Q- A patient is to be given a blood transfusion. The blood is to flow through a wide tube from a raised bottle to a needle inserted in the vein. The inside diameter of the 3.8 cm long needle is 0.4 mm and the required flow rate is 4 cm^3 of blood per minute. How high should the bottle be placed above the needle? Assume the blood pressure is 20 torr above atmospheric pressure. (Density of blood = $1.05*10^3$ kg/m^3 and its viscosity is $4*10^{-3}$ Pa.s)

1 torr = 1 atm/760 = $1.01*10^5/760$ = 132.9 Pa

Or ΔP = 20 torr = 2658 Pa

Now if the height of the bottle from the needle is h then pressure of the blood from the bottle is given by

$$P_1 = P_0 + h\rho g$$

Pressure of blood (other end of the needle) will be

$$P_2 = P_0 + P$$

Hence the pressure difference across the needle will be

$$P_1 - P_2 = P_0 + h\rho g - P_0 - P$$

Or $$P_1 - P_2 = h\rho g - P$$

Now the volume flow rate of a fluid through a tube of radius r and length L is given by

$$\frac{dQ}{dt} = \frac{\pi(P_1 - P_2)r^4}{8\eta L}$$

Or $$\frac{dQ}{dt} = \frac{\pi(h\rho g - P)r^4}{8\eta L}$$

Substituting the values in SI units we get

$$\frac{4.0*10^{-6}}{60} = \frac{3.14*(h*1.05*10^3*9.8 - 2658)*\left(\frac{0.4*10^{-3}}{2}\right)^4}{8*4*10^{-3}*0.038}$$

Or $$\frac{4.0*10^{-6}}{60} = \frac{3.14*(10290\ h - 2658)*1.6*10^{-15}}{1.22*10^{-3}}$$

Or $$(10290\ h - 2658) = \frac{4.0*10^{-6}*1.22*10^{-3}}{60*3.14*1.6*10^{-15}}$$

Or $$(10290h - 2565) = 16189$$

Or $$h = \frac{16189+2658}{10290} = \mathbf{1.83\ m}$$