1. Blood Filtration

a) For a tube, surface area divided by pore volume is $2/R$, so surface area divided by solid volume S_o is given by:

$$S_o = \frac{(2/R)\,(\omega)}{(1-\omega)}$$

$$= \frac{(2 / 50*10^{-6}) * (0.4)}{0.6}$$

$$\boldsymbol{S_o = 26{,}666.7\ m^{-1}}$$

b) The flow rate Q is given by:

$$Q = \frac{\Pi\,(\Delta P)\,R^4}{8\,\mu\,L}$$

$$Q = \frac{\Pi\,(1.013 * 10^4) * (50 * 10^{-6})^4}{8 * 0.0027 * 15 * 10^{-3}}$$

$$\boldsymbol{Q = 6.14 * 10^{-10}\ m^3/s}$$

c) To determine the Reynolds Number, we need to first calculate U_o as follows:

$$U_o = K^{-1}\,\frac{\Delta P\omega}{L\mu}\quad\frac{\omega^2}{S_o^2\,(1-\omega)^2}$$

$$(1/2)*[(1.013*10^4*.4)/(15*10^{-3}*.0027)] * [(0.4)^2/(26{,}666.7)^2$$

$$\boldsymbol{=0.3125\ m/s}$$

$$\boldsymbol{Re} = \frac{\rho U_o}{\mu*(1-\omega)\,S_o} = \frac{1060*0.1488}{0.0027*0.6*26{,}666.7} \quad \boldsymbol{= 0.767}$$

d) The entrance length is determined by:

$$\boldsymbol{Le} = \frac{Re*2*50*10^{-6}}{100} \quad \boldsymbol{= 3.66\ x\ 10^{-7}\ m}$$

Le<<L so the entrance length approximation is valid and our flow is fully developed.

e)

i) For a packed bed of spheres, S_o is given by:

$S_o = (3/R)$

$S_o = (3 / 500 * 10^{-6})$

$S_o = 6000\ m^{-1}$

ii) For a packed bed of spheres, $\omega = 0.26$

And so, to determine U_o:

$$U_o = K^{-1} \frac{\Delta P \omega}{L \mu} \frac{\omega^2}{S_o^2 (1-\omega)^2}$$

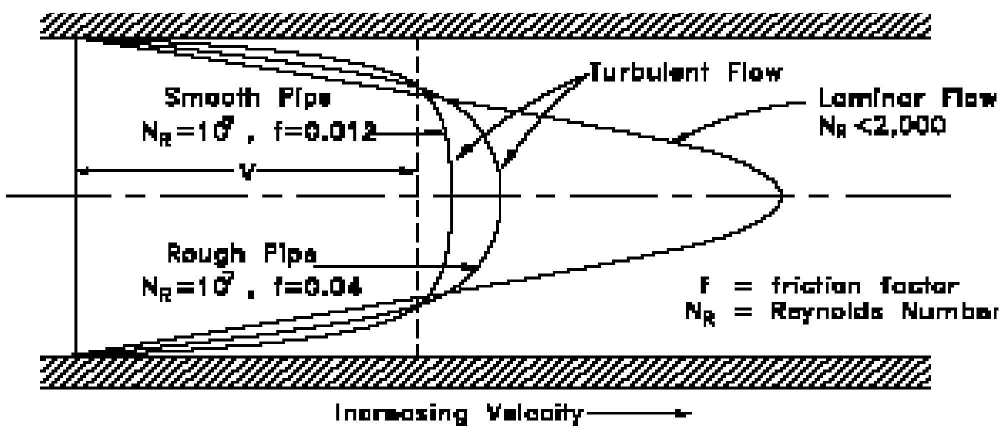
$U_o = (1/4.2) * [(1.013 * 10^4 * 0.26) / (15 * 10^{-3} * 0.0027)] * [\{(0.26)^2\} / \{(6000^2) * (0.74^2)\}]$

$U_o = 0.053\ m/s$

Now to determine the Reynolds Number:

$$\boldsymbol{Re} = \frac{\rho U_o}{\mu * (1-\omega) S_o} = \frac{1060*0.053}{0.0027*0.74*6000} = \boldsymbol{4.21}$$

f) For the tube, qualitative turbulent and laminar flows are depicted in the graphic below:



Courtesy of: *http://www.engineersedge.com/fluid_flow/flow_velocity_profiles.htm*

g) The size of the AIDS virus is 0.1µm. The radius of the tubes is 50 µm which means that should the AIDS virus be in the blood, it would not be filtered by this process. Rather, the virus would flow through the tube with the components of blood that are less than 100 µm (tube diameter) in size. Because of the relatively large radius of the tube, it can only be counted on to separate blood constituents that are larger than the tube diameter in size.