Q1. $\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_f$

$h_f = z_1 - z_2 = 0.9\ m = \frac{128 \mu L Q}{\pi \rho g d^4} = \frac{128(0.0012)(1.2m)Q}{\pi(789)(9.81)(0.002)^4}$

$Q \doteq 1.90E-6\ m^3/s = \underline{0.00684\ m^3/h}$

$Re = \frac{4\rho Q}{\pi \mu d} \doteq 795$

Q2. (a) $P_1 - P_2 = (133100 - 9790\ \frac{N}{m^3})(0.135m) + (9790\ \frac{N}{m^3})(3m)$

$= \underline{46.01\ kPa}$

(b) $h_L = \frac{\Delta P}{\gamma_w} - \Delta z$

$= \frac{46010\ Pa}{9790\ N/m^3} - 3m = \underline{1.7\ m}$

$f = (h_L)\left(\frac{d}{L}\right)\left(\frac{2g}{V^2}\right)$

$= (1.7m)\left(\frac{0.06m}{5m}\right)\left(\frac{2(9.81\ m/s^2)}{(4\ m/s)^2}\right)$

$= \underline{0.025}$

Q3. Given $\rho = 10^3\ kg/m^3$; $\nu = 1 \times 10^{-6}\ m^2/s$; $Q = 300\ L/min = \left(\frac{1}{200}\right) m^3/sec$

d (diameter) = 40mm = 0.04 m; L (length) = 8m

Velocity $(V) = \frac{Q}{\text{Area of pipe}} = \frac{Q}{\left(\frac{\pi}{4} \times d^2\right)} = \frac{1 \times 4}{(200)(\pi)(0.04)^2} = 3.978\ m/sec$

$Re = \frac{\rho V D}{\mu} = \frac{VD}{\nu} = \frac{3.978 \times 0.04}{1 \times 10^{-6}} = 159120$

i.e. Re (Reynold's Number) is greater than 4000, hence the flow is turbulent

$f = \frac{0.046}{(Re)^{0.2}}$

$= \frac{0.046}{(159120)^{0.2}} = 4.1919 \times 10^{-3}$

$\therefore f = \underline{0.0041919}$

Q3. Continuation

head loss due to friction (h_f) $= \frac{FLQ^2}{3(d)^5} = \frac{4.1919 \times 10^{-3} \times 8 \times \left(\frac{1}{200}\right)^2}{3 \times (0.04)^5}$

$= 2.7291$

$\boxed{\therefore h_f = 2.7291 \text{ m of water}}$

Power required to supply by pump = specific weight $\times Q \times h_f$

$P = \rho g \times Q \times h_f$

$= 10^3 \times 9.81 \times \left(\frac{1}{200}\right) \times 2.7291$

$\boxed{\therefore \text{The power required for supply by pump} = 133.86 \text{ watts}}$

Q4. $V = \frac{Q}{A} = \frac{\left(\frac{11}{3600}\right)}{\left(\frac{\pi}{4}\right)(0.03)^2} = 4.32 \text{ m/s}$; $Re = \frac{\rho V d}{\mu} = \frac{998(4.32)(0.03)}{0.001}$

$= 129000$

The energy eqn. yields value of head loss

$$\frac{P_{atm}}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_{atm}}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_f$$

or $h_f = 4 - \frac{(4.32)^2}{2(9.81)} = 3.05 \text{ m}$

$h_f = (f)\left(\frac{L}{d}\right)\frac{V^2}{2g}$ or $3.05 = f\left(\frac{5.0}{0.03}\right)\frac{(4.32)^2}{2(9.81)}$

$\boxed{f \doteq 0.0192}$

$$\frac{1}{(0.0192)^{\frac{1}{2}}} = -2.0 \log_{10}\left[\frac{\varepsilon/d}{3.7} + \frac{2.51}{129000\,(0.0192)^{1/2}}\right]$$

$\frac{\varepsilon}{d} \doteq 0.000394$

$\boxed{\varepsilon = 0.000394\,(0.03) \doteq 1.2\,E{-5} \text{ m} \doteq 0.012}$