WB2F pg 109.

water

$\rho = 998.2 \text{ kg/m}^3$

$\mu = 1.002 \text{ mPa·s} = 1.002(10^{-3}) \text{ Pa·s}$

$L = 30 \text{ m}$ pipe

$D = 7.793 \text{ cm} = 0.07793 \text{ m}.$

$Q = 4\frac{\ell}{\text{min}} * \frac{1 \text{ min}}{60 \text{ s}} * \frac{1 \text{ m}^3}{1000 \ell} = 6.67(10^{-5}) \text{ m}^3/\text{s}$

(a) to check if Laminar or Turbulent, check Reynolds' number, Re

$$Re = \rho \bar{u} D / \mu$$

$$\bar{u} = Q/A = \left[6.67(10^{-5}) \text{ m}^3/\text{s}\right] / \left[\tfrac{1}{4}\pi (0.07793 \text{ m})^2\right]$$

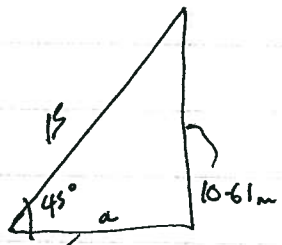
$$= 0.01398 \text{ m/s}$$

$$\text{So } Re = (998.2)(0.01398)(0.07793) / (1.002(10^{-3}))$$

$$= 1085$$

since $< 2100 \Rightarrow$ Laminar Flow

(b) since laminar, use Hagen-Poiseuille Eq'n:



$$-\left[\frac{P_2 - P_1}{L} + \rho g \frac{h_2 - h_1}{L}\right] = \frac{32 \mu \bar{u}}{D^2}$$

take reservoir pressure P_2 = 1 atm = 101.325 kPa.

$\frac{a}{30} = \cos 45°$

$= 10.61 \text{ m}$

so then:

$$\left[\frac{101325 - P_1}{30} + \frac{(998.2)(9.81)(10.61)}{30}\right] = -32\frac{\left(1.002(10^{-3})\right)(0.01398)}{0.07793^2}$$

or $P_1 = 205224\ Pa$

(c) $P_{power} = -\Phi \Delta P$

$= -\Phi (P_2 - P_1)$

$= -\left[6.67 (10^{-5}) \frac{m^3}{s}\right]\left[101325 - 205224\ Pa\right]$

$= 6.93\ W$ note $1\ Pa \cdot m^3 = 1\ J$