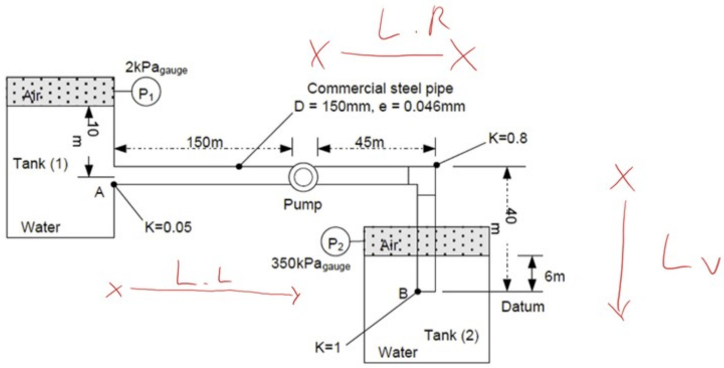
//QUESTION6



{Water is pumped from a large tank (1) to a second large tank (2) through a pipe system
as shown below. For a steady flow of 100L/s, what size pump is required assuming the
pump has an ?=0.85? Assume steady incompressible water flow with ?=1000kg/m3,
µ=1225x10-6 Ns/m2. [43.08 kW].}

//Given
//dE/dt=0[W] because its steady flow
V_dot=100[L/s]***convert**(L/s;m^3/s)
n=0,85[dim]
g=9,81[m/s^2]

rho=1000[kg/m^3] //Constan because the flow is incompressible
mu=1225E-6 [N-s/m^2]

P_1=2[kPa]***convert**(kPa;Pa)
z_1=10[m]
L_L=150[m]

L_R=45[m]
L_V=40[m]

e_steel=0,046[mm]***convert**(mm;m)
D_steel=150[mm]***convert**(mm;m)
A_s=pi*(D_steel)^2/4

z_2=40[m]
P_2=350[kPa]***convert**(kPa;Pa)

//Velcocity along horizontal steel pipe
V=V_dot/A_s
V_A=V
z_A=0[m] //I am seting my datum to be at point A [Ref point]

z_B=-40[m]   //Datum at A makes point B -40m below Ref Point

P_A/rho+V_A^2/2-z_1*g=P_1/rho
z_air_to_B=-6[m] //Height from the Air gauge to the Point B , Where Ref point is at the Air guage
P_B/rho +z_air_to_B*g=P_2/rho

// Losses
k_tot=0,05[dim]+0,8[dim]+1[dim]

h_minor=k_tot*(V^2)/2/g

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Re=(rho*V*D_steel)/mu   //Re>40000, The flow is not laminar

(1/sqrt(f)) =-2*log10((e_steel/D_steel)/3,7 + 2,51/(Re*sqrt(f)))

L_tot=L_L + L_R+L_V
h_major=f*(L_tot/D_steel)*(V^2/2/g)

{h_major = f * (L_tot/D_steel )* V^2/(2)  } //V is const through out the Pipe as the Diameter is the same and volumetric flow rate

//Head Calculations
h_friction=h_minor+h_major //Total losses head
h_pressure=(P_B-P_A)/rho/g  //Pressure Head
h_elevation=z_A+z_B
h_pump=h_friction+h_pressure+h_elevation

W_dot_pump_s=rho*g*V_dot*h_pump   //Ideal if there were no reversiblilies
W_dot_pump_a=W_dot_pump_s/n
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$$\dot{V} = 100 \ [L/s] \cdot \left| 0{,}001 \cdot \frac{m^3/s}{L/s} \right|$$

$$n = 0{,}85 \ [dim]$$

$$g = 9{,}81 \ [m/s^2]$$

$$\rho = 1000 \ [kg/m^3]$$

$$\mu = 0{,}001225 \ [N\text{-}s/m^2]$$

$$P_1 = 2 \ [kPa] \cdot \left| 1000 \cdot \frac{Pa}{kPa} \right|$$

$$z_1 = 10 \ [m]$$

$$L_L = 150 \ [m]$$

$$L_R = 45 \ [m]$$

$$L_V = 40 \ [m]$$

$$e_{steel} = 0{,}046 \ [mm] \cdot \left| 0{,}001 \cdot \frac{m}{mm} \right|$$

$$D_{steel} = 150 \ [mm] \cdot \left| 0{,}001 \cdot \frac{m}{mm} \right|$$

$$A_s = \pi \cdot \frac{D_{steel}^2}{4}$$

$$z_2 = 40 \ [m]$$

$$P_2 = 350 \ [kPa] \cdot \left| 1000 \cdot \frac{Pa}{kPa} \right|$$

$$V = \frac{\dot{V}}{A_s}$$

$$V_A = V$$

$$z_A = 0 \ [m]$$

$$z_B = -40 \ [m]$$

$$\frac{P_A}{\rho} + \frac{V_A^{\ 2}}{2} - z_1 \cdot g = \frac{P_1}{\rho}$$

$$z_{air;to;B} = -6 \ [m]$$

$$\frac{P_B}{\rho} + z_{air;to;B} \cdot g = \frac{P_2}{\rho}$$

$$k_{tot} = 0,05 \ [dim] + 0,8 \ [dim] + 1 \ [dim]$$

$$h_{minor} = k_{tot} \cdot \frac{V^2}{2 \cdot g}$$

$$Re = \frac{\rho \cdot V \cdot D_{steel}}{\mu}$$

$$\frac{1}{\sqrt{f}} = -2 \cdot \mathbf{log}\left[\frac{e_{steel}}{D_{steel} \cdot 3,7} + \frac{2,51}{Re \cdot \sqrt{f}} \right]$$

$$L_{tot} = L_L + L_R + L_V$$

$$h_{major} = f \cdot \frac{L_{tot}}{D_{steel}} \cdot \frac{V^2}{2 \cdot g}$$

$$h_{friction} = h_{minor} + h_{major}$$

$$h_{pressure} = \frac{P_B - P_A}{\rho \cdot g}$$

$$h_{elevation} = z_A + z_B$$

$$h_{pump} = h_{friction} + h_{pressure} + h_{elevation}$$

$$\dot{W}_{pump;s} = \rho \cdot g \cdot \dot{V} \cdot h_{pump}$$

$$\dot{W}_{pump;a} = \frac{\dot{W}_{pump;s}}{n}$$

SOLUTION

Unit Settings: SI C kPa kJ mass deg

A_s = 0,01767 [m^2]	D_{steel} = 0,15 [m]	e_{steel} = 0,000046 [m]
f = 0,016 [dm]	g = 9,81 [m/s^2]	$h_{elevation}$ = -40 [m]
$h_{friction}$ = 43,94 [m]	h_{major} = 40,92 [m]	h_{minor} = 3,019 [m]
$h_{pressure}$ = 33,11 [m]	h_{pump} = 37,04 [m]	k_{tot} = 1,85 [dim]
L_L = 150 [m]	L_R = 45 [m]	L_{tot} = 235 [m]
L_V = 40 [m]	μ = 0,001225 [$N\text{-}s/m^2$]	n = 0,85 [dim]
P_1 = 2000 [Pa]	P_2 = 350000 [Pa]	P_A = 84089 [Pa]
P_B = 408860 [Pa]	Re = 692919 [dim]	ρ = 1000 [kg/m^3]
V = 5,659 [m/s]	V_A = 5,659 [m/s]	$\dot{V}$ = 0,1 [m^3/s]
$\dot{W}_{pump,a}$ = 42751 [W]	$\dot{W}_{pump,s}$ = 36338 [W]	z_1 = 10 [m]
z_2 = 40 [m]	z_A = 0 [m]	$z_{air,to,B}$ = -6 [m]
z_B = -40 [m]		

2 potential unit problems were detected.