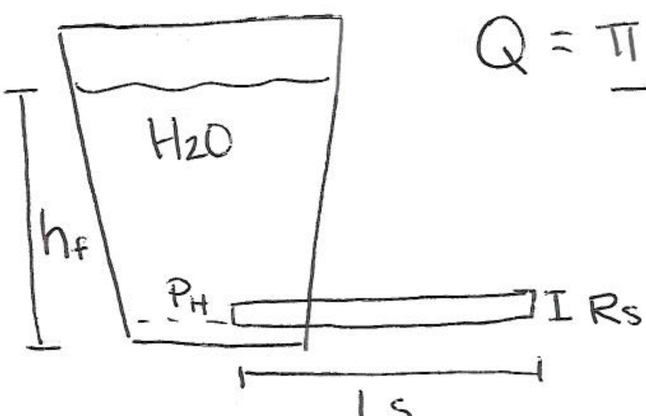
Fluid Mechanics & Viscosity

Fundamental Dimensions	SI (mks)	(Dr. Skip's) cgs	Engineering
Mass (M)	kg	g	lb mass
Length (L)	m	cm	ft
time (t)	s	s	s
Temperature (T) (K) Absolute	°C (K)	°C (K)	°F (R)
Density H_2O (ρ_f)	$1000 \frac{kg}{m^3}$	$1.0 \frac{g}{cm^3}$	$62.4 \frac{lb_m}{ft^3}$
Viscosity H_2O (μ_f)	$1 mPa\text{-}s = 10^{-3} Pa\text{-}s$	$1 cP = 10^{-2}$ Poise	

(Q) = Volumetric Flow Rate

$Re < 2100$

$$Q = \frac{\pi R_s^4 (\rho_f g h_f)}{8 \boxed{\mu_F} L_s}$$



$$Q = \int_{r=0}^{r=R} v_x(y)\, dy$$

Unit Conversions:

454 g/lbm

2.2 kg/lbm

2.54 cm/in

$$\left(\frac{1\,g}{cm^3}\right)\left(\frac{2.2\,lb_m}{kg}\right)\left(\frac{kg}{10^2 g}\right)\left(\frac{2.54\,cm}{in}\right)^3\left(\frac{12 [illegible]}{ft}\right. [illegible]$$

$$= 62.4 \frac{lb_m}{ft^3}$$

$$\left(\frac{1\,g}{cm^3}\right)\left(\frac{kg}{1000\,g}\right)\left(\frac{100\,cm}{m}\right)^3$$

$$= 1000 \frac{kg}{m^3}$$

Fluid Mechanics of Showering:

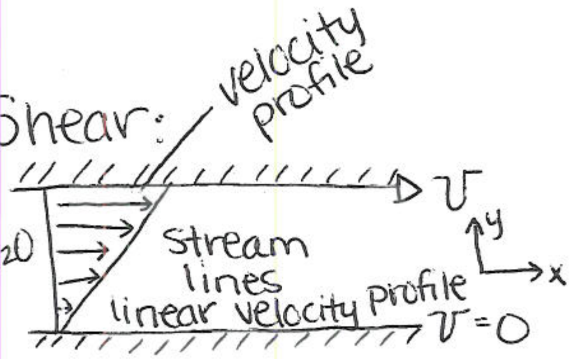
Q [=] Volumetric Flow Rate = $\frac{\text{volume}}{\text{time}} \left(\frac{L^3}{t}\right)$

v [=] velocity $\left(\frac{L}{t}\right) = \frac{Q}{A_x} \frac{\left(\frac{L^3}{t}\right)}{(L^2)}$

Density (ρ) [=] $\left(\frac{M}{L^3}\right)$

Viscosity (μ_f) = $\frac{\text{shear stress}}{\text{shear rate}}$

Shear:



drag flow

Shear stress: $\frac{\text{force}}{\text{area}} = \frac{ma}{\text{area}}$ [=] $\frac{ML/t^2}{L^2}$

pressure = stress [=] $\left(\frac{M}{Lt^2}\right)$

Pascal [=] $\frac{Kg}{m \cdot s^2}$

Boundry Conditions:

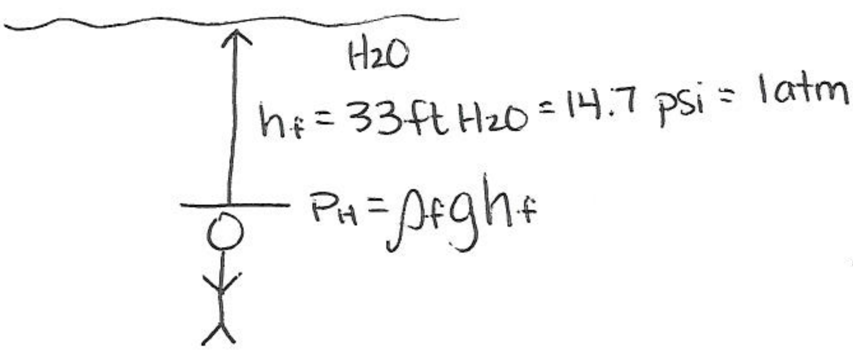
@ BC#1 @ x = 0 $v_x = 0$ noslip

BC#2 @ x = Y $v_x = U$ no slip

Shear rate: $\frac{dv_x(y)}{dy} = \frac{\Delta v_x}{\Delta y}$ [=] $\frac{L/t}{L}$ [=] t^{-1}

Viscosity [=] $\frac{\frac{M}{Lt^2}}{t^{-1}}$ Pa-s (mks) [=] $\frac{M}{L \cdot t} * \frac{Kg}{m \cdot s}$ Poise (cgs) [=] $\frac{M}{L \cdot t} = \frac{g}{cm \cdot s}$

Pressure Head:



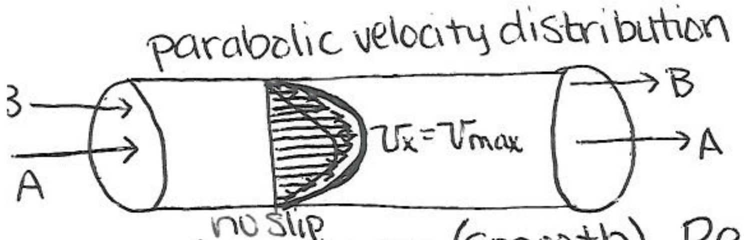
Specific Gravity (S.G)

$S.G. = \frac{\rho_f}{\rho_{H_2O} @ 4°C}$

S.G. (Hg) = 13.6

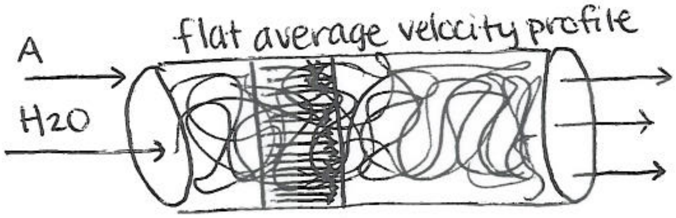
Dimensionless Group

Fluid Flow in Pipes:



- A exists before B
- maintain relative positions.

Laminar (Smooth) $Re < 2100$



- exit at the same time
- position in unknown
- mixing flow

Turbulent (Rough) $Re > 2300$

Reynolds Number: (Dimensionless Group)

$$Re \,[=]\, \frac{(\text{density})(\text{velocity})(\text{diameter})}{(\text{viscosity})} \,[=]\, \frac{\rho_f v_x D_p}{\mu_f} \,[=]\, \frac{\left(\frac{M}{L^3}\right)\left(\frac{L}{t}\right)(L)}{\left(\frac{M}{L \cdot t}\right)}$$

What flow rate should the pump be set at in order to reach Turbulent Flow?