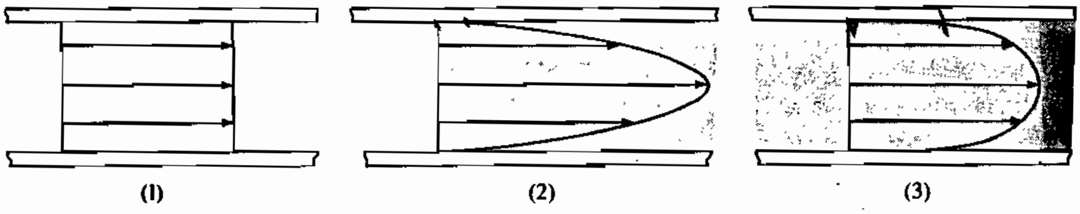
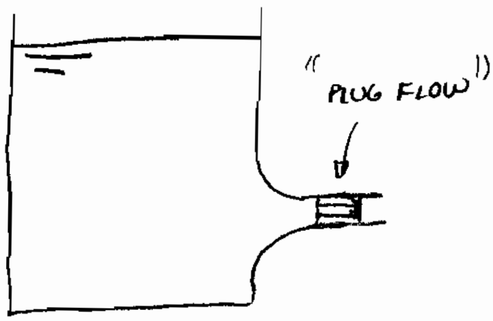
10.1 Consider the mean-velocity profiles for flow in the pipes shown. Match the profiles with the following: a) turbulent flow, b) obviously a case of hypothetical flow (zero viscosity), c) laminar case, d) $\alpha = 1.0$, e) $\alpha = 1.05$, f) $\alpha = 2.00$.



PROBLEM 10.1

(1) "HYPOTHETICAL FLOW" WITH $\alpha = 1.0$

THIS FLOW ACTUALLY DOES OCCUR TO A VERY GOOD APPROXIMATION AT EXIT OF A BELL-MOUTH INLET. IT IS CALLED A "UNIFORM VELOCITY PROFILE" OR "PLUG FLOW"



(2) FULLY DEVELOPED LAMINAR PIPE FLOW WITH $\alpha = 2.0$

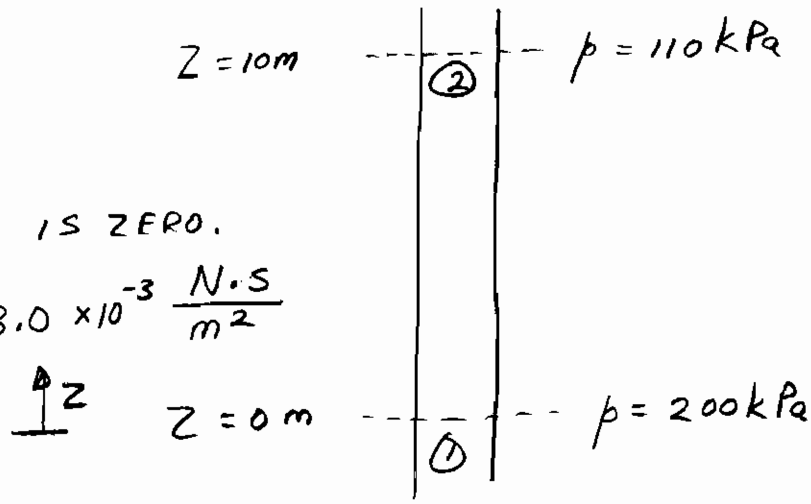
(3) FULLY DEVELOPED TURBULENT PIPE FLOW WITH $\alpha = 1.05$

10.2

GIVEN: $\gamma = 8 \ \frac{kN}{m^3}$

ACCELERATION IN PIPE IS ZERO.

$D = 1 cm$ AND $\mu = 3.0 \times 10^{-3} \ \frac{N \cdot s}{m^2}$



FIND: (a) DIRECTION OF LIQUID MOTION.

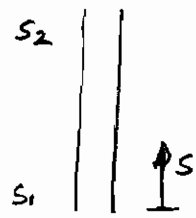
(b) MEAN VELOCITY.

SOLUTION:

(a) CALCULATE PIEZOMETRIC PRESSURE AT ① AND AT ②. LIQUID WILL FLOW TOWARDS POINT WHICH HAS LOWER PIEZOMETRIC PRESSURE.

$$p_1 + \gamma z_1 = 200 \ kPa$$
$$p_2 + \gamma z_2 = 190 \ kPa$$

$\boxed{\text{LIQUID FLOW FROM ① TO ②.}}$



(b) $$\bar{V} = \frac{r_0^2}{8\mu}\left[-\frac{d}{ds}(p + \gamma z)\right]$$

$$\bar{V} = \frac{(.005)^2}{8(3.0 \times 10^{-3})}\left[-\left(\frac{190{,}000 - 200{,}000}{10}\right)\right]$$

$$\boxed{\bar{V} = 1.04 \ m/s}$$

10.2 CONTINUED

$$Re = \frac{DV\rho}{\mu} = \frac{DV\gamma}{\mu g}$$

$$Re = \frac{(0.01)(1.04)(8000)}{(.003)(9.8)}$$

$$Re = 2830$$

NOTE THAT FLOW IS <u>NOT</u> LAMINAR

SINCE $Re > 2000$.

10.7

GIVEN: GLYCERIN AT $T = 30°C$ FLOWS AT A RATE OF $8 \times 10^{-6}\ \frac{m^3}{s}$ THROUGH A HORIZONTAL TUBE WITH A 30 mm DIAMETER.

FIND: PRESSURE DROP PER 10 m.

SOLUTION:

$$\frac{p_1}{\gamma} + \cancel{z_1}^{\,0} + \cancel{\alpha_1 \frac{V_1^2}{2g}} = \frac{p_2}{\gamma} + \cancel{z_2}^{\,0} + \cancel{\alpha_2 \frac{V_2^2}{2g}} + h_L$$

CANCEL

$$p_1 - p_2 = \gamma h_L \qquad h_L = \frac{32 \mu \bar{V} L}{\gamma D^2}$$

LAMINAR FLOW

$$p_1 - p_2 = \frac{32 \mu \bar{V} L}{D^2} \qquad \bar{V} = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

$$p_1 - p_2 = \frac{128 \mu Q L}{\pi D^4} \qquad \bar{V} = .0113\ \frac{m}{s}$$

FIGURE A.2 $\mu = 0.7\ \frac{N \cdot s}{m^2}$

$$p_1 - p_2 = \frac{128\,(0.7)(8 \times 10^{-6})(10)}{\pi\,(.03)^4} = 2800\ Pa$$

10.7 CONITINUED

CHECK THE REYNOLDS NUMBER

$$Re = \frac{DV}{\nu}$$

FIGURE A.3 $\nu = 5 \times 10^{-4} \frac{m^2}{s}$

$$Re = \frac{(.03)(.0113)}{5 \times 10^{-4}} = 0.678$$

$Re < 2000$ THE FLOW IS LAMINAR