HW#1

1.13) $Q = \dfrac{\pi R^4 \Delta p}{8 \mu l}$ $\quad [R^4] = L^4 \quad [\Delta p] = FL^{-2}$

$[\mu] = FL^{-2}T \quad [l] = L$

as Q is volume flow rate, $[Q] = L^3T^{-1}$

Testing: $\left[\dfrac{\pi R^4 \Delta p}{8 \mu l}\right] = \dfrac{[\pi]}{8}\dfrac{[R^4][FL^{-2}]}{[FL^{-2}T][R]} = \dfrac{[\pi]}{8}[L^3T^{-1}]$

$\therefore [\pi/8] = 1$ & this is a general homogenous as no constant has units

1.26) $v/\sqrt{gl}$

First method: $Fr = 10/\sqrt{32.2 \cdot 2} = 1.246$

Second method: $Fr = 3.048/\sqrt{9.81 \cdot .6096} = 1.246$

I assume its significance is dimensionless parameters can be found w/ any unit system.

1.33) $\rho = 775\ kg/m^3$

Specific gravity $= \rho_{fuel}/\rho_{H_2O} = 775\ kg/m^3 / 1000\ kg/m^3$

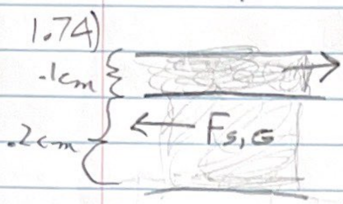
$\Rightarrow .775$

Specific weight $= \rho_{fuel} \cdot g = 775\ kg/m^3 \cdot 9.81\ m/s^2$

$\Rightarrow 7602.75\ N/m^3$

HW#1 - cont

1.74)



know $F_s = \frac{\mu V}{h} A$

$\therefore F_{s,w} = \frac{\mu_w v_w}{h_w} \cdot A_w$ & $F_{s,g} = \frac{\mu_g v_g}{h_g} A_g$

assume $A_w = A_g$ & $2h_w = h_g$

$\Sigma F = 0$, $F_{s,w} - F_{s,g} = 0 \Rightarrow F_{s,w} = F_{s,g} \Rightarrow \frac{\mu_w v_w}{h_w} A_w = \frac{\mu_g v_g}{h_g} A_g$

$\Rightarrow \frac{\mu_w v_w}{h_w} = \frac{\mu_g v_g}{2h_w} \Rightarrow 2\mu_w v_w = \mu_g v_g \Rightarrow v_g = \frac{2\mu_w v_w}{\mu_g}$

$v_g = \frac{2 \cdot 1.002e^{-3}\ Ns/m^2 \cdot 2m/s}{1.99e^{-2}\ Ns/m^2} =$

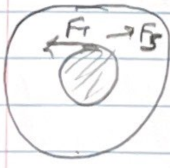
$$\boxed{v_g = .2014\ m/s}$$

1.87) $\omega = \frac{d\theta}{dt}$ $\tau =$ ~~torque~~ $\ell =$ length $R_o =$ outer $R_i =$ inner

a) relate $\mu, \omega, \tau, \ell, R_o, R_i$

$\tau = r \times F$, but $r \perp F$ $\therefore \tau = Fr$ (torque), $F_T = \tau / R_i$

Inner $SA = 2\pi R_i \ell = A_i$ Outer $SA = 2\pi R_o \ell = A_o$



$F_s = \frac{\mu v}{(R_o - R_i)} A_i$ $v = \omega R_i$, $\therefore F_s = \frac{\mu \omega R_i}{(R_o - R_i)} A_i$

HW#1 - cont

now, know all vars, so plug into force balance

$\Sigma F = ma$, but no acceleration in system, so...

$$\Sigma F = 0 = F_\tau - F_s \Rightarrow F_\tau = F_s$$, now plugging in...

$$\Rightarrow \tau / R_i = \frac{\mu \omega R_i}{(R_o - R_i)} \cdot A_i = \frac{\mu \omega R_i}{(R_o - R_i)} \cdot 2\pi R_i \ell = \frac{2\pi \mu \omega R_i^2 \ell}{(R_o - R_i)}$$

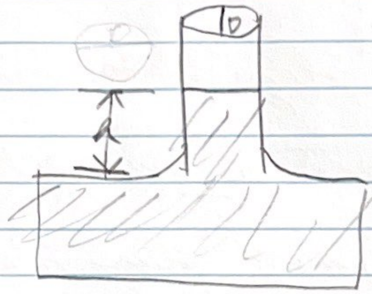
$$\Rightarrow \boxed{\tau = \frac{2\pi \mu \omega R_i^3 \ell}{(R_o - R_i)}}$$

e) I coded this because I don't want to do the math by hand. There is a python notebook below with my work.

Answer: $\mu = 2.4474 \ \frac{lbs \cdot s}{ft^2}$

$\mu = 117.1819 \ Pa \cdot s$

HW#1-cont

1.119) 

$D = .125$ in $\quad h = .150$ in

find θ

$$h = \frac{2\sigma \cos\theta}{\rho g R}$$

$$\Rightarrow \cos\theta = \frac{h\rho g R}{2\sigma} \Rightarrow \theta = \text{acos}\left(\frac{h\rho g R}{2\sigma}\right)$$

$h = .15$ in $= \frac{.15}{12}$ ft $= 3/240$ ft

$R = D/2 = .125/2$ in $= 1/192$ ft

$\sigma = 5.03e^{-3}$ lb/ft

$\rho g =$ specific weight $= \gamma = 62.37$ lb/ft^3

$$\theta = \text{acos}(.4036\ldots) = 66.195°$$

$$\theta = 66.195°$$

HW #1 - cont'd

1.A)

$\sigma = .025 \ N/m$

$50 \ mm = .05 \ m$

$$\Delta P = \frac{2\sigma}{R} = \frac{2 \cdot .025 \ N/m}{.025 m} = 2 \ N/m^2$$

However, this is a bubble, so ΔP is really 2x

$$\boxed{\Delta p = 4 \ N/m^2}$$