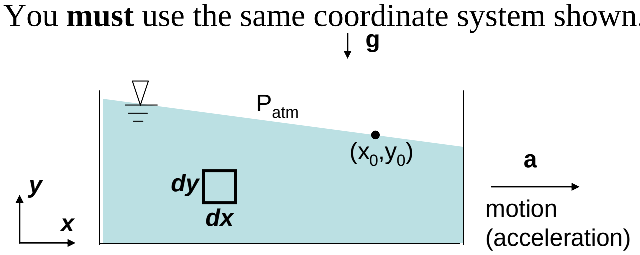
P1. (25)
The Port of Tripoli is equipped to handle ships coming from the northern part of the Mediterranean (sea water $\rho_w = 1050\,kg/m^3$) with a gross (total) weight below 5000 metric tons (1 metric ton is equivalent to 1000 kg). Big ships that exceed this limit are sent south to the Port of Beirut which can handle them. Some ships try to falsify their gross weight so they can dock in Tripoli and not have to sail to Beirut to save on fuel cost. To prevent this from happening and damaging their docks, the Port Authority of Tripoli hired you as the marine engineer in charge of estimating the weights of ships before they enter the port. You have divers and technicians who work under you and who can produce accurate measurements of ships dimensions above and beneath water.
Your crew presents you with the following dimensions of a specific ship (see drawing). The ship is 80 m long. The ship bottom is submerged under 7.5 m of water. Will you allow this vessel to enter your port or will you send it away to Beirut? Show your detailed solution steps clearly to get credit.

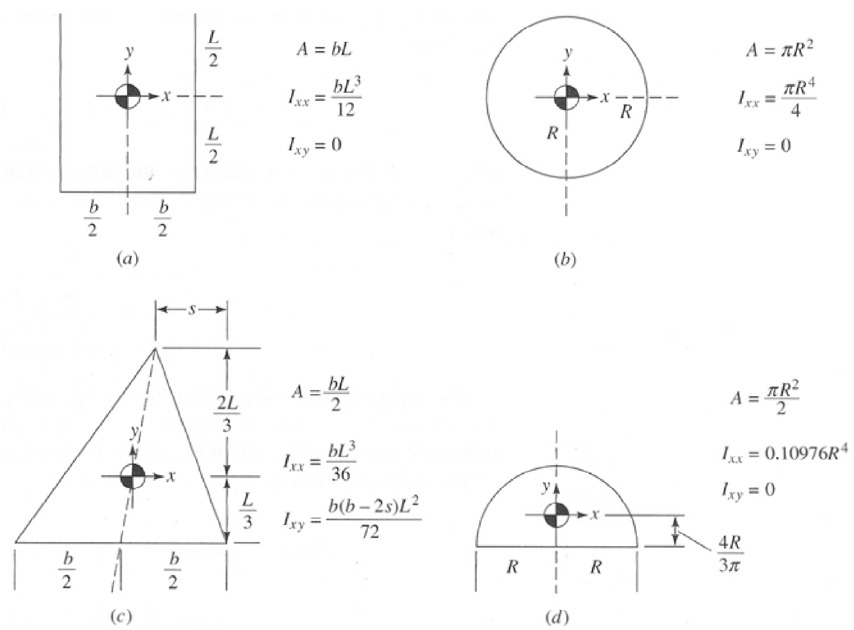


P2. (45)
Consider the oil reservoir shown in the figure ($\rho_{oil} = 828\,kg/m^3$). A circular gate (AB) placed at the bottom of the reservoir and hinged at A is used to control the oil flow out of the container. Under static conditions find the required stopping force at B needed to keep the gate from opening. Consider the oil height h = 2.5 m and the radius of the gate R = 0.25 m. The atmospheric pressure acts on both sides of the gate.



P3. (30)
Consider the shown fluid moving horizontally as a rigid body at constant linear acceleration (**a**). Start with a small control volume $dx\,dy\,dz$ and proceed to show that the pressure at any point in the fluid is given by: $P(x,y) = \rho g(y_0 - y) + \rho a(x_0 - x) + Patm$.
You **must** use the same coordinate system shown.





$$F = \gamma h_{CG} A \qquad y_{CP} = -\frac{I_{xx}\sin\theta}{h_{CG}A} \qquad x_{CP} = -\frac{I_{xy}\sin\theta}{h_{CG}A}$$

$$f(x+dx) = f(x) + f'(x)dx + \ldots$$

$$F_B = \rho g \forall, Buoyancy$$

$$\gamma = \rho g$$

Weight of ship = Buoyancy Force

$$W = \rho_w * g * \forall_{submerged}$$

$$W = 1050 * g * (7.5 \times 7.5 \times 80)$$

$$m = \frac{W}{g} = 4725 \times 10^3 \text{ kg}$$

$$= 4725 \text{ Ton} < 5000 \text{ Ton}$$

Yes, we can let it enter the Tripoli port.

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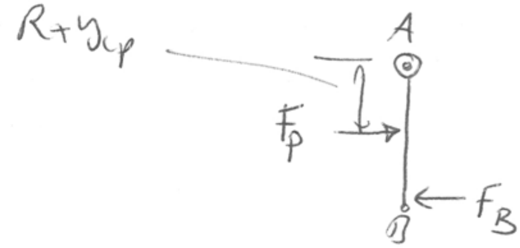
Gate $\Sigma M_A = 0$



$$F_P (R + y_{cp}) = F_B * (2R)$$

$$F_B = \frac{F_P}{2R} (R + y_{cp})$$

$$F_P = \rho g H_{CG} A = 828 \times 9.8 \times (2.5 - 0.25) [\pi \times 0.25^2]$$

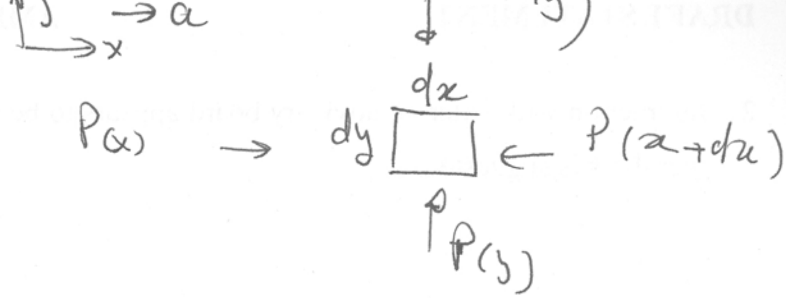
$$= 3584.8 \text{ N}$$

$$|y_{cp}| = \frac{\pi R^4}{4} * \sin 90 * \frac{\cancel{\rho g}}{\cancel{F_P}} * \frac{1}{A H_{CG}}$$

$$= \frac{\pi \overset{0.25^2}{\cancel{0.25^4}}}{4} \times 1 \times \frac{1}{\cancel{\pi\, 0.25^2} \times (2.5 - 0.25)} = 6.94 \times 10^{-3} \text{ m}$$

$$F_B = 1842.2 \text{ N}$$

P_3



$$\sum dF_x = (dm)\,a_x$$

$$(P(x) - P(x+dx))\,\cancel{dy\,dz} = dx\,\cancel{dy\,dz}\,\rho\, a$$

$$\Rightarrow \frac{\partial P}{\partial x} = -\rho a \quad \Rightarrow P(x,y) = -\rho a x + f(y)$$

$$\sum dF_y = 0 \qquad dF_P = dW$$

$$(P(y) - P(y+dy))\,\cancel{dx}\,\cancel{dz} = \rho\,\cancel{dx}\,dy\,\cancel{dz}\; g$$

$$\frac{\partial P}{\partial y} = -\rho g \quad \Rightarrow P(x,y) = -\rho g\, y + h(x)$$

$$\Rightarrow P(x,y) = -\rho a x - \rho g y + c$$

$$P(x_0, y_0) = P_{atm} = -\rho a x_0 - \rho g y_0 + c$$

$$c = P_{atm} + \rho a x_0 + \rho g y_0$$

$$\Rightarrow P(x,y) = \rho a\,(x_0 - x) + \rho g\,(y_0 - y) + P_{atm}$$