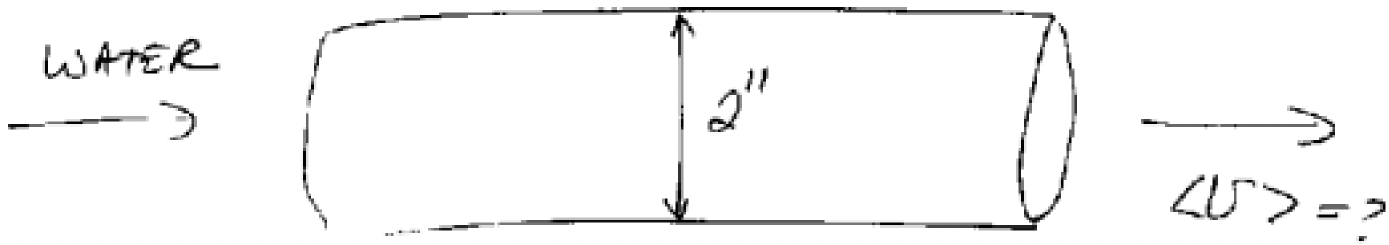
(ΔP/L GIVEN)

10-7-0.
CM3110

CALCULATE AVERAGE VELOCITY FOR GIVEN ΔP/L



$\rho = 62.4 \; lbm/ft^3$

$\mu = 6.7197 \times 10^{-4} \; lbm/ft\,s$

$$\frac{\Delta P}{L} = 1.90 \times 10^{-2} \frac{lbf}{in^2\, in}\left(\frac{12 in}{ft}\right)^3 \left(\frac{32.174 \; ft\; lbm}{s^2 \; lbf}\right)$$

$$\frac{\Delta P}{L} = 1.06 \times 10^{3} \; lbm/ft^2 s^2$$

WE NEED TO KNOW IF IT IS LAMINAR OR TURBULENT. WE'LL GUESS <u>LAMINAR</u>.

HAGEN-POISEUILLE LAW:

$$\langle v \rangle = \frac{\Delta P}{L}\frac{D^2}{32\mu}$$

ASSUMING LAMINAR FLOW,

$$\langle V \rangle = \left(\frac{1.06\times10^{3}\ \text{lbm}}{\text{ft}^2\ \text{s}^2}\right)\left(\frac{2}{12}\ \text{ft}\right)^2 \frac{1}{32}\left(\frac{\text{ft s}}{6.7197\times10^{-4}\ \text{lbm}}\right)$$

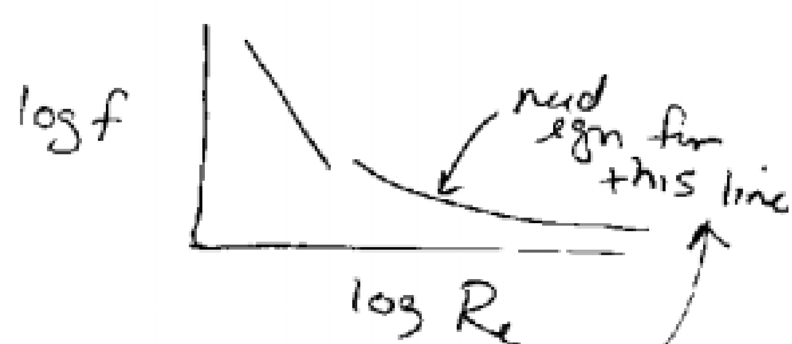
$$= 1364.5\ \frac{\text{ft}}{\text{s}}$$ (assuming laminar)

CHECK Re:

$$Re = \frac{\rho V D}{\mu} = \frac{\left(62.4\ \frac{\text{lbm}}{\text{ft}^3}\right)\left(1364.5\ \frac{\text{ft}}{\text{s}}\right)\left(\frac{2}{12}\ \text{ft}\right)}{6.7197\times10^{-4}\ \frac{\text{lbm}}{\text{ft s}}}$$

$$= 2.1\times10^{7}\ !$$ NOT LAMINAR

<u>TURBULENT</u> <u>FLOW</u>



See lecture 14

(ΔP/L given)

$$\frac{1}{\sqrt{f}} = 4 \log_{10} Re\sqrt{f} - 0.4$$

$$\frac{\rho v D}{\mu} \sqrt{\frac{\Delta P}{L} \frac{D}{2} \frac{L}{\rho}} \frac{1}{v}$$

NOTE: THIS is INDEP. OF v

∴ we can calculate f directly from this correlation

I used Excel (see next pg)

$$f = 3.6 \times 10^{-3}$$

definition of f:

$$f = \frac{\Delta P}{L} \frac{D}{2} \frac{1}{\rho v^2} \quad \#$$

solve for v (see next pg)

(ΔP/L given)

	deltaP/L=	1.90E-02	lbf/in3	wrong units	
	D=	0.16666667	ft		
	density=	62.4	lbm/ft3		
	viscosity=	6.72E-04	lbm/fts		
	deltaP/L=	1.06E+03	lbm/s2ft2		
1/sqrt(f)=	1.67E+01		from correlation (v is not needed)		
f=	3.60E-03		calculated friction factor		
v=	19.78	ft/s	from definition of f		
Re=	3.06E+05		from definition of Re $= \frac{\rho V D}{\mu}$		
f=(check)	3.60E-03		yes, checks out		
		b) for laminar flow:			
		Re_max=	2100		
		f@Re_max	7.62E-03		=16/Re_max
		v@Re_max	1.36E-01	ft/s	from definition of Re
		DeltaP/L=	1.05E-01	lbm/s2ft2	from definition of f
		DeltaP/L=	1.89E-06	lbf/in3	

check Re: $Re = \frac{\rho V D}{\mu} = 3.06\times10^{5}$ turbulent

double check calculation (in case of error in entering)

$$f = \frac{1}{\left(4\log\left(3.06\times10^{5}\sqrt{3.6\times10^{-3}}\right) - 0.4\right)^2}$$

$= 3.6\times10^{-3}$

Answer: $\boxed{\langle v \rangle = 20\ ft/s}$ turbulent

b) What would $\frac{\Delta P}{L}$ need to be for flow to change to laminar?

$$Re_{max, laminar} = 2100 = \frac{\rho V D}{\mu}$$

$$\Rightarrow V = 1.36 \times 10^{-1} \text{ ft/s}$$

$$f = \frac{16}{Re} = \frac{16}{2100} = 7.62 \times 10^{-3}$$

$$\frac{\Delta P}{L} = \underbrace{\frac{2 f \rho V^2}{D}}_{\text{from definition of } f} = \boxed{1.89 \times 10^{-6} \frac{lb_f}{(in)^2 in}}$$