FLUIDS

FLOW RATE

$$Q = AV$$

$Q = \frac{ft^3}{s}, \frac{Gal}{min}, gpm$

449 gpm/cfs.

FULL/CIRCULAR

$$A = \frac{\pi D^2}{4}$$

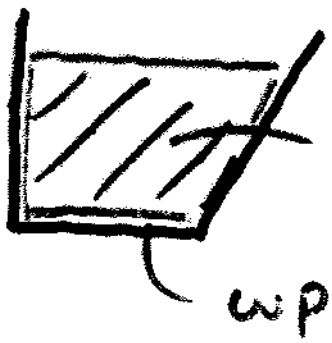
$$V = \frac{4Q}{\pi D^2}$$

FOR FULL-FLOW CIRCULAR

HYDRAULIC RADIUS - R

$$R = \frac{\text{Flow Area } ft^2}{\text{WET Perim } ft}$$

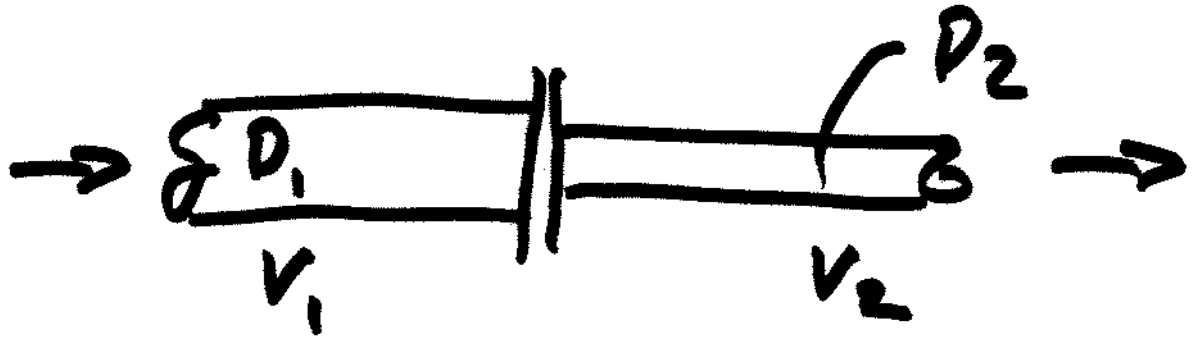
$$R = \frac{A}{WP}$$



$$R = D/4$$

FULL FLOW/CIRCULAR

VARIATION OF VEL w/ DIAMETER / FULL FLOW.



$$A_1 V_1 = A_2 V_2$$

$$\frac{\pi D_1^2}{4} V_1 = \frac{\pi D_2^2}{4} V_2$$

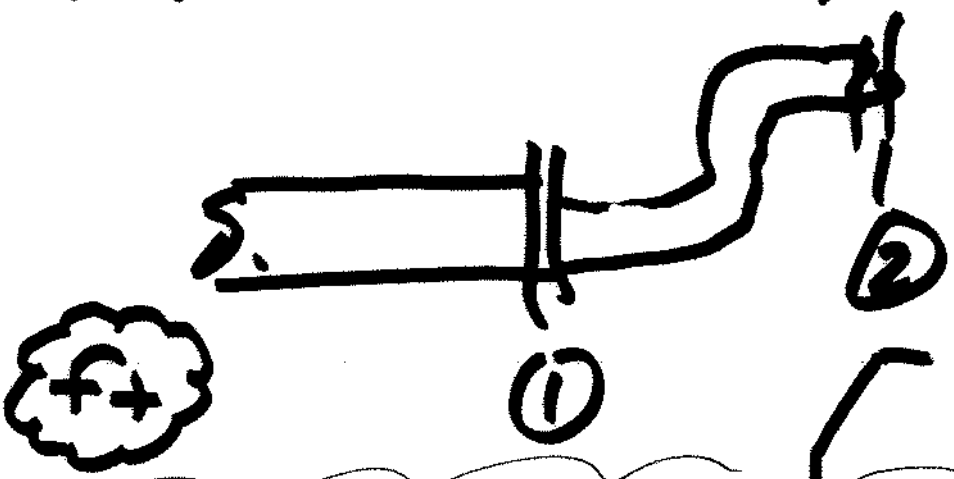
$$\frac{V_1}{V_2} = \left(\frac{D_2}{D_1}\right)^2$$

Ex: FIND VEL OF FLOW IN A 6" pipe conveying 2 cfs.

$$V = \frac{4Q}{\pi D^2} = \frac{4(2)}{\pi (1/2)^2} = 10.2 \text{ ft/s}$$

FLUID FLOW SYSTEMS

GENERAL ENERGY EQ.



PIPE FRICT

PUMP HEAD

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} - h_f - h_m + h_p = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

MINOR LOSSES: VALVES FITTINGS

PIPE FRICTION

① DARCY EQ.

$$h_f = f \frac{L}{D} \frac{V^2}{2g}$$

$$N_R = \frac{VD}{\nu}$$ ← kinematic viscosity

17-9 → ε/D

V - ft/s
L - ft
D - ft : Dia
g - 32.2 ft/s²
f - FRICTION FACTOR.

STRAIGHT PIPE FRICTION

HAZEN WILLIAMS - h_f

Q ↑ ft.

$$h_f = 0.002083\, L \left(\frac{100}{C}\right)^{1.85} \frac{(gpm)^{1.85}}{(d_{inch})^{4.8655}}$$

C - MTL. ROUGHNESS

90 100 140

100 ↑ OLD STEEL

140 ↑ NEW STEEL.

$$h_f = 168\, L \left(\frac{100}{C}\right)^{1.85} \frac{(Q)^{1.85}}{(d_{in})^{4.8655}}$$

$Q = ft^3/s$

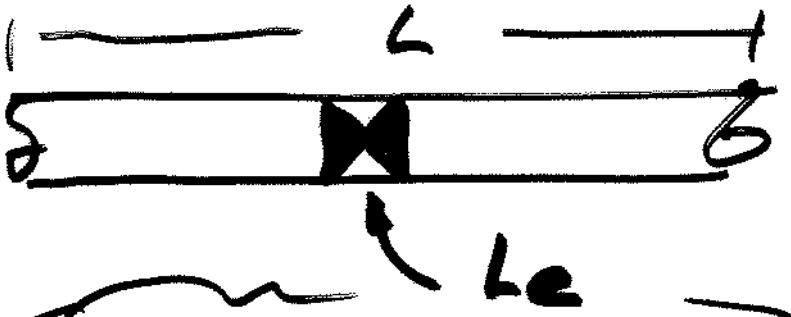
MINOR LOSSES → VALVES, FITTINGS

LOSS COEFFICIENTS

$$h_m = K \frac{V^2}{2g}$$

MINOR LOSSES

EQUIVALENT LENGTHS



$$h_m = f \frac{L_e}{D} \frac{V^2}{2g}$$

DARCY OR HAZEN WILL.

$$h_f + h_m = f \frac{(L + L_e)}{D} \frac{V^2}{2g}$$

$$K = f_T \left(\frac{L_e}{D} \right)$$

↑ TURBULENT FRICT. FACTOR FOR PIPE.

$$f = \frac{0.25}{\left(\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{(Re)^{0.9}}\right)\right)^2}$$

↑ MOODY DIAGRAM 17-6

$$f_T = \frac{0.25}{\left[\log\left(\frac{\varepsilon/D}{3.7}\right)\right]^2}$$

$$K = \frac{0.25}{\left[\log\left(\frac{\varepsilon/D}{3.7}\right)\right]^2}\left(\frac{Le}{D}\right)$$

PUMPS

$$\text{PWR TRANSFERRED HORSE} = \frac{\gamma h_p Q}{550 \text{ HORSE/FT.LB/S}}$$

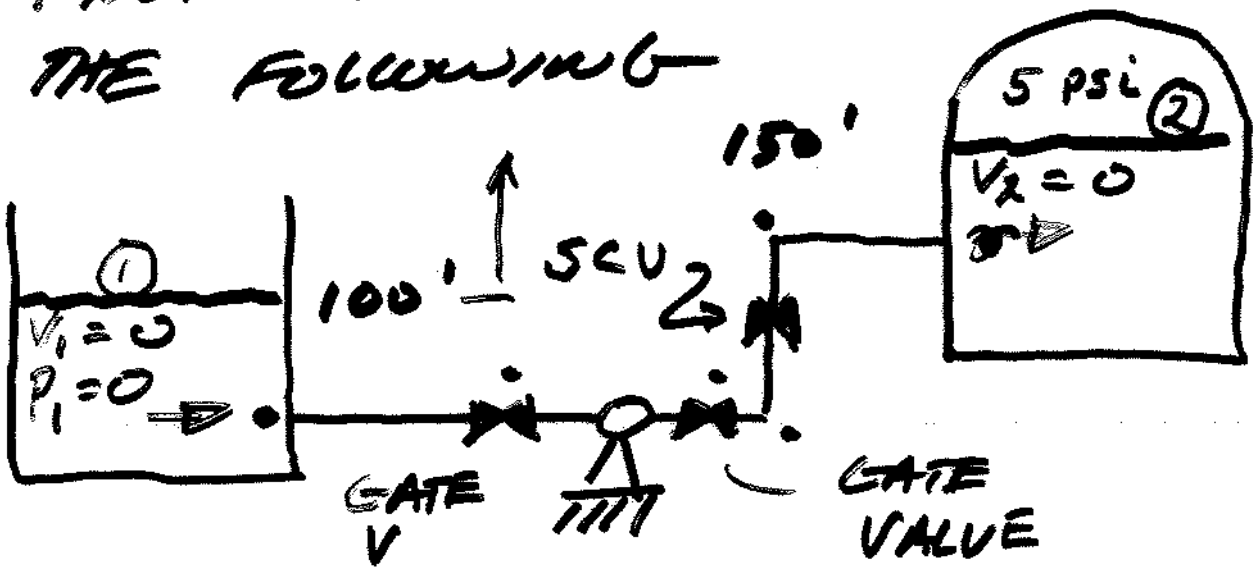
$$\text{PWR "PAY" FOR} = \frac{\gamma h_p Q}{550 E}$$

E = 0.5 - 0.95

h_p = Pump Head from GEE

EXAMPLE

FIND THE POWER TO DO THE FOLLOWING



Flow = 3 ft^3/s

comm. STEEL, D = 6"

L = 800 ft.

$$\frac{P_1}{\gamma}\uparrow 0 + z_1 + \frac{V_1^2}{2g} - h_f - h_m + h_p = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}\uparrow 0$$

$z_1 \downarrow 0$, $\frac{V_1^2}{2g} \downarrow 0$

$$h_p - h_f - h_m = \frac{P_2}{\gamma} + z_2$$

$$PWR = \frac{\gamma h_p Q}{550}$$

$$\rightarrow \boxed{h_p = \frac{P_2}{\gamma} + z_2 + h_f + h_m}$$

PIPE FRICTION

DARCY EQ.

$$h_f = f \frac{L}{D} \frac{V^2}{2g}$$

$$N_R = \frac{VD}{\nu} = \frac{15.3(1/2)}{1.05 \times 10^{-5}} = 7.3 \times 10^5$$

$$V = \frac{4Q}{\pi D^2} = \frac{4(3)}{\pi (0.5)^2} = 15.3 \text{ ft/s}$$

A-13 → $\nu = 1.05 \times 10^{-5}$

17-4 $\quad \frac{\varepsilon}{D} = \frac{0.0002}{0.5'} = \underline{0.0004}$

MOODY (17-6)