Problem 1.

a) $\Sigma F_x$ on $AEBF$

We need to know $\gamma_1$ and $\gamma_2$.

For $\gamma_1$, use buoyancy on the floating cube:

$$\gamma_{\text{f1}} \cdot V_{\text{body}} = W_{\text{body}}$$

$$\gamma_{\text{f1}} = \frac{W_{\text{body}}}{V_{\text{body}}}$$

$W_{\text{body}} = F_B$

$$A \cdot L_b \cdot \gamma_{\text{f1}} = A \left( \frac{H_1 + H_2}{2} \right) \gamma_1$$

$$\gamma_1 = \frac{5}{4} \gamma_{\text{f1}}$$

$$= \frac{5}{4} \left( 8 \text{ kN/m}^3 \right)$$

$$\gamma_1 = 10 \text{ kN/m}^3$$

For $\gamma_2$, use the manometer on the right side.

$$\gamma_1 (h_1 + h_2) - \gamma_2 (h_3 + h_5) - \gamma_{\text{h2}} h_5 = 0$$

$$\gamma_2 = \frac{\gamma_1 (h_1 + h_2) + \gamma_{\text{h2}} h_5}{h_3 + h_5}$$

$$= \frac{(14 \text{ kN/m}^3)(3-2) \text{ m} + (130 \text{ kN/m}^3)(0.2 \text{ m})}{4 \text{ m}}$$

$$= 26 \text{ kN/m}^3$$

$$\gamma_2 = 10 \text{ kN/m}^3$$

$$\gamma_1 = \gamma_2$$

Control volume for $\Sigma F_x$:

$$\Sigma F_x = F_{x1} - F_{x2}$$

$$\Sigma F_x = 0$$

b) Vertical hydrostatic force on $ABC$

Force on face $AB$  Force on face $BC$

$$F_{ABC} = \gamma_1 \left( \frac{2 \text{ m} \times 1 \text{ m}}{2} \right) \left( 10 \text{ m} \right)$$

$$= (10 \text{ kN/m}^3) (10 \text{ m}^3)$$

$$F_{ABC} = 100 \text{ kN}$$, applied at the centroid of the volume of fluid $V_{ABC}$

c) Vertical hydrostatic force on $DEF$

Some magnitude as $F_{ABC}$ but in opposite direction!

Force on face $EF$  Force on face $DE$

$$F_{DEF} = 100 \text{ kN}$$
d) \( h_5 \) (with \( D = 0.2 \text{ cm} \)) = \( h_5 \) (with \( D > 2 \text{ cm} \))

Surface tension acts on both sides of the manometer!

\[ h_{5, \text{new}} = h_{5, \text{old}} = 0.20 \text{ m} \]

Surface tension cancels!

e) If the cube is fully submerged, it displaces a larger volume \( \Rightarrow \) \( H \) on the left side increases

The pressure on surface AB increases, and the pressure on surface BC increases, the resultant vertical hydrostatic force acting on ABC stays the same!
Problem 2.

Concepts involved:
- Linear momentum
- Shear stress.

\[ F_{\mu} = \frac{\partial \dot{V}}{\partial \nu} \]

What is \( V_{out} \)?
We need absolute velocity.
Let \( U \) be \( \frac{Q}{A_{jet}} \)

\[ \Rightarrow V_{out} = -U + V_s \]

\[ -F_{\mu} = g \frac{Q}{A_{jet}} (-U + V_s) \]

\[ F_{\mu} = g \frac{Q}{A_{jet}} (U - V_s) \ldots (1) \]

b) Shear stress on the layer of fluid:

\[ F_{\mu} = \frac{2\zeta A}{\delta} \]

and \( \zeta = \frac{\mu \Delta V}{\delta} = \frac{\mu V_s - 0}{\delta} = \frac{\mu V_s}{\delta} \)

\[ F_{\mu} = \frac{\mu V_s A}{\delta} \ldots (2) \]

Let \( (1) = (2) \)

\[ g \frac{Q}{A_{jet}} (U - V_s) = \frac{\mu V_s A}{\delta} \]

and solve for \( V_s \):

\[ -V_s = \frac{\mu V_s A}{gQ\delta} - \frac{Q}{A_{jet}} \]

\[ V_s \left( 1 + \frac{\mu A}{gQ\delta} \right) = \frac{Q}{A_{jet}} \]

\[ V_s = \frac{Q}{A_{jet}} \left( 1 + \frac{\mu A}{gQ\delta} \right)^{-1} \ldots (3) \]