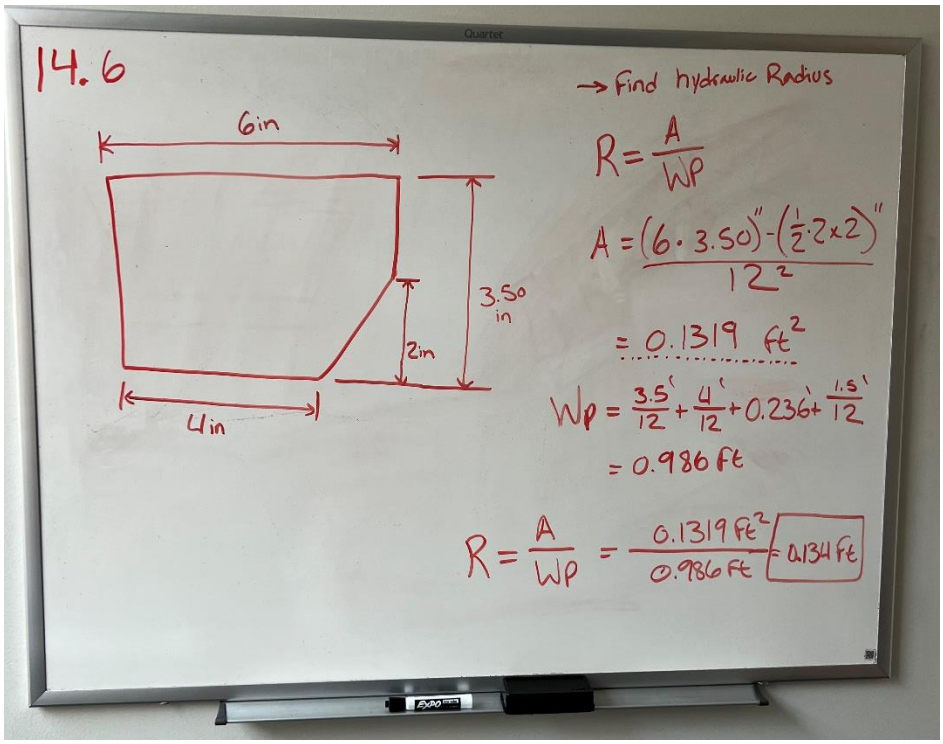
Homework 2.3 Fluid Mechanics

Group 1

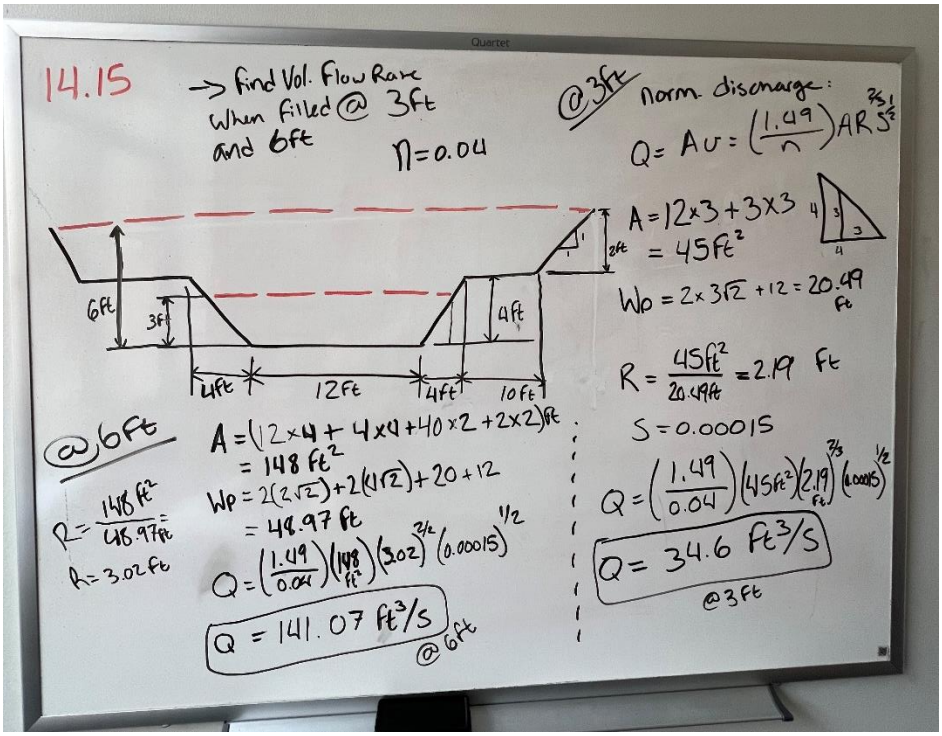
February 29, 2024

Homework Questions

14.6

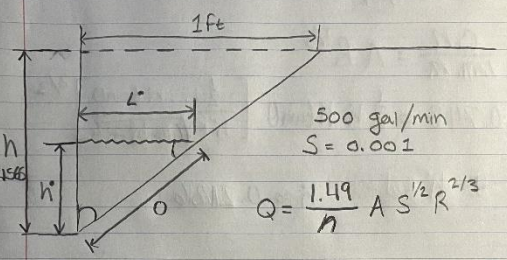


14.15


14.15
→ find Vol. Flow Rate when filled @ 3ft and 6ft
n = 0.04
@3ft
norm. discharge:
Q = AV = (1.49/n) AR^(2/3) S^(1/2)
A = 12×3 + 3×3 = 45ft²
Wp = 2×3√2 + 12 = 20.49 ft
R = 45ft²/20.49ft = 2.19 ft
S = 0.00015
Q = (1.49/0.04)(45ft²)(2.19 ft)^(2/3)(0.00015)^(1/2)
Q = 34.6 ft³/s @3ft
6ft
3ft
4ft
4ft
12Ft
4Ft
10Ft
@6ft
A = (12×4 + 4×4 + 40×2 + 2×2) ft
= 148 ft²
Wp = 2(2√2) + 2(11√2) + 20 + 12
= 48.97 ft
R = 148 ft²/48.97ft
R = 3.02 ft
Q = (1.49/0.04)(148 ft²)(3.02)^(2/3)(0.00015)^(1/2)
Q = 141.07 ft³/s @6ft

14.21

14.21



500 gal/min
S = 0.001

$Q = \frac{1.49}{n} A S^{1/2} R^{2/3}$

Putting things in terms of h'

$\tan\theta = \frac{L'}{h'} = \sqrt{h^2 - (h'\cdot\tan)^2}$

$L' = h' \tan\theta$

$\theta = 67.44^\circ$

$A = \frac{1}{2} h' \, h' \tan\theta$

* Problem uses values from 14.20

$Wp = 0 + h'$

$\tan(67.44) = 2.41$

$R = \frac{\frac{1}{2} h' \, h' \tan\theta}{0 + h'}$

$0 = h' + \sqrt{(h'\tan\theta)^2 + h'^2}$

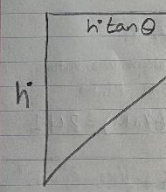
$Q = 500 \text{ gal/min} = 1.114 \text{ ft}^3/\text{s}$

$\frac{Qn}{1.49} = A R^{2/3}$

$0.748 = \frac{1}{2} h' \, h' \tan\theta \left[\frac{\frac{1}{2} h' \, h' \tan\theta}{h' + \sqrt{(h'\tan\theta)^2 + h'^2}}\right]^{2/3}$

$h' \approx 0.2136$

$A = \frac{1}{2}(0.2136)(0.2136 \tan(67.44))$



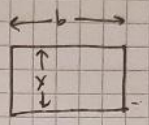
$A = 0.0549 \text{ ft}^2$

14.36

14.36) $Q = 1.25\ ft^3/s$, $v = 2.75\ ft/s$ $\Big\}$ $A = \frac{Q}{v} = 0.4545\ ft^2$

RECT. $A = 2.0y^2 = 0.4545$

$y = 0.4767\ ft$

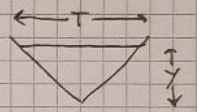


$T = b = 2y = 0.9534\ ft$

$WP = 4y = 1.9068\ ft$

$R = y/2 = 0.238\ ft$

TRIANGLE $A = y^2 = 0.4545 \rightarrow y = 0.6742\ ft$



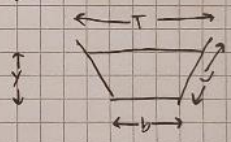
$T = 2y = 1.3484\ ft$

$WP = 2.83y = 1.91\ ft$

$R = 0.354y = 0.239\ ft$

TRAPEZOID $A = 1.73y^2 = 0.4545 \rightarrow y = 0.513\ ft$

$L = b = 1.155y = 0.593\ ft$

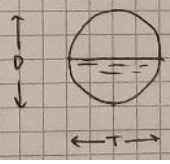


$T = 2.309y = 1.185\ ft$

$WP = 3.46y = 1.775\ ft$

$R = y/2 = 0.2565\ ft$

SEMI-CIRCLE $A = \frac{1}{2}\pi y^2 = 0.4545 \rightarrow y = 0.538\ ft$

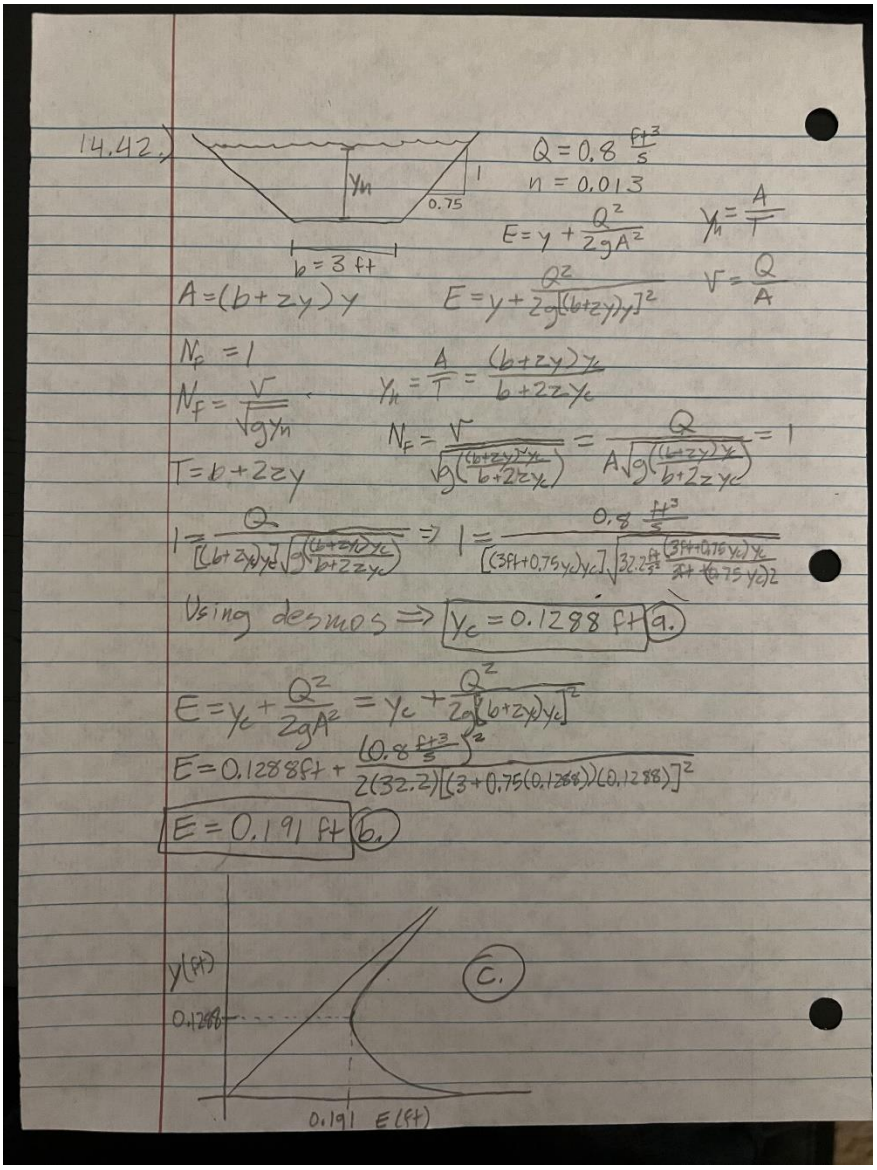


$T = D = 2y = 0.269\ ft$

$WP = \pi y = 1.690\ ft$

$R = y/2 = 0.269\ ft$

14.42


14.42.
y_n
1
0.75
$b = 3$ ft
$Q = 0.8 \frac{ft^3}{s}$
$n = 0.013$
$E = y + \frac{Q^2}{2gA^2}$
$y_h = \frac{A}{T}$
$A = (b+zy)y$
$E = y + \frac{Q^2}{2g[(b+zy)y]^2}$
$V = \frac{Q}{A}$
$N_c = 1$
$N_F = \frac{V}{\sqrt{gy_h}}$
$y_h = \frac{A}{T} = \frac{(b+zy)y}{b+2zy_c}$
$N_F = \frac{V}{\sqrt{g\left(\frac{(b+zy)y}{b+2zy_c}\right)}} = \frac{Q}{A\sqrt{g\left(\frac{(b+zy)y}{b+2zy_c}\right)}} = 1$
$T = b+2zy$
$1 = \frac{Q}{[(b+zy)y]\sqrt{g\left(\frac{(b+zy)y}{b+2zy_c}\right)}} \Rightarrow 1 = \frac{0.8 \frac{ft^3}{s}}{(3ft+0.75y_c)y_c\sqrt{32.2\frac{ft}{s^2}\left(\frac{(3ft+0.75y_c)y_c}{3ft+(0.75y_c)2}\right)}}$
Using desmos $\Rightarrow$ $y_c = 0.1288$ ft (a.)
$E = y_c + \frac{Q^2}{2gA^2} = y_c + \frac{Q^2}{2g[(b+zy)y_c]^2}$
$E = 0.1288ft + \frac{(0.8 \frac{ft^3}{s})^2}{2(32.2)[(3+0.75(0.1288))(0.1288)]^2}$
$E = 0.191$ ft (b.)
y(ft)
0.1288
0.191 E(ft)
c.

d) $E = y + \frac{v^2}{2g}$

$= y + \frac{Q^2}{A^2 \cdot 2g} \rightarrow 0.481\ ft$

$E = 0.481 = y_2 + \frac{Q^2}{A^2 \cdot 2g} \rightarrow y_2 = 0.477\ ft$

e) @ $y_1 = 0.05$

$V = \frac{Q}{A} = 5.267\ ft/s$

$N_F = \frac{V}{\sqrt{g y_h}} = \frac{V}{\sqrt{g \frac{A}{T}}}$

$= 1.178$

@ $y_2 = 0.477\ ft$

$V = \frac{Q}{A} = 0.5\ ft/s$

$N_F = \frac{V}{\sqrt{g y_h}} = \frac{V}{\sqrt{g \frac{A}{T}}}$

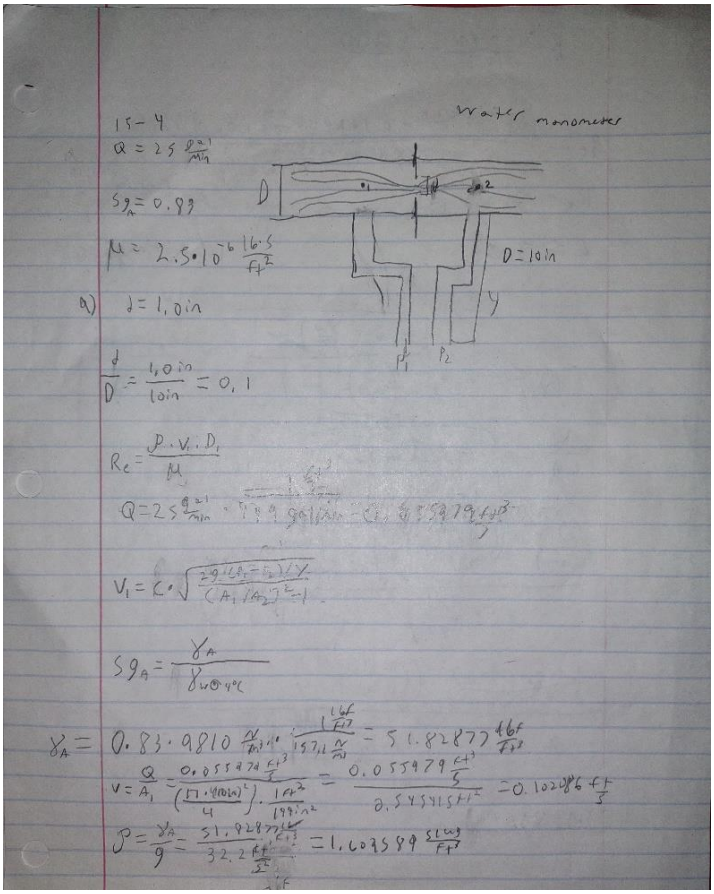
$= 0.134$

f) $n = 0.013$

$R = \frac{A}{wp} \rightarrow R_1 = 0.0486\ ft,\ R_2 = 0.382\ ft$

$S = \left(\frac{Q_n}{1.5 \cdot A R^{2/3}}\right)^2 \rightarrow S_1 = 0.0119,\ S_2 = 0.0000685$

15.4


15-4
water manometer
Q = 25 gal/min
Sg_A = 0.83
μ = 2.5·10^-5 lb·s/ft²
a) d = 1.0 in
D = 10 in
y
P1
P2
d/D = 1.0 in / 10 in = 0.1
Re = ρ·V1·D1 / μ
V1 = C·√(2g·(p1/γ − p2/γ) / (1 − (A1/A2)²))
Sg_A = γ_A / γ_water@4°C
γ_A = 0.83 · 9810 N/m³ · 1 lbf / 157.1 N/m³ = 51.82877 lbf/ft³
v = Q/A1 = 0.055474 ft³/s / ((π·(1.0 in)²/4) · 1 ft²/(12 in)²) = 0.055479 ft³/s / 0.5454154 ft² = 0.102286 ft/s
ρ = γ_A/g = 51.92877 lbf/ft³ / 32.2 ft/s² = 1.613589 slug/ft³

$D = \frac{10in \cdot 1ft}{12in} = 0.8333ft$

$Re = \frac{1.609589 \frac{slug}{ft^3} \cdot 0.102086 \frac{ft}{s} \cdot 0.8333ft}{2.850 \cdot 10^{-5} \frac{lbf \cdot s}{ft^2}}$

$Re = 5.48 \cdot 10^4$

$C \approx 0.595$

$A_2 = \frac{\pi (1.2in)^2}{4} \cdot \frac{1ft^2}{144in^2}$

$A_2 = 0.005459ft^2$

$Q = C A_1 \cdot \sqrt{\frac{2gh\left(\frac{\gamma_w}{\gamma_A}\right) - 1}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$

$\frac{Q}{CA} = \sqrt{\frac{2gh\left(\frac{\gamma_w}{\gamma_A}\right) - 1}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$

$\left(\frac{Q}{CA_1}\right)^2 \cdot \left(\left(\frac{A_1}{A_2}\right)^2 - 1\right) + 1 = 2g\left(\frac{\gamma_w}{\gamma_A}\right) h$

$h = \frac{\left(\frac{0.55679 \frac{ft^3}{s}}{0.595 \cdot 0.5511 ft^2}\right)^2 \cdot \left(\left(\frac{0.5391ft^2}{0.005459ft^2}\right)^2 - 1\right) + 1}{2 \cdot 32.2 \frac{ft}{s^2} \cdot \left(\frac{9481 \frac{N}{m^3} \cdot \left(\frac{1 lbf}{4.448 N}\right)}{51.82677 \frac{N}{m^3}}\right)}$

$h = 3.33854ft$

b) for what is different between a → b is $\lambda = 0.7in$ fuctefor

$A_2 = \frac{\pi \cdot (0.7in)^2}{4} \cdot \frac{1}{144} = 0.267254ft^2$

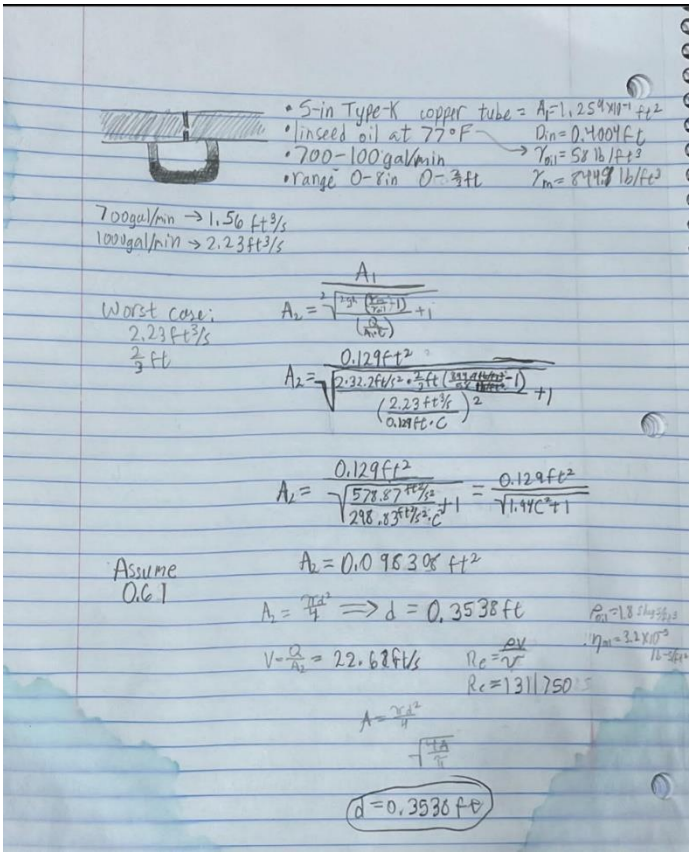
$\frac{d}{D} = 0.7$

$C = 0.619$

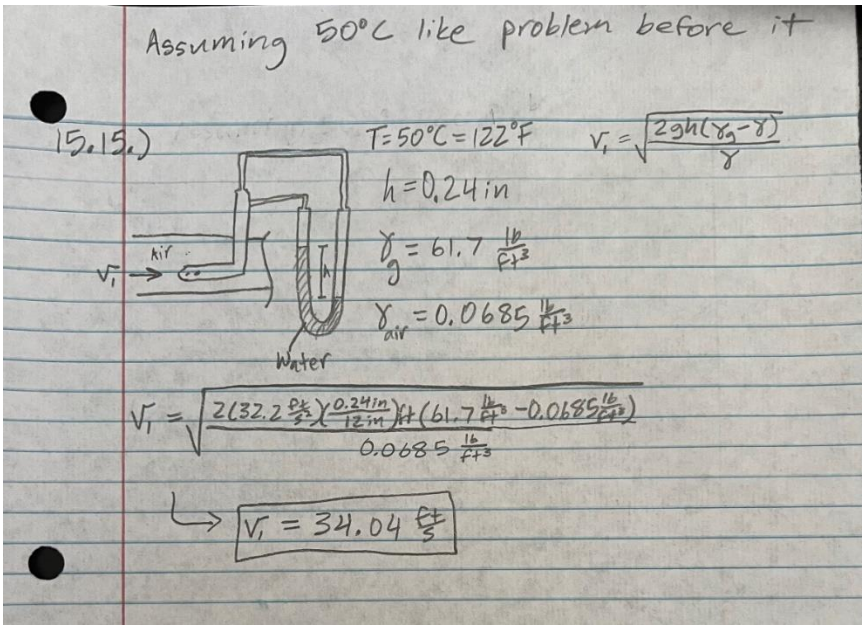
$h = \frac{\left(\frac{0.55679 \frac{ft^3}{s}}{0.619 \cdot 0.5391ft^2}\right)^2 \cdot \left(\left(\frac{0.5391ft^2}{0.267254ft^2}\right)^2 - 1\right) + 1}{2 \cdot 32.2 \frac{ft}{s^2} \cdot \left(\frac{9481 \frac{N}{m^3} \cdot \left(\frac{1 lbf}{4.448 N}\right)}{51.82677 \frac{N}{m^3}}\right)}$

$h = 0.019983ft$

15.9


• 5-in Type-K copper tube = $A_f = 1.254 \times 10^{-1}\ ft^2$
$D_{in} = 0.4004\ ft$
• linseed oil at 77°F → $\gamma_{oil} = 58\ lb/ft^3$
$\gamma_m = 8.94 \times 10^3\ lb/ft^3$
• 700–1000 gal/min
• range 0–8 in 0–⅔ ft
700 gal/min → 1.56 ft³/s
1000 gal/min → 2.23 ft³/s
Worst case:
2.23 ft³/s
⅔ ft
$A_2 = \frac{A_1}{\sqrt{\frac{2gh\left(\frac{\gamma_m}{\gamma_{oil}} - 1\right)}{\left(\frac{Q}{A_1 C}\right)^2} + 1}}$
$A_2 = \frac{0.129\ ft^2}{\sqrt{\frac{2 \cdot 32.2\ ft/s^2 \cdot \frac{2}{3}\ ft \left(\frac{333\ lb/ft^3}{58\ lb/ft^3} - 1\right)}{\left(\frac{2.23\ ft^3/s}{0.129\ ft \cdot C}\right)^2} + 1}}$
$A_2 = \frac{0.129\ ft^2}{\sqrt{\frac{578.87\ ft^2/s^2}{298.83\ ft^2/s^2 \cdot C^2} + 1}} = \frac{0.129\ ft^2}{\sqrt{1.94C^2 + 1}}$
Assume 0.61
$A_2 = 0.109308\ ft^2$
$A_2 = \frac{\pi d^2}{4} \Rightarrow d = 0.3538\ ft$
$V = \frac{Q}{A_2} = 22.68\ ft/s$
$R_e = \frac{\rho V}{\nu}$
$R_e = 131{,}750$
$A = \frac{\pi d^2}{4}$
$\sqrt{\frac{4A}{\pi}}$
$d = 0.3538\ ft$

15.15


Assuming 50°C like problem before it
15.15.)
$T = 50°C = 122°F$
$V_1 = \sqrt{\frac{2gh(\gamma_g - \gamma)}{\gamma}}$
$h = 0.24\ in$
$\gamma_g = 61.7\ \frac{lb}{ft^3}$
$\gamma_{air} = 0.0685\ \frac{lb}{ft^3}$
air
V_1
h
Water
$V_1 = \sqrt{\frac{2(32.2\ \frac{ft}{s^2})(\frac{0.24\ in}{12\ in})ft(61.7\ \frac{lb}{ft^3} - 0.0685\ \frac{lb}{ft^3})}{0.0685\ \frac{lb}{ft^3}}}$
$V_1 = 34.04\ \frac{ft}{s}$

Review of Solved Problems and Old Test Solutions

There are seven devices commonly used to measure flow: venturi meter, flow nozzle, rotameter, turbine flowmeter, vortex flowmeter, magnetic flowmeter, and orifice plate. You can also use a pitot tube, a rotating cup anemometer, and a hot-wire anemometer to measure the velocity of a fluid. The orifice plate is the most common because it is cheap to buy and produce. After all, it is just a piece of metal with a hole in it whereas the others require more complicated manufacturing techniques. The orifice is not necessarily placed in the middle of the plate. Sometimes it can be placed at the bottom if there is sediment or some other material in the water. This allows the particles to continue flowing through rather than building up in the pipe and altering the flow properties. The orifice can also be placed at the top of the plate if there are bubbles in the flow. This prevents the bubbles from becoming trapped at the top of the pipe and disrupting the flow.

In Chapter 14, we looked at how a fluid's discharge is affected by the shape of the channel that it flows through. Additionally, the object that the channel is made of and the perimeter that the fluid is touching in the channel also influence its discharge rate. This is because the more fluid that's touching the sides of the channel, the more energy that the channel will take due to friction (this also plays into the channel's composition as this decides friction force). In the example problem for chapter 14, we learned that it's not possible to solve for *h* directly. To find h, we must use Excel and manually try different values. We would have to keep guessing h values until the left side of the equation matches the right side. This is defined by the percentage difference. The percentage difference that's closest to zero percent is our h.

Looking at the older tests, each question is split up into several sections that each help to describe the question in its entirety. These parts include the purpose, diagram, source, design considerations, data/variables, materials, procedure, calculations, summary, and analysis. Using these sections, you can fully explain the problem, and what methods and data you used to reach that conclusion, making it so that the professor who reads your work can get a better understanding of how you completed the problem. This can also help with figuring out what went wrong if the answer isn't the same as the solution, which can be good for getting points back through having the correct process, but maybe a variable is off, or something went wrong in the calculation (calculator error).