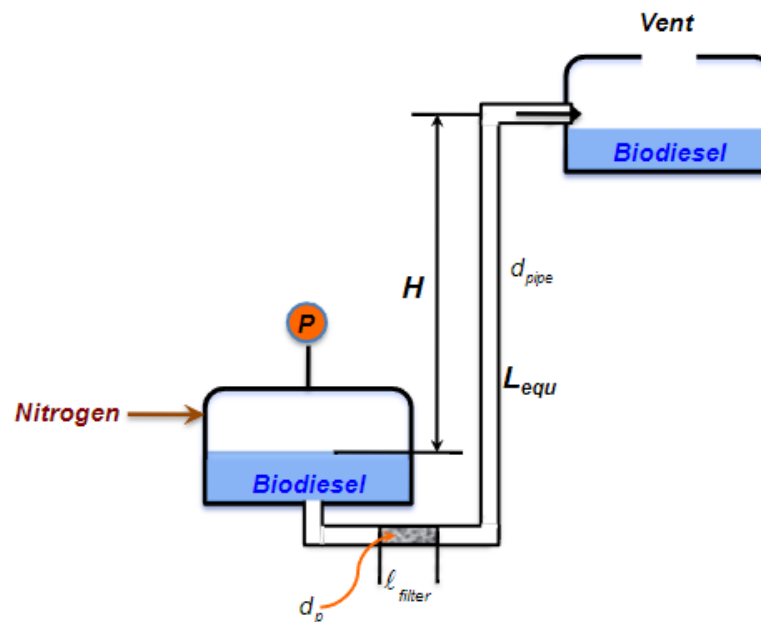


1. (60 points) Figure below shows how nitrogen gas under a pressure $P_{N_2} = 190,000$. [Pa] (this is gauge pressure) can be used for 'pumping' a flammable fuel (biodiesel) through an elevation increase of $H = 10$. [m]. A particle filter (packed bed) is installed in the pipeline to filter particulates in the biodiesel fuel. The filter was made from sintered SS particles $d_p = 500$ [μm]; the length of the filter is $\ell_{\text{filter}} = 0.01$ [m].

a) What is the flow rate of biodiesel $F_{\text{biodiesel}}$ [m^3/s], if it flows through a commercial steel pipe of diameter $d_{\text{pipe}} = 0.025$ [m]. The equivalent length (all pipe fittings are included) of the pipe is $L_{\text{equ}} = 100$. [m]

(Note: Neglect exit kinetic energy effects.)



Data: $\rho_{\text{biodiesel}} = 880$. [kg/m^3];	$\mu_{\text{biodiesel}} = 0.005$ [kg/ms];	$L_{\text{equ}} = 100$. [m];
$d_{\text{pipe}} = 0.025$ [m];	$H = 10$. [m]	$P_{N_2\text{-gauge}} = 190,000$. [Pa]
$P_{\text{atm}} = 100,000$. [Pa]	$d_p = 500$ [μm];	$\ell_{\text{filter}} = 0.01$ [m]
$F_{\text{biodiesel}} = ???$ [m^3/s]		