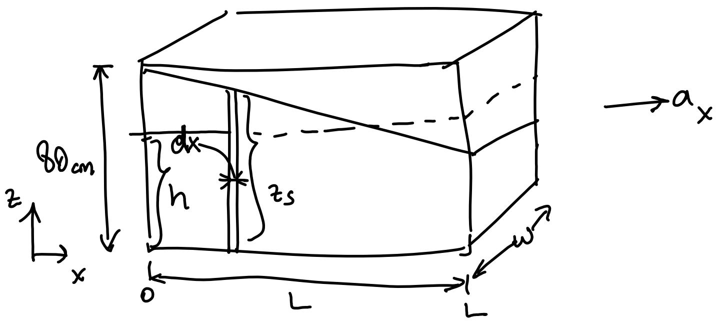
An 80-cm-high fish tank of rectangular cross section 2 m × 0.6 m that is initially filled with water is to be transported on the back of a truck. The truck accelerates from 0 to 90 km/h in 10 seconds. If it is desired that no water spills during acceleration, determine the maximum allowable initial water height in the tank. If it is wanted to carry as much fluid as possible in the tank, would you recommend the tank to be aligned with the long or short side parallel to the direction of motion?



$$a_x = \frac{90\,000}{60\times 60}\times\frac{1}{10} = 2.5\ m/s$$

$$-\vec{\nabla}p - \rho g\hat{k} = \rho\vec{a}$$

$$-\left(\frac{\partial p}{\partial x}\hat{i} + \frac{\partial p}{\partial y}\hat{j} + \frac{\partial p}{\partial z}\hat{k}\right) - \rho g\hat{k} = \rho a_x\hat{i}$$

$$\left.\begin{aligned}
\hat{i}:&\quad -\frac{\partial p}{\partial x} = \rho a_x\\
\hat{j}:&\quad -\frac{\partial p}{\partial y} = 0\\
\hat{k}:&\quad -\frac{\partial p}{\partial z} = \rho g
\end{aligned}\right\}$$

$$p = p(x,z)$$

$$dp = \underbrace{\frac{\partial p}{\partial x}}_{-\rho a_x}dx + \underbrace{\frac{\partial p}{\partial z}}_{-\rho g}dz$$

$$dp = -\rho a_x dx - \rho g dz$$

$$p = -\rho a_x x - \rho g z + C$$

$$p = p_{atm} \ @\ z = z_s \Rightarrow \quad p_{atm} = -\rho a_x x - \rho g z_s + C$$

$$z_s = \underbrace{\frac{C - p_{atm}}{\rho g}}_{C_1} - \frac{a_x}{g}x$$

$$\boxed{z_s = C_1 - \frac{a_x}{g}x}$$

Volume of water inside the take in motion and at rest should be the same!

→ Let h show the height of water when the container is at rest!

$$\underbrace{h \cancel{w} L}_{\text{initial volume}} = \int_0^L z_s \cancel{w}\, dx$$

$$hL = \int_0^L \left(C_1 - \frac{a_x}{g}x\right) dx$$

$$hL = \left[C_1 x - \frac{a_x}{2g}x^2\right]\Bigg|_0^L$$

$$hL = C_1 L - \frac{a_x}{2g}L^2$$

$$\boxed{h = C_1 - \frac{a_x}{2g}L}$$

@ $x=0$, $z_s = 0.8\,m \Rightarrow z_s = C_1 - \frac{a_x}{g}x \Rightarrow 0.8 = C_1 - \frac{a_x}{g}\cdot 0 \Rightarrow \boxed{C_1 = 0.8}$

$$\Rightarrow h = 0.8 - \frac{a_x}{2g}L$$

If $L = 2m \Rightarrow h = 0.8 - \frac{2.5}{\cancel{2}\times 10}\times \cancel{2} = 0.8 - 0.25 = 0.55m.$

If $L = 0.6m \Rightarrow h = 0.8 - \frac{2.5}{2\times 10}\times 0.6 = 0.725m.$ ⟸ The container's short side should be aligned with the direction of motion!