1A.

Let b=1.470mm L=the length of glass plate

$$2\sigma L = \rho_w ghLb$$

$$\rightarrow 2\sigma = \rho_w ghb$$

$$\rightarrow h = 2\sigma/(\rho_w gb)$$

$$\sigma = 0.0735, \rho_w = 1\times10^3 kg\cdot m^{-3}, g = 10m\cdot s^{-2}, \mathrm{b} = 1.470\mathrm{mm}$$

$$\mathrm{h} = \frac{2\times0.0735}{1\times10^3\times10\times1.470\times10^{-3}} m = 0.1m = 10mm$$

1B.

$$P_{atm}(\pi R^2) + 2\times(2\pi R)\sigma = P_{int}(\pi R^2)$$

$$\rightarrow \Delta\mathrm{P} = P_{int} - P_{atm} = \frac{4\sigma}{R}$$

D=5mm→R=2.5mm $\sigma = 0.025(\mathrm{N/m})$

$$\Delta\mathrm{P} = \frac{4\times0.025}{2.5\times10^{-3}} Pa = 40Pa$$

5A.

Part (a): velocity of water leaving (3)

$$z_1 - z_3 = 4m$$

$p_1 = p_3 = 0$ (atmospheric pressure, 0 gage pressure)

$v_1 \approx 0$ (large tank)

Applying Bernoulli equation between (1) and (3)

$$\frac{p_1}{\rho} + \frac{v_1^2}{2} + gz_1 = \frac{p_3}{\rho} + \frac{v_3^2}{2} + gz_3$$

$$\frac{v_3^2}{2} = g(z_1 - z_3)$$

$$v_3 = \sqrt{2g(z_1 - z_3)} = \sqrt{2\times10\times4} = 4\sqrt{5} = 4\times2.24 = 8.96 \ \mathrm{m/s}$$

Part (b): water pressure in tube at (4)

Applying continuity equation between (4) and (3):

$$A_4 v_4 = A_3 v_3$$

Since $A_4 = A_3, v_4 = v_3 = 8.96m/s$

Applying Bernoulli equation between (4) and (3)

$$\frac{p_4}{\rho} + \frac{v_4^2}{2} + gz_4 = \frac{p_3}{\rho} + \frac{v_3^2}{2} + gz_3$$

$$\frac{P_4}{\rho} = g(z_3 - z_4) \quad (z_3 - z_4) = 4m$$

$$P_4 = \rho g(z_3 - z_4) = 1000\times10\times(-4) \ \mathrm{Pa} = -40 \ \mathrm{kPa}$$

5B

Part (a): velocity of water leaving (3)

$$z_1 - z_3 = 4m$$

$p_1 = p_3 = 0$ (atmospheric pressure, 0 gage pressure)

$v_1 \approx 0$ (large tank)

Applying Bernoulli equation between (1) and (3)

$$\frac{p_1}{\rho}+\frac{v_1^2}{2}+gz_1=\frac{p_3}{\rho}+\frac{v_3^2}{2}+gz_3$$

$$\frac{v_3^2}{2}=g(z_1-z_3)$$

$$v_3=\sqrt{2g(z_1-z_3)}=\sqrt{2\times10\times4}=4\sqrt{5}=4\times2.24=8.96\ \text{m/s}$$

Part (b): water pressure in tube at (2)

Applying continuity equation between (2) and (3):

$$A_2v_2=A_3v_3$$

Since $A_2=A_3, v_2=v_3=8.96m/s$

Applying Bernoulli equation between (2) and (3)

$$\frac{p_2}{\rho}+\frac{v_2^2}{2}+gz_2=\frac{p_3}{\rho}+\frac{v_3^2}{2}+gz_3$$

$$\frac{P_2}{\rho}=g(z_3-z_2)\quad (z_2-z_3)=6m$$

$$P_2=\rho g(z_3-z_2)\text{=}1000\times10\times(-6)\ \text{Pa}=-60\ \text{kPa}$$

Solutions L2 + L6

Solution 2. A

2.121 The uniform beam in the figure is of size L by h by b, with $b,h \ll L$. A uniform heavy sphere tied to the left corner causes the beam to float exactly on its diagonal. Show that this condition requires (a) $\gamma_b = \gamma/3$; and (b) $D = [Lhb/\{\pi(SG-1)\}]^{1/3}$.

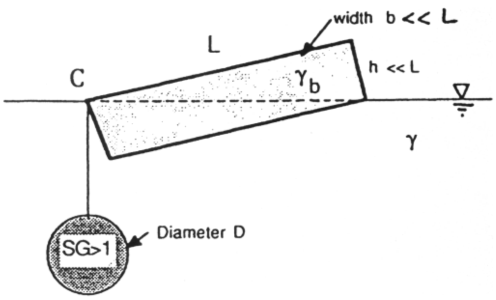


Fig. P2.121

Solution: The beam weight $W = \gamma_b Lhb$ and acts in the center, at L/2 from the left corner, while the buoyancy, being a perfect triangle of displaced water, equals $B = \gamma Lhb/2$ and acts at L/3 from the left corner. Sum moments about the left corner, point C:

$$\sum M_C = 0 = (\gamma_b Lhb)(L/2) - (\gamma Lhb/2)(L/3), \quad \text{or:} \quad \boldsymbol{\gamma_b = \gamma/3} \quad \textit{Ans. (a)}$$

Then summing vertical forces gives the required string tension T on the left corner:

$$\sum F_z = 0 = \gamma Lbh/2 - \gamma_b Lbh - T, \quad \text{or} \quad T = \gamma Lbh/6 \quad \text{since} \quad \gamma_b = \gamma/3$$

$$\text{But also} \quad T = (W-B)_{sphere} = (SG-1)\gamma\frac{\pi}{6}D^3, \quad \text{so that} \quad D = \left[\frac{\mathbf{Lhb}}{\boldsymbol{\pi}\mathbf{(SG-1)}}\right]^{1/3} \quad \textit{Ans. (b)}$$

Solution 2. B

2.65 Gate AB in Fig. P2.65 is semi-circular, hinged at B, and held by a horizontal force P at point A. Determine the required force P for equilibrium.

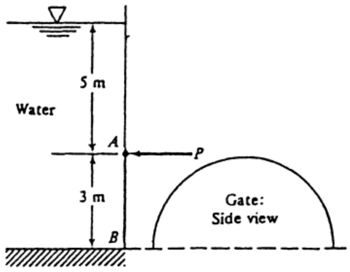
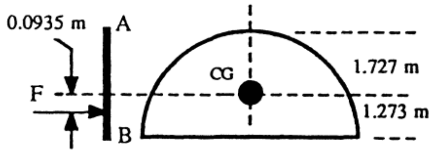


Fig. P2.65

Solution: The centroid of a semi-circle is at $4R/3\pi \approx 1.273$ m off the bottom, as shown in the sketch at right. Thus it is $3.0 - 1.273 = 1.727$ m down from the force P. The water force F is



$$F = \gamma h_{CG} A = (9790)(5.0 + 1.727)\frac{\pi}{2}(3)^2$$
$$= 931000 \text{ N}$$

The line of action of F lies below the CG:

$$y_{CP} = -\frac{I_{xx}\sin\theta}{h_{CG}A} = -\frac{(0.10976)(3)^4 \sin 90^\circ}{(5+1.727)(\pi/2)(3)^2} = -0.0935 \text{ m}$$

Then summing moments about B yields the proper support force P:

$$\sum M_B = 0 = (931000)(1.273 - 0.0935) - 3P, \quad \text{or:} \quad P = \mathbf{366000\ N} \quad \textit{Ans.}$$

Solution 6. A

Write the given relation and count variables:

$$Q = f(R, \mu, \frac{\mathrm{d}p}{\mathrm{d}x}) \quad \text{four variables} \, (n = 4)$$

Make a list of the dimensions of these variables using the $\{MLT\}$ system: There are three primary

Q	R	μ	$\mathrm{d}p/\mathrm{d}x$
L^3T^{-1}	L	$ML^{-1}T^{-1}$	$ML^{-2}T^{-2}$

dimensions (M, L, T), hence $j = 3$. By trial and error we determine that $R, \mu,$ and $\mathrm{d}p/\mathrm{d}x$ cannot be combined into a pi group. Then $j = 3$, and $n - j = 4 - 3 = 1$. There is only *one* pi group, which we find by combining Q in a power product with the other three:

$$\Pi_1 = R^a \mu^b (\frac{\mathrm{d}p}{\mathrm{d}x})^c Q^1 = (L)^a (ML^{-1}T^{-1})^b (ML^{-2}T^{-2})^c (L^3T^{-1}) = M^0L^0T^0$$

Equate exponents:

$$\begin{cases} b + c = 0 \\ a - b - 2c + 3 = 0 \\ -b - 2c - 1 = 0 \end{cases}$$

Solving simultaneously, we obtain $a = -4$, $b = 1$, and $c = -1$. Then

$$\Pi_1 = R^{-4} \mu^1 (\frac{\mathrm{d}p}{\mathrm{d}x})^{-1} Q$$

or

$$\Pi_1 = \frac{Q\mu}{R^4(\mathrm{d}p/\mathrm{d}x)} = \text{const}$$

Solution 6. B

The functional relationship is $\delta = f(x, U, \mu, \rho)$, with $n = 5$ variables and $j = 3$ primary dimensions (M, L, T). Thus we expect $n - j = 5 - 3 = 2$ Pi groups:

$$\Pi_1 = \rho^a x^b \mu^c \delta = M^0L^0T^0 \quad \text{if } a = 0, b = -1, c = 0 : \Pi_1 = \frac{\delta}{x}$$

$$\Pi_2 = \rho^a x^b \mu^c U = M^0L^0T^0 \quad \text{if } a = 1, b = 1, c = -1 : \Pi_2 = \frac{\rho U x}{\mu}$$

Thus $\delta/x = f(\rho Ux/\mu) = f(Re_x)$.

7.for plannar couette flow, $\frac{\partial}{\partial x}=0, \frac{\partial}{\partial z}=0,$

So for mass conservation, $\frac{\partial v}{\partial y}=0.$

For momentum conservation, $\frac{d^2u}{dy^2}=0.$

So, we can deduce that $u_1=c_1y+c_2$ in fluid 1, and $u_2=c_3y+c_4$ in fluid 2, and the boundary conditions are:

$$y=0, u=0; y=d, u_1=u_2; y=h, u=U;$$

And in h, we have $\tau_1=\tau_2, \mu_1\frac{\partial u_1}{\partial y}=\mu_2\frac{\partial u_2}{\partial y}$

We have

$$\begin{cases} c_4=0 \\ c_3d=c_1d+c_2 \\ U=c_1h+c_2 \\ \mu_1c_1=\mu_2c_2 \end{cases}$$

So $c_1=\frac{U}{h-d+\frac{\mu_1 d}{\mu_2}}, c_2=\frac{(\frac{\mu_1}{\mu_2}-1)dU}{h-d+\frac{\mu_1 d}{\mu_2}}, c_3=\frac{\mu_1}{\mu_2}\frac{U}{h-d+\frac{\mu_1 d}{\mu_2}}$

So in fluid 1, $u_1=\frac{Uy+(\frac{\mu_1}{\mu_2}-1)dU}{h-d+\frac{\mu_1 d}{\mu_2}}, u_2=\frac{\mu_1}{\mu_2}\frac{U}{h-d+\frac{\mu_1 d}{\mu_2}}y$

8.

$$\mu=\rho v=900\times 0.0002=0.18kg/(m\cdot s)$$

$$z=10\times\sin 40°=6.43m$$

To calculate the head loss, we have

$$z_2+\frac{p_2}{\rho g}+h_f=z_1+\frac{p_1}{\rho g}$$

So $h_f=4.68m$

V=2.63,according to the equation given in the hint,

So Re=$\frac{Vd}{\nu}=790$

7.

$$\begin{cases} \frac{Du_x}{Dt} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \nu(\frac{\partial^2 u_x}{dx^2} + \frac{\partial^2 u_x}{dy^2} + \frac{\partial^2 u_x}{dz^2}) \\ \frac{Du_y}{Dt} = -\frac{1}{\rho}\frac{\partial p}{\partial y} + \nu(\frac{\partial^2 u_y}{dx^2} + \frac{\partial^2 u_y}{dy^2} + \frac{\partial^2 u_y}{dz^2}) \\ \frac{Du_z}{Dt} = -\frac{1}{\rho}\frac{\partial p}{\partial z} + \nu(\frac{\partial^2 u_z}{dx^2} + \frac{\partial^2 u_z}{dy^2} + \frac{\partial^2 u_z}{dz^2}) \end{cases}$$

Apply the condition, $\frac{\partial u_y}{\partial} = 0, \frac{\partial u_z}{\partial} = 0$,so

$$0 = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \nu\frac{d^2 u_x}{dy^2}$$

$$0 = -\frac{1}{\rho}\frac{\partial p}{\partial y}$$

8.$v = \frac{Q}{A} = \frac{\frac{11}{3600}}{\frac{\pi}{4}\times 0.03^2} = 4.32m/s$

$$Re = \frac{\rho v d}{\mu} = 129681$$

For head loss , we have

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + h_f$$

Take the surface of tank and the outlet of the pipe as reference ,

$p_1 = p_2 = p_{atm}, z_1 = 4, v_1 = 0$

$$h_f = z_1 - \frac{v_2^2}{2g} = 3.07$$

And $h_f = f\frac{L}{d}\frac{v^2}{2g}$,so $f = 0.0197$,from moody chart ,we can get $\frac{\epsilon}{d} = 0.0004$

So$\epsilon = 0.012mm$