ENGR30002 SM1 2021 Assignment 1

Michael Le

TOTAL POINTS

7.2 / 10

QUESTION 1

1 Question 1 2 / 3.5

- **- 0 pts** All correct answers
- ✓ **- 0.5 pts K_entrance, K_exit**
- ✓ **- 0.5 pts Incorrect velocity**
- ✓ **- 0.5 pts Incorrect Re**
- **- 0.5 pts** Incorrect f_F
- **- 0.5 pts** Incorrect pump power: Batu
- **- 0.5 pts** Incorrect pump power: Sukun
- **- 0.5 pts** Incorrect pump power: Gumung

Incorrect v and Re affected the final answers. No penalties on the rest of the wrong answers.

QUESTION 2

2 Question 2 (a) 0.5 / 1

- **- 0 pts** Correct
- ✓ **- 0.5 pts Partially correct**
- **- 1 pts** Incorrect answer

QUESTION 3

3 Question 2 (b) 2.5 / 2.5

- ✓ **- 0 pts Correct**
- **- 0.5 pts** Incorrect equation (cavitation occurs before the pump):
- **- 0.5 pts** Incorrect length of the pipe before the pump
- **- 1 pts** No work for length of the pipe before the pump
- **- 0.5 pts** Incorrect height (but minor mistakes)
- **- 1 pts** Incorrect height (but showed all work)
- **- 2 pts** Incorrect height (no work)
- **- 2.5 pts** Wrong page selection or No pages

QUESTION 4

4 Question 3 2.2 / 3

- **- 0 pts** Correct
- **- 0.5 pts** Incorrect frictional head losses
- **- 0.5 pts** Incorrect minor losses
- ✓ **- 0.5 pts Incorrect power (but showed all work)**
- **- 2.5 pts** Incorrect power (No work)
- **- 1 pts** No power but showed all work
- **- 1 pts** No comparison
- ✓ **- 0.3 pts Compared but less explanation or incorrect answer**
- **- 0.5 pts** Compared but not enough explanation or incorrect
- **- 1 pts** No comparisson
- **- 3 pts** No submission or incomplete answer

Michael Le (998211) ASSIGNMENT 1 ENGR30002.

Question 1

Source 1 Batu Asah,	Source 2 Sukun Spring,	Source 3, Gunnung Tank.
$D = 0.05m$	$D=0.05m$	$D=0.05m$
$L=641m$	$L=351m$	$L=1157m$
$\varepsilon = 0.046\times10^{-3}m$	$\varepsilon=0.046\times10^{-3}m$	$\varepsilon=0.046\times10^{-3}m$
$\Delta z = 30m$	$\Delta z=50m$	$\Delta z=125m$,

$$Q = \frac{40kl}{1\,day} \times \frac{1\,day}{24\,hours} \times \frac{1\,hr}{60\,mins} \times \frac{1\,min}{60\,seconds} \times \frac{1\,m^3}{1\,kl}$$

$= 0.0004629629\overline{6}\ m^3/s$ (SI units)

$\simeq 0.0004629$

$= 4.629\times10^{-4} m^3/s.$

Assume the water fluid is incompressible!!

$Q = Q_{Batu Asah} = Q_{Sukun Spring} = Q_{Gunnung Tank} = 4.629\times10^{-4} m^3/s$

$A = A_{Batu Asah} = A_{Sukun Spring} = A_{Gunnung Tank} = \frac{\pi}{4}(0.05)^2 m^2$

$Q = VA$

$V = \frac{Q}{A} = \frac{4.629\times10^{-4}m^3/s}{\frac{\pi}{4}(0.05)^2 m^2} = 0.2357530341 m/s.$

$\frac{\varepsilon}{D} = \frac{0.046mm}{50mm} = \frac{0.046}{50} = 0.00092$ (for all 3 water sources).

Reading from the Moody-Chart

$\rho = 998.19\ kg/m^3$ water density at 20°C.
$\mu = 0.0010005\ Pa{\cdot}s$ water viscosity at 20°C.

$Re = \frac{\rho v D}{\mu} = \frac{998.19\,kg/m^3 \times 0.2357\,m/s \times 0.05m}{0.0010005\,Pa.s}$

The Reynolds number for all the 3 water resources!

$= 11757.79$

$= 1.175779\times10^4$

$f_F = 0.007875$

Fanning friction factor

Using the Mechanical Balance Equation.

$\alpha = 1$ for turbulent flow

$$\boxed{\frac{\Delta P}{\rho} + \frac{1}{2}(\Delta v^2) + g\Delta z + W_s + 2f_F\frac{Lv^2}{D} = 0}$$

Apply the system between the surface for all three sources. Both pressures at both ends (i.e. all connected to Bukit Kayu Tank.) are open to Atmospheric pressure. $\Delta P = 0$.

Source 1 Batu Asah,

$$-W_{s_1} = \left(\frac{1}{2}(0.2375^2 - 0^2) + 9.81 \times 30 + 2(0.007875) \times 641 \times \frac{0.2375^2}{0.05}\right) \text{J/kg}$$

$= 305.72$ J/kg.

Power required

$P_1 = -W_{s_1}G = 305.72$ J/kg $\times 998.19$ kg/m^3 $\times 4.629 \times 10^{-4}$ m^3/s
$= 141.26$ J/s (soln 1)

Source 2 Sukun Spring,

$$-W_{s_2} = \left(\frac{1}{2}(0.2375^2 - 0^2) + 9.81 \times 50 + 2(0.007875) \times 351 \times \frac{0.2375^2}{0.05}\right) \text{J/kg}$$

$= 496.74$ J/kg

Power required

$P_2 = -W_{s_2}G = 496.74$ J/kg $\times 998.19$ kg/m^3 $\times 4.629 \times 10^{-4}$ m^3/s
$= 229.52$ J/s (soln 2)

Source 3 Gumming Tank,

$$-W_{s_3} = \left(\frac{1}{2}(0.2375^2 - 0^2) + 9.81 \times 125 + 2(0.007875) \times 1157 \times \frac{.2375^2}{0.05}\right) \text{J/kg}$$

$= 1246.84$ J/kg

$P_3 = -W_{s_3}G = 576.11$ J/s (soln 3). $\left(= 1246.84 \text{ J/kg} \times 998.19 \text{ kg/m}^3 \times 4.629 \times 10^{-4} \text{ m}^3/\text{s}\right)$

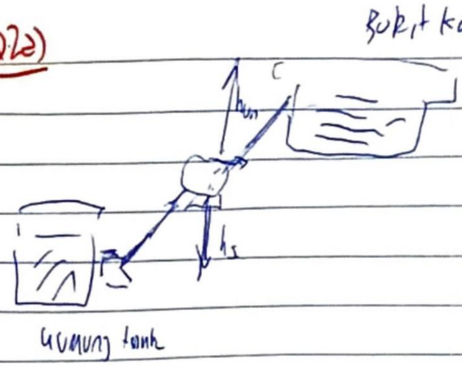
We choose Butu Asah because it consumes the least power compared to the other two resources. which is the same as the background summary conclusion.

1 Question 1 **2 / 3.5**

- **- 0 pts** All correct answers
- ✓ **- 0.5 pts** **K_entrance, K_exit**
- ✓ **- 0.5 pts** **Incorrect velocity**
- ✓ **- 0.5 pts** **Incorrect Re**
- **- 0.5 pts** Incorrect f_F
- **- 0.5 pts** Incorrect pump power: Batu
- **- 0.5 pts** Incorrect pump power: Sukun
- **- 0.5 pts** Incorrect pump power: Gumung

Incorrect v and Re affected the final answers. No penalties on the rest of the wrong answers.

Q2a)



No, this can have lead to cavitation, there would cause pressure to be located at the suction side of the pump. This can cause sudden and unwanted noise and vibration in the system, results in loss of head and efficiency. This formulation and collapse of the bubble cause pressure waves in the system that result in mechanical ~~energy~~ ~~fatigue~~ damage to the pump.

Hence, $P_{\text{suction side}} > P_{\text{suction side}}$.

We are interested in the ~~action~~ suction head.

$$h_s > \frac{P_{vp}}{\rho g}$$

In this case the suction head is halfway up the hill, $h_s \le h_{up}$.

Q2b)

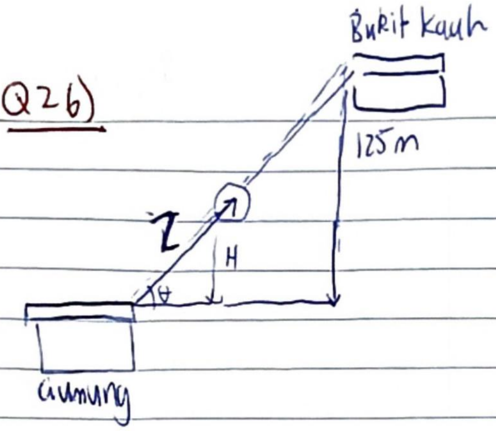
2 Question 2 (a) **0.5 / 1**

- **- 0 pts** Correct

✓ **- 0.5 pts Partially correct**

- **- 1 pts** Incorrect answer

Q2b)



$\sin\theta = \frac{125m}{1157m}$

$H = Z\sin\theta$

$H = 0.1081Z$

$Z = 9.256H$

NPSHa would show how close the fluid gets close to cavitation

$$NPSHa = \frac{P - P_{vp}}{\rho g} + z - h_f$$

(Assume the tanks are exposed to the atmosphere $P = 101325\,Pa$)

$$NPSHa = \frac{P - P_{vp}}{\rho g} - H - \frac{2fZv^2}{Dg} > 0$$

$$= \frac{101325 - 2340}{1000 \times 9.81} - H - 0.12279\,H > 0$$

$H \approx 10.09m$

$\rightarrow 1.12279H < 10.1 \rightarrow H < 8.98m.$

8.98m is the maximum ~~height~~ height to which the pump should be moved.

3 Question 2 (b) **2.5 / 2.5**

- ✓ **- 0 pts** Correct
- **- 0.5 pts** Incorrect equation (cavitation occurs before the pump):
- **- 0.5 pts** Incorrect length of the pipe before the pump
- **- 1 pts** No work for length of the pipe before the pump
- **- 0.5 pts** Incorrect height (but minor mistakes)
- **- 1 pts** Incorrect height (but showed all work)
- **- 2 pts** Incorrect height (no work)
- **- 2.5 pts** Wrong page selection or No pages

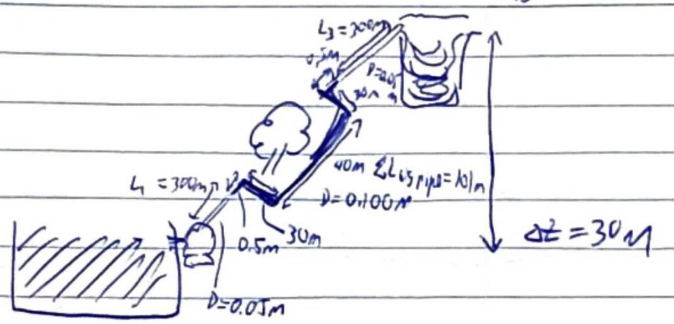
Question 3

$$\frac{\cancel{\Delta P}}{\cancel{\rho}} + \frac{1}{2}(\Delta v^2) + W_s + g\Delta z + F = 0$$

Open to Patm Batu Asah Spring and Bukit Kauh Tank

$\Delta z = 30m$

$$\frac{1}{2}(\Delta v^2) + W_s + g\Delta z + \left(\frac{2f_F(L)v^2}{D} + \frac{1}{2}\Sigma K v^2\right) = 0$$



■ 100mm new steel pipe

□ 50mm steel pipe.

$\Delta P = 0\,kPa$

$$\underset{\substack{\uparrow \\ \text{work-shift}}}{-W_s} = \frac{1}{2}(\Delta v^2) + g\Delta z + \underbrace{\left(\frac{2f_F L v^2}{D} + \frac{1}{2}\Sigma K v^2\right)}_{\parallel \atop F}$$

Assume it is incompressible flow, (ρ is constant through the two different diameter pipes (ie. 50mm & 100mm)

$Q = v_1 A_1 = v_2 A_2$

Small pipe

$$v_1 = \frac{Q_1}{A_1} = \frac{4.629 \times 10^{-4}\,m^3/s}{\frac{\pi}{4}(50\times10^{-3})^2 m^2} = 0.2375\,m/s$$

ρ (water density at 20°C)

$$Re_1 = \frac{\rho v_1 D_1}{\mu} = \frac{998.19\,kg/m^3 \times 0.2375\,m/s \times 0.05m}{0.0010005\,Pa\cdot s}$$

μ (water viscosity at 20°C)

$= 1.175779 \times 10^4$

$$\frac{\varepsilon}{D_1} = \frac{0.046mm}{50\,mm} = 0.00092$$

from the Moody chart

$f_{F_1} = 0.007875$

big pipe

$$V_2 = \frac{Q}{A_2} = \frac{4.629\times10^{-4}\ m^3/s}{\frac{\pi}{4}(0.1)^2\ m^2} = 0.05893825853\ m/s$$

(water density at 20°C)

$$Re = \frac{\rho V_2 D_2}{\mu} = \frac{998.19\ kg/m^3 \times 0.05893825853\ m/s \times 0.1\ m}{0.0010005\ Pa.s}$$

$=\mu$ (water viscosity at 20°C)

$= 5880.217919$

$= 5.880\times10^4$

$$\frac{\epsilon}{D_2} = \frac{0.046mm}{0.1m} = 0.00046$$

from the Moody Chart

$f_{F_2} = 0.00512$

Calculating K values (resistence coefficients)

$K_{exit} = 1.0,\ K_{entry} = 0.5$

$$K_{ex} = \left(1-\left(\frac{D_1}{D_2}\right)^2\right)^2 = \left(1-\left(\frac{1}{2}\right)^2\right)^2 = \frac{3^2}{4^2} = \frac{9}{16}$$

$$K_{con} = \left(\left(\frac{D_2}{D_1}\right)^2-1\right)^2 = (2^2-1)^2 = 9$$

$K_{90^\circ elbow} = 0.8$

Using the Mechanical Energy Balance Equation.
focusing on F

$$F = \frac{2f_{F_1} L V_1^2}{D_1} + \frac{2f_{F_2} L_2 V_2^2}{D_2} + \frac{1}{2}K_{ex}V_1^2 + \frac{1}{2}K_{90^\circ elbow}\times 4V_2^2 + \frac{1}{2}K_{con}V_2^2 + \frac{1}{2}K_{entry}V_1^2$$

$$+\frac{1}{2}K_{exit}V_2^2 + \frac{2f_{F_3}L_3V_1^2}{D_1} \quad (\text{NOTE, } f_{F_3} = f_{F_1})$$

$$= \left(\frac{2(0.007875)300(0.2375)^2}{0.05} + \frac{2(0.00512)101(0.05894)^2}{0.1}\right.$$

$$+\frac{1}{2}\left(\frac{9}{16}\right)0.2375^2 + 2(0.8)(0.05894)^2 + 0.5\times9\times(0.05894)^2$$

$$\left.+\frac{1}{2}(0.5)(0.2375)^2 + \frac{1}{2}(1)(0.05894)^2 + \frac{2\times0.007875\times300(0.2375)^2}{0.05}\right) J/kg$$

$= (5.33 + 0.0359287 + 0.28125 + 0.0055582772 6 + 0.0156326$

$+ 0.0141015625 + 0.0017369618 + 5.33)\ J/kg$

$= 11.0142\ J/kg$

$-W_s = (0.2375^2 - 0.05894^2)/2 + 9.81 \times 30 + 11.0142$
$= 305.34 \ J/kg$ -

Power required (100% efficiency).

$P = -W_s G = 305.34 J/kg \times 998.19 \ kg/m^3 \times 4.629 \times 10^{-4} \ m^3/s$
$= 141.08 \ J/s$.

The Power in this question compared to Q1 is slightly less. Due to 90° bends around the tree due to the resistence coefficient K, which the steel pipe diameter changes from the first and last 300m. Before and after the fluid enters into a bigger pipe. ~~Due to friction~~ This heavy impacts the friction loss !!

4 Question 3 **2.2 / 3**

- **- 0 pts** Correct
- **- 0.5 pts** Incorrect frictional head losses
- **- 0.5 pts** Incorrect minor losses
- ✓ **- 0.5 pts Incorrect power (but showed all work)**
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