Fluid project

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Design of lab water network

The main purpose of doing this is to know how the water flow in pipes and the different cases and there effects on friction factor, value of flow rate, pressure ..etc

Our experiment consists of different steps:

First step:

The first and most important steps is to determine the material of the pipe and its schedule that we use to get the diameter.

Pipeline material:

The pipes are made of Poly vinyl Chloride Piping **pvc,** as shown in figure:

- **PVC** is a plastic material that is commonly used in plumbing , **pvc** pipes are used for resisting to rust & corrosion , resisting to high water pressure, Low cost, Easy installation, no welding or metalwork.
- For **pvc** you may have heard the term “schedule”. Despite its deceiving title, schedule doesn't have anything to do with time. A **pvc** pipe’s schedule has to do with the thickness of its walls.in our project we have max allowable working pressure**16** bar& diameter **2** inch"nominal diameter."

Though the outside diameter of a schedule 80 pipe and a schedule 40 pipe are the same, 80 pipe has thicker walls. This standard of measuring pipe came from a need to have a universal system for referring to PVC. Since different wall thicknesses are beneficial in different situations, the ASTM (American Society for Testing and Materials) came up with the schedule40 and 80 system for classifying the two common types.

- The main differences between Schedule 40 and Schedule 80 are:
  1- Water Pressure Rating
  2- Sizing & Diameter (Wall Thickness)
  3- Color
  4- Application & Use.

- Both schedule 40 and 80 PVC are used widely around the world. Each one has its benefits in different applications. Schedule 40 pipe has thinner walls, so it is best for applications involving relatively low water pressure. Schedule 80 pipe has thicker walls and is able to withstand higher PSI (pounds per square inch). This makes it ideal for industrial and chemical applications.
- both schedule 80 and schedule 40 PVC pipe have the exact same outside diameter. This is possible because schedule 80’s extra wall thickness is on the inside of the pipe. This means schedule 80 pipe will have a slightly more restricted flow – even though it may be the same pipe diameter as an equivalent schedule 40 pipe. This means schedule 40 and 80 pipe do fit together and can be used together if necessary.
- The only thing to be careful of is that the lower pressure handling schedule 40 parts meet the pressure requirements of your

application. Your pipe line is only as strong as your weakest part or joint, so even one schedule 40 part used in a higher pressure schedule 80 line can cause severe damage.

- schedule 40 pipe is white in color, while schedule 80 is often gray to distinguish it from 40.

- schedule 40 PVC is capable of handling impressive pressure, and it is likely more than adequate for any unheavy application and better to save money to get best flow with low cost.

second step: pressure measurement

There is different devices that measure the pressure but we will we explain the concept of one of them.

Pressure Gauge is a device which is used to measure pressure in a system. The pressure measured by a pressure gauge is always above the atmospheric pressure. Hence, absolute pressure of the system is obtained by adding atmospheric pressure to the pressure measured by gauge pressure. To different kinds of error may normally be expected in a gauge of this type. First, there is the possibility of hysteresis due to friction and backlash, so that the gauge will tend to read lower values then the pressure is increasing than when decreasing. Secondly, there is the graduation error due to the scale being marked off incorrectly. So, while calibrating a pressure gauge, firstly, one must check that pressure gauge loading is set to zero. If not, then calculate the zero error and then add it to the final reading to obtain the accurate result.

After we take the pressure we had to make a calibration for them because of the human mistakes and the device.

Calibration of pressure

$\mathbf{Z_1}$ = 0.2 m , $\mathbf{Z_2}$ =2.5 m , $\mathbf{Z_3}$ = 1.12 m , $\mathbf{Z_4}$ = 1 m

First section:

$P_4 = P_1 + rho*g*z$

$P_4 = 110000 = P_1 - 1000*9.8*(1 - 0.2)$

P_1 =117840 Pascal

Error1=17840 pascal

$P_4 = P_2$ + rho*g*z

P_4 = 110000 = P_2 +1000*9.8*(2.485-1)

P_2 =95447 Pascal

Error2=20447 pascal

$P_4 = P_1$ + rho*g*z

P_4 =110000=P_3 + 1000*9.8*(1.125-1)

P_3 =108775 pascal

Error3=18775 pascal

	P1	P2	P3	P4
STATIC	1.1784	0.95447	1.08775	1.1
VALVE 1	1.2784	1.00447	0.88775	0.8
VALVE 2	1.0784	1.00447	1.08775	1
PARALLEL	0	1.05447	0.88775	0.8

Pressures in the table are in bar

Second section:

$P_4 = P_1$ + rho*g*z

100000=P_1 - 9800*0.8

P_1 =107840 pascal

Error1 =7840 pascal

$P_4 = P_2$ + rho*g*z

P_4 = 100000 =P_2 +1000*9.8*(2.485-1)

P_2 =85447 pascal

Error2 =9607 pascal

$P_4 = P_1$ + rho*g*z

$P_4 = 100000 = P_3 + 1000*9.8*(1.125-1)$

$P_3 = 98775$ pascal

Error3 =8775 pascal

	static	valve 1	valve 2	parallel
p1	1.0784	0.90598	1.0439	0.90598
p2	0.85447	0.64779	0.7857	0.6133
p3	0.98775	0.73775	0.93775	0.71775
p4	1	0.7	0.92	0.65

Pressures in the table are in bar

Third section:

$P_4 = P_1 + rho*g*z$

$P_4 = 140000 = P_1 - 9800*0.8$

$P_1 = 147840$ pascal

Error1=7840 pascal

$P_4 = P_2 + rho*g*z$

$P_4 = 140000 = P_2 + 1000*9.8*(2.485-1)$

$P_2 = 125447$ pascal

Error2 =13447 pascal

$P_4 = P_1 + rho*g*z$

$P_4 = 140000 = P_3 + 1000*9.8*(1.125-1)$

$P_3 = 138775$ pascal

Error3 =8775 pascal

	P1	P2	P3	P4
STATIC	1.4784	1.25447	1.38775	1.4
VALVE 1	1.2784	1.03447	1.08775	1
VALVE 2	1.3784	1.21447	1.28775	1.3
PARRALEL	1.2784	0.98447	0.98775	0.9

Pressures in the table are in bar

Section four:

$P_4 = P_1 + rho*g*z$

$90000 = P_1 - 9800*0.8$

$P_1 = 97840$pascal

Error1 =7840 pascal

$P_4 = P_2 + rho*g*z$

$P_4 = 90000 = P_2 + 1000*9.8*(2.485-1)$

$P_2 = 75447$ pascal

Error2 =20447 pascal

$P_4 = P_1 + rho*g*z$

$P_4 = 90000 = P_3 + 1000*9.8*(1.125-1)$

$P_3 = 88775$ pascal

Error3 =8775 pascal

	P1	P2	P3	P4
STATIC	0.9784	0.75447	0.88775	0.9
VALVE 1	0.9784	0.75447	0.68775	0.62
VALVE 2	0.9784	0.6045	0.78775	0.8
PARRALEL	0.9784	0.55447	0.48775	0.56

Pressures in the table are in bar

Section five:

$P_4 = P_1 + rho*g*z$

$100000 = P_1 - 9800*0.8$

$P_1 = 107840$pascal

Error1 =2840 pascal

$P_4 = P_2 + rho*g*z$

$P_4 = 100000 = P_2 + 1000*9.8*(2.485-1)$

$P_2 = 75447$ pascal

Error2 =9398 pascal

$P_4 = P_1 + rho*g*z$

$P_4 = 100000 = P_3 + 1000*9.8*(1.125-1)$

$P_3 = 98775$ pascal

Error3 =3775 pascal

	P1	P2	P3	P4
STATIC	1.0784	0.85398	0.98775	1
VALVE 1	0.9184	0.71398	0.73775	0.75
VALVE 2	0.9784	0.78398	0.83775	0.9
PARRALEL	0.8984	0.67998	0.68775	0.7

Pressures in the table are in bar

Note:

The values of pressures in the tables are taken experimentally ,so there may be measurement errors due to one or more reasons of the following:

- Pressure gauge failure due to corrosion
- Zero-point error – The start of the measuring range is too high or too low (this is the zero offset), thus shifting the entire scale up or down by that zero offset value.

- Human error in reading the value measured by the pressure gaug

Calculating volumetric flow rate Q

First section

	Valve 1 open	Valve 2 open	Both valves open
Δm	52 kg	26 kg	67 kg
Time	24.5 s	32.8 s	28
Mass flow rate	2.12418 kg/s	0.79268 kg/s	2.3928 kg/s
Q	$2.124*10^{-3}$ m^3/s	$0.7926*10^{-3}$ m^3/s	$2.39*10^{-3}$ m^3/s

Reynolds number=(ρ*Q*4)/(μ*π*d)

P:density

Q: volumetric flow rate

μ: dynamic viscosity

d: inner diameter

Reynolds number at valve 1 open = (1000*2.124*10^{-3} *4)/(0.001*22/7*0.0525)=51491

Reynolds number at valve 2 open = (1000*0.79268*10-3 *4)/(0.001*22/7*0.0525)=19200

Reynolds number at both valves open = (1000*2.3928*10^{-3} *4)/(0.001*22/7*0.0525)=58031. 8

Second section:

	Valve 1 open	Valve 2 open	Both valves open
Δm	97 kg	35 kg	77 kg
Time	48 s	45 s	30.5
Mass flow rate	2.0208kg/s	0.7777kg/s	2.5246kg/s
Q	$2.0208*10^{-3}$ m^3/s	$0.7777*10^{-3}$ m^3/s	$2.5246*10^{-3}$ m^3/s

Reynolds number at valve 1 open = $(1000*2.0208*10^{-3}*4)/(0.001*22/7*0.0525)$ = 48990

Reynolds number at valve 2 open = $(1000*0.7777*10^{-3}*4)/(0.001*22/7*0.0525)$ = 18836.4

Reynolds number at both valves open = $(1000*2.52459*10^{-3}*4)/(0.001*22/7*0.0.052)$=61188

Section three

	Valve 1 open	Valve 2 open	Both valves open
Δm	64 kg	29 kg	79 kg
Time	22 s	34 s	29 s
Mass flow rate	2.909 kg/s	0.8529 kg/s	2.724 kg/s
Q	$2.909*10^{-3}$ m^3/s	$0.8529*10^{-3}$ m^3/s	$2.724*10^{-3}$ m^3/s

Reynolds number at valve 1 open = (1000*2.909 *10-3 *4)/(0.001*22/7*0.0525) =70521

Reynolds number at valve 2 open = $(1000*0.8529*10^{-3}*4)/(0.001*22/7*0.0525)$ =20678

Reynolds number at both valves open = (1000*2.724*10^{-3} *4)/(0.001*22/7*0.0.052)=66036

Section four:

	Valve 1 open	Valve 2 open	Both valves open
Δm	68. 5kg	47 kg	90. 5kg
Time	34.35 s	56.5 s	40 s
Mass flow rate	1.994 kg/s	0.8318 kg/s	2.2596 kg/s
Q	1.994*10^{-3} m^3/s	0.8318*10^{-3} m^3/s	2.2596*10^{-3} m^3/s

Reynolds number at valve 1 open = (1000*1.994 *10^{-3}*4)/(0.001*22/7*0.0525) =49940

Reynolds number at valve 2 open = (1000*0.8318*10^{-3} *4)/(0.001*22/7*0.0525)=18012

Reynolds number at both valves open = (1000*2.2596*10^{-3} *4)/(0.001*22/7*0.0.052)=59442

	Valve 1 open	Valve 2 open	Both valves open
Δm	35 kg	32.5 kg	90 kg
Time	17 s	43.7 s	36.7 s
Mass flow rate	2.06 kg/s	0.743 kg/s	2.452 kg/s
Q	2.06*10^{-3} m^3/s	0.743*10^{-3} m^3/s	2.452*10^{-3} m^3/s

Reynolds number at valve 1 open = (1000*2.06 *10^{-3}*4)/(0.001*22/7*0.0525)= 48340

Reynolds number at valve 2 open = (1000*0.743*10^{-3} *4)/(0.001*22/7*0.0525)=20170

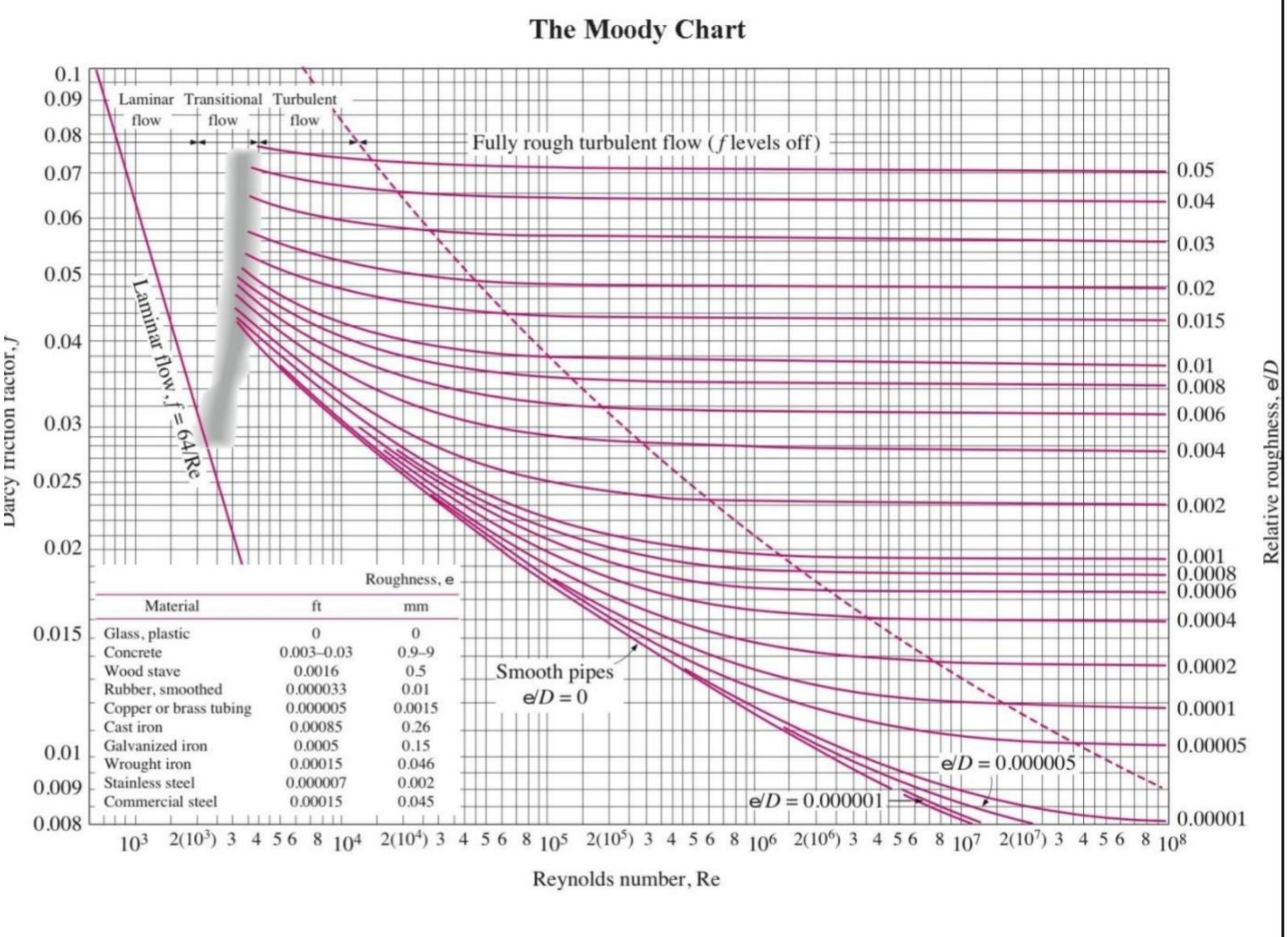
Reynolds number at both valves open = $(1000*2.2596*10^{-3}*4)/(0.001*22/7*0.0.052)=54764$

Note:

The values of mass and time in tables are taken experimently, so there may be some errors due to one ore more of the following reasons:

- There is a problem with the mass measuring device
- There is a problem with the stop watch
- Human mistakes in reading the measured values

From Moody Chart: ε/D



Reynolds number	Friction factor
70521.21	0.019
52490.9	0.020775
49940	0.020897
48990	0.020987
48340	0.02105
20678.788	0.02567
20169.697	0.0258295
19200	0.026144
18836.4	0.026267
18012.12	0.02656
66036.4	0.01965
61187.878	0.01998
59442.42	0.020107
58031.83	0.0202
54763.64	0.0204735

Getting (f): friction factor

Z_1=0.2m Z_2=2.5 m Z_3=1.12m Z_4=1m

H_L=$\frac{0.8*f*l*Q^2}{d^5*g}$

Getting L_{eqv} for each pipe:

$L_{eqv1\rightarrow2}$= (1.67) m

L_t = 1.67 + 0.2 + 6.375 + 2.5 =10.745m

$L_{eqv1\rightarrow3}$= 3*(1.67) + 3.65 =8.66m

L_t = 0.866 + 0.2 + 6.375 + 5.7 + 12.21 + 4.4 =37.545m

$L_{eqv2\rightarrow3}$= 2*(1.67) + 3.65 =6.99m

L_t = 5.7 – 2.5 + 12.21 + 4.4 + 6.99 = 26.8m

$H_{L1\rightarrow2}$ = $(0.8 * f * L_{eqv} * Q^2) / (g * d^5)$ =2199246.017 f * Q^2

$H_{L1\rightarrow3}$ = $(0.8 * f * L_{eqv} * Q^2) / (g * d^5)$ =7684568.795 f * Q^2

$H_{L2\rightarrow3}$ = $(0.8 * f * L_{eqv} * Q^2) / (g * d^5)$ =5485322.778 f * Q^2

h_L (elbow 90) = 5.5 ft = 1.67 m

h_L (tee inlet or outlet) = 12 ft =3.65 m

(1)Bernoulli equation:

EQUIVALENT NUMBER OF FEET STRAIGHT PIPE FOR DIFFERENT FITTINGS

Size of Fittings, Inches	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"
90° Ell	1.5	2.0	2.7	3.5	4.3	5.5	6.5	8.0	10.0	14.	15
45° Ell	0.8	1.0	1.3	1.7	2.0	2.5	3.0	3.8	5.0	6.3	7.1
Long Sweep Ell	1.0	1.4	1.7	2.3	2.7	3.5	4.2	5.2	7.0	9.0	11.0
Close Return Bend	3.6	5.0	6.0	8.3	10.0	13.0	15.0	18.0	24.0	31.0	37.0
Tee-Straight Run	1	2	2	3	3	4	5				
Tee-Side Inlet or Outlet	3.3	4.5	5.7	7.6	9.0	12.0	14.0	17.0	22.0	27.0	31.0
Globe Valve Open	17.0	22.0	27.0	36.0	43.0	55.0	67.0	82.0	110.0	140.0	160.0
Angle Valve Open	8.4	12.0	15.0	18.0	22.0	28.0	33.0	42.0	58.0	70.0	83.0
Gate Valve - Fully Open	0.4	0.5	0.6	0.8	1.0	1.2	1.4	1.7	2.3	2.9	3.5
Check Valve (Swing)	4	5	7	9	11	13	16	20	26	33	39
Check Valve (Spring)	4	6	8	12	14	19	23	32	43	58	

Section (1):

Valve 1:

Applying Bernoulli equation (1→2)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.278*(10^5)}{9.8*1000} + 0.2 = \frac{1.004*(10^5)}{9.8*1000} + 2.5 + h_L$$

h_L=0.4952m = 2199246.017 f * Q^2 → Q = 0.00212 m^3/ sec→ f = 0.05

Valve 2:

Applying Bernoulli equation (1→3)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.00447*(10^5)}{9.8*1000} + 2.5 = \frac{0.88775*(10^5)}{9.8*1000} + 1.12 + h_L$$

h_L = -1.02m = 7684568.795 f * Q^2 → Q = 0.00079 m^3/ sec→ <u>f = -0.213</u>

Applying Bernoulli equation (2→3)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.00447*(10^5)}{9.8*1000} + 2.5 = \frac{1.08775*(10^5)}{9.8*1000} + 1.12 + h_L$$

h_L = 0.5252m = 5485322.778 f * Q^2 → Q = 0.00079 m^3/ sec

f = 0.135

parallel:

Applying Bernoulli equation (2→3)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.05447*(10^5)}{9.8*1000} + 2.5 = \frac{0.88775*(10^5)}{9.8*1000} + 1.12 + h_L$$

h_L= 3.076m = 5485322.778 f * Q^2 → Q = 0.00239 m^3/ sec→ f = 0.0982

Section (2):

Valve 1:

Applying Bernoulli equation (1→2)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + + h_L$$

$$\frac{0.90598*(10^5)}{9.8*1000} + 0.2 = \frac{0.64779*(10^5)}{9.8*1000} + 2.5 + h_L$$

h_L = 0.3345m = 2199246.017 f * Q^2 → Q = 0.002 m^3/ sec

f = 0.038

Valve 2:

Applying Bernoulli equation (1→2)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.0439*(10^5)}{9.8*1000} + 0.2 = \frac{0.7857*(10^5)}{9.8*1000} + 2.5 + h_L$$

h_L = 0.3346m = 5485322.778 f * Q^2 → Q = 0.00078 m^3/ sec

f = 0.25

parallel:

Applying Bernoulli equation (1→3)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{0.90598*(10^5)}{9.8*1000} + 0.2 = \frac{0.71775*(10^5)}{9.8*1000} + 1.12 + h_L$$

h_L= 0.99m = 7684568.795 f * Q^2 → Q = 0.0025 m^3/ sec→ f = 0.0207

Section (3):

Valve 1:

Applying Bernoulli equation (1→2)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.2784*(10^5)}{9.8*1000} + 0.2 = \frac{1.03447*(10^5)}{9.8*1000} + 2.5 + h_L$$

h_L = 0.189m = 2199246.017 f * Q^2 → Q = 0.0029 m^3/ sec

f = 0.0102

Valve 2:

Applying Bernoulli equation (2→3)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.21447*(10^5)}{9.8*1000} + 2.5 = \frac{1.28775*(10^5)}{9.8*1000} + 1.12 + h_L$$

h_L = 0.6272m = 5485322.778 f * Q^2 → Q = 0.00085 m^3/ sec

f = 0.158

parallel:

Applying Bernoulli equation (1→2)

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z + h_L$$

$$\frac{1.27841*(10^5)}{9.8*1000} + 0.2 = \frac{0.98447*(10^5)}{9.8*1000} + 2.5 + h_L$$

h_L= 0.699m = 2199246.017 f * Q^2 → Q = 0.0027 m^3/ sec

f = 0.0436

Section (4):

Valve 1:

Applying Bernoulli equation (1→3)

$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$ +h_L

$\frac{0.9784*(10^5)}{9.8*1000}$ + 0.2 = $\frac{0.68775*(10^5)}{9.8*1000}$ +1.12 + h_L

h_L = 2.04m = 7684568.795 f * Q^2 → Q = 0.0019 m^3/ sec

f = 0.0667

Valve 2:

Applying Bernoulli equation (1→3)

$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$ +h_L

$\frac{0.9784*(10^5)}{9.8*1000}$ + 0.2 = $\frac{0.78775*(10^5)}{9.8*1000}$ + 1.12 + h_L

h_L = 1.02m = 7684568.795 f * Q^2 → Q = 0.00083 m^3/ sec

f = 0.192

parallel:

Applying Bernoulli equation (1→3)

$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$ +h_L

$\frac{0.9784*(10^5)}{9.8*1000}$ + 0.2 = $\frac{0.48775*(10^5)}{9.8*1000}$ +1.12 + h_L

h_L= 2.7m = 7684568.795 f * Q^2 → Q = 0.00225 m^3/ sec

f = 0.0695

Section (5):

Valve 1:

Applying Bernoulli equation (1→2)

$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$ +h_L

$\frac{0.9184*(10^5)}{9.8*1000}$ + 0.2 = $\frac{0.73775*(10^5)}{9.8*1000}$ +1.12 + h_L

h_L = 0.918m = 7684568.795 f * Q^2 → Q = 0.00206 m^3/ sec

f = 0.0281

Valve 2:

Applying Bernoulli equation (1→3)

$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$ +h_L

$\frac{0.9784*(10^5)}{9.8*1000}$ + 0.2 = $\frac{0.83775*(10^5)}{9.8*1000}$ + 1.12 + h_L

h_L = 0.51m = 7684568.795 f * Q^2 → Q = 0.00074 m^3/ sec

f = 0.121

parallel:

Applying Bernoulli equation (1→3)

$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$ +h_L

$\frac{0.8984*(10^5)}{9.8*1000}$ + 0.2 = $\frac{0.68775*(10^5)}{9.8*1000}$ +1.12 + h_L

h_L= 1.22m = 7684568.795 f * Q^2 → Q = 0.0024 m^3/ sec

f = 0.0276

Bernoulli	**Section(1)**	**Section(2)**	**Section(3)**	**Section(4)**	**Section(5)**
Valve(1)	f=0.05	f=0.038 f=-0.213	f=0.0102	f=0.0667	f=0.0281
Valve(2)	f=0.153	f=0.25	f=0.158	f=0.192	f=0.121
parallel	f=0.0982	f=0.0207	f=0.0436	f=0.0695	f=0.0276

(f from Bernoulli equ.)

Using EES

Equations Window

```
"Swamee-Jain"
"f = 0.25 / ( log10( 5.74/ Re ^0.9 ) )^2"
{for ( pvc:smooth pipe )}
f = 0.25 / ( log10( 5.74/ Re ^0.9 ) )^2

"f_smmoth=0.316*(Re^-0.25) :Blasius formula"
f_smooth = 0.316 / (Re^0.25)


"section A"
f_1A = 0.25 / ( log10( 5.74/ (Re_1A) ^0.9 ) )^2
f_2A = 0.25 / ( log10( 5.74/ (Re_2A)^0.9 ) )^2
f_3A = 0.25 / ( log10( 5.74/ (Re_3A)^0.9 ) )^2
Re_1A=51490.91
Re_2A=19200
Re_3A=58031.83

"section B"
f_1B = 0.25 / ( log10( 5.74/ (Re_1B) ^0.9 ) )^2
f_2B = 0.25 / ( log10( 5.74/ (Re_2B)^0.9 ) )^2
f_3B = 0.25 / ( log10( 5.74/ (Re_3B)^0.9 ) )^2
Re_1B=48989.091
Re_2B=18836.363
Re_3B=61187.878
```

Equations Window

```
"section C"
f_1C = 0.25 / ( log10( 5.74/ (Re_1C) ^0.9 ) )^2
f_2C = 0.25 / ( log10( 5.74/ (Re_2C)^0.9 ) )^2
f_3C = 0.25 / ( log10( 5.74/ (Re_3C)^0.9 ) )^2
Re_1C=70521.212
Re_2C=20678.788
Re_3C=66036.363

"section D"
f_1D = 0.25 / ( log10( 5.74/ (Re_1D) ^0.9 ) )^2
f_2D = 0.25 / ( log10( 5.74/ (Re_2D)^0.9 ) )^2
f_3D = 0.25 / ( log10( 5.74/ (Re_3D)^0.9 ) )^2
Re_1D=49939.394
Re_2D=18012.1212
Re_3D=59442.4242

"section E"
f_1E = 0.25 / ( log10( 5.74/ (Re_1E) ^0.9 ) )^2
f_2E = 0.25 / ( log10( 5.74/ (Re_2E)^0.9 ) )^2
f_3E = 0.25 / ( log10( 5.74/ (Re_3E)^0.9 ) )^2
Re_1E=48339.393
Re_2E=20169.697
Re_3E=54763.636
```

Solution

Main

Unit Settings: SI C kPa kJ mass deg

$f_{1A} = 0.02062$ $f_{1B} = 0.02086$ $f_{1C} = 0.01924$ $f_{1D} = 0.02077$ $f_{1E} = 0.02092$ $f_{2A} = 0.02608$ $f_{2B} = 0.02621$ $f_{2C} = 0.0256$

$f_{2D} = 0.02651$ $f_{2E} = 0.02576$ $f_{3A} = 0.02008$ $f_{3B} = 0.01985$ $f_{3C} = 0.01952$ $f_{3D} = 0.01997$ $f_{3E} = 0.02034$ $Re_{1A} = 51491$

$Re_{1B} = 48989$ $Re_{1C} = 70521$ $Re_{1D} = 49939$ $Re_{1E} = 48339$ $Re_{2A} = 19200$ $Re_{2B} = 18836$ $Re_{2C} = 20679$ $Re_{2D} = 18012$

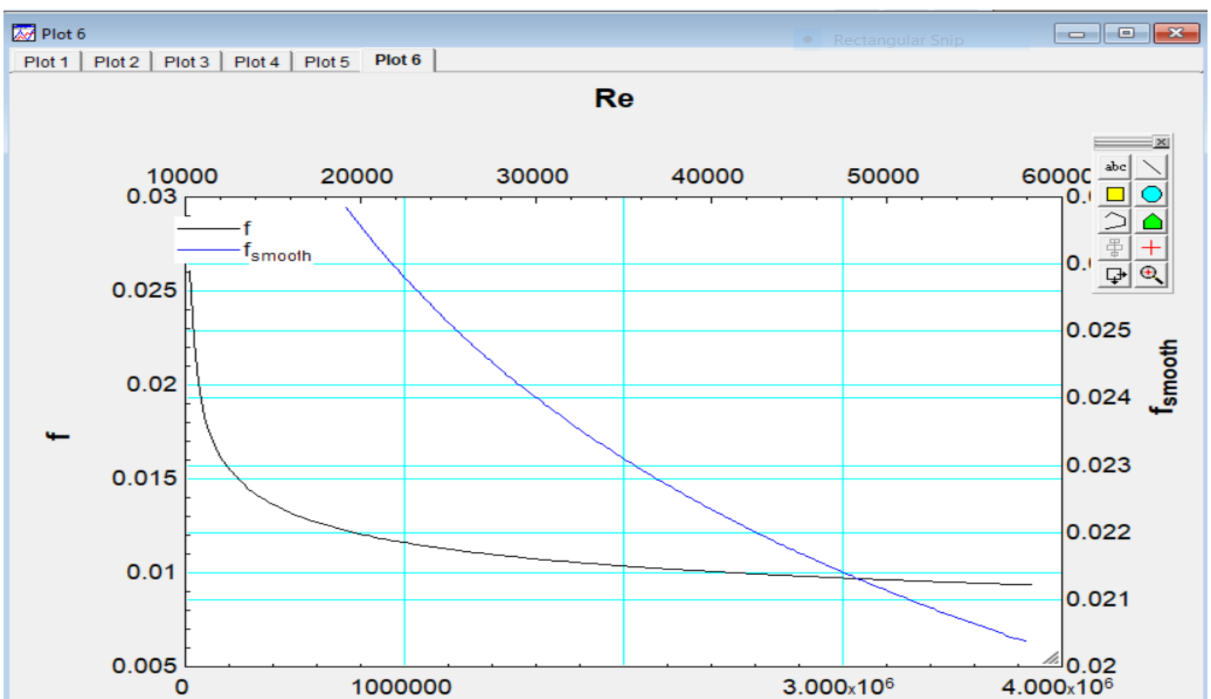
$Re_{2E} = 20170$ $Re_{3A} = 58032$ $Re_{3B} = 61188$ $Re_{3C} = 66036$ $Re_{3D} = 59442$ $Re_{3E} = 54764$

No unit problems were detected.

<u>Section A:</u>

1..100	f	Re
Run 1	0.02608	19200
Run 2	0.02008	58032
Run 3	0.01798	96864
Run 4	0.01678	135695
Run 5	0.01595	174527
Run 6	0.01534	213359
Run 7	0.01485	252191
Run 8	0.01446	291023
Run 9	0.01412	329855
Run 10	0.01383	368686
Run 11	0.01358	407518
Run 12	0.01336	446350
Run 13	0.01316	485182
Run 14	0.01298	524014
Run 15	0.01282	562846
Run 16	0.01267	601677
Run 17	0.01253	640509
Run 18	0.0124	679341
Run 19	0.01228	718173
Run 20	0.01217	757005
Run 21	0.01207	795837
Run 22	0.01197	834668
Run 23	0.01188	873500

1..100	f_{smooth}	Re
Run 1	0.02684	19200
Run 2	0.02036	58032
Run 3	0.01791	96864
Run 4	0.01646	135695
Run 5	0.01546	174527
Run 6	0.0147	213359
Run 7	0.0141	252191
Run 8	0.01361	291023
Run 9	0.01319	329855
Run 10	0.01282	368686
Run 11	0.01251	407518
Run 12	0.01223	446350
Run 13	0.01197	485182
Run 14	0.01174	524014
Run 15	0.01154	562846
Run 16	0.01135	601677
Run 17	0.01117	640509
Run 18	0.01101	679341
Run 19	0.01085	718173
Run 20	0.01071	757005
Run 21	0.01058	795837
Run 22	0.01045	834668
Run 23	0.01034	873500



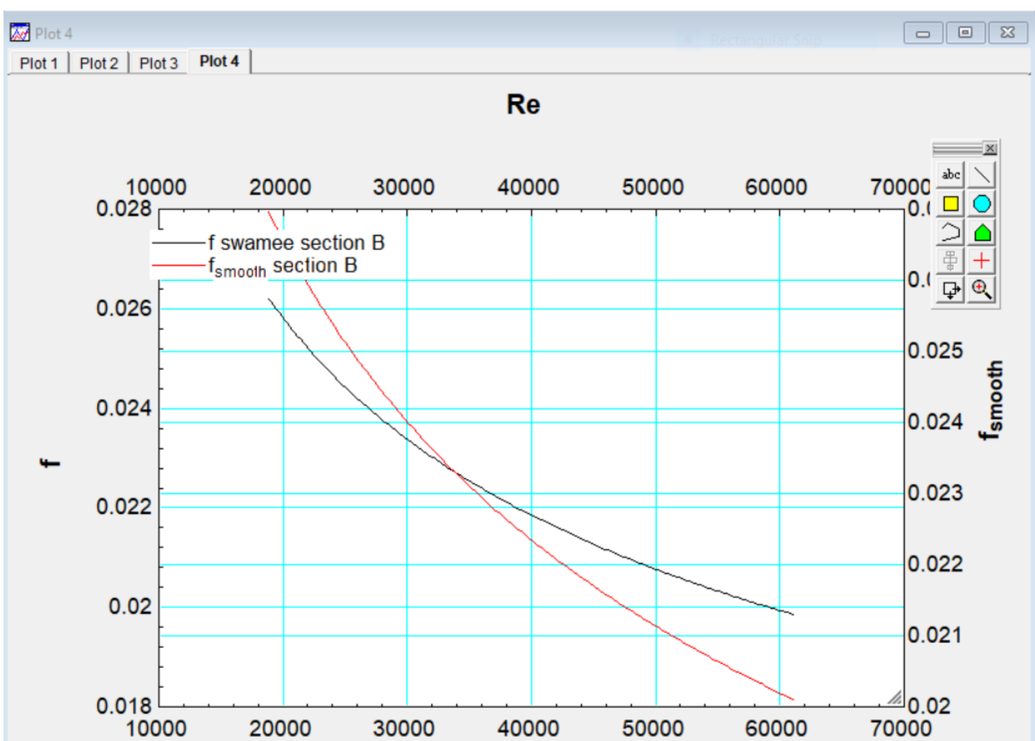
Section B:

Parametric Table — Table 1

1..100	f	Re
Run 18	0.02417	26109
Run 19	0.02407	26537
Run 20	0.02398	26964
Run 21	0.02389	27392
Run 22	0.0238	27820
Run 23	0.02371	28248
Run 24	0.02363	28676
Run 25	0.02354	29103
Run 26	0.02346	29531
Run 27	0.02338	29959
Run 28	0.0233	30387
Run 29	0.02322	30815
Run 30	0.02315	31242
Run 31	0.02307	31670
Run 32	0.023	32098
Run 33	0.02293	32526
Run 34	0.02286	32954
Run 35	0.02279	33381
Run 36	0.02272	33809

Parametric Table — Table 2

1..100	f_{smooth}	Re
Run 18	0.02486	26109
Run 19	0.02476	26537
Run 20	0.02466	26964
Run 21	0.02456	27392
Run 22	0.02447	27820
Run 23	0.02437	28248
Run 24	0.02428	28676
Run 25	0.02419	29103
Run 26	0.02411	29531
Run 27	0.02402	29959
Run 28	0.02393	30387
Run 29	0.02385	30815
Run 30	0.02377	31242
Run 31	0.02369	31670
Run 32	0.02361	32098
Run 33	0.02353	32526
Run 34	0.02345	32954
Run 35	0.02338	33381
Run 36	0.0233	33809



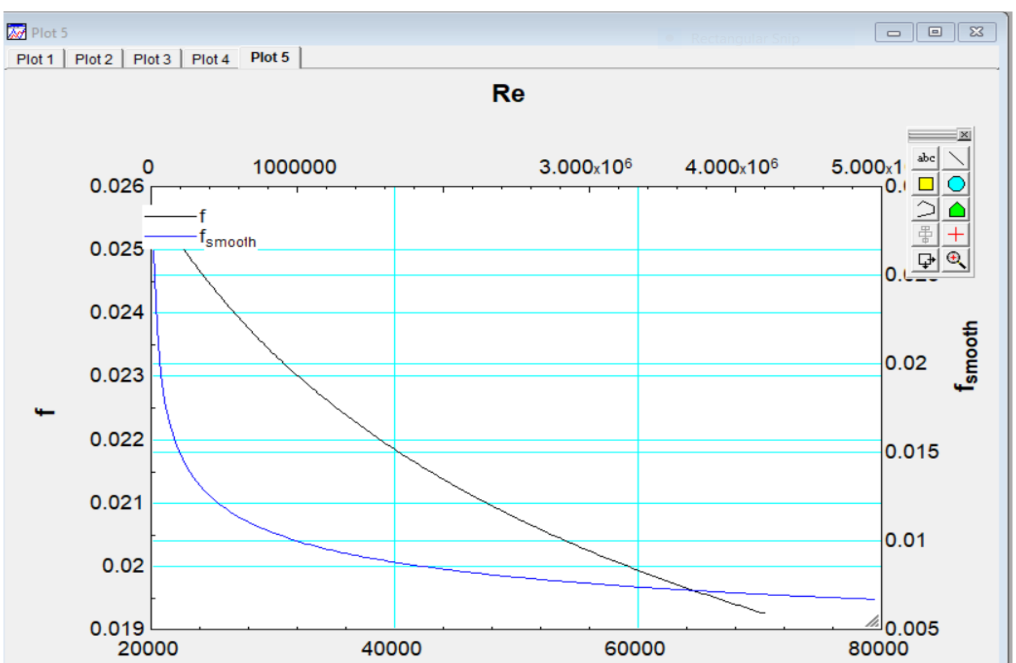
Section C:

Parametric Table — Table 3

1..100	f	Re
Run 18	0.02352	29238
Run 19	0.02342	29741
Run 20	0.02333	30245
Run 21	0.02324	30748
Run 22	0.02315	31251
Run 23	0.02306	31755
Run 24	0.02297	32258
Run 25	0.02289	32762
Run 26	0.02281	33265
Run 27	0.02273	33769
Run 28	0.02265	34272
Run 29	0.02257	34776
Run 30	0.02249	35279
Run 31	0.02242	35783
Run 32	0.02235	36286
Run 33	0.02227	36789
Run 34	0.0222	37293
Run 35	0.02213	37796
Run 36	0.02207	38300
Run 37	0.022	38803
Run 38	0.02193	39307

Parametric Table — Table 4

1..100	f_{smooth}	Re
Run 1	0.02635	20679
Run 2	0.01939	70521
Run 3	0.01697	120364
Run 4	0.01556	170206
Run 5	0.01459	220048
Run 6	0.01386	269891
Run 7	0.01329	319733
Run 8	0.01282	369576
Run 9	0.01242	419418
Run 10	0.01207	469261
Run 11	0.01177	519103
Run 12	0.01151	568945
Run 13	0.01127	618788
Run 14	0.01105	668630
Run 15	0.01085	718473
Run 16	0.01067	768315
Run 17	0.01051	818158
Run 18	0.01035	868000
Run 19	0.01021	917842
Run 20	0.01008	967685
Run 21	0.009949	1.018E+06



	(2)Getting f from Swamee-Jain:	**(3)Getting f from Blusius formula:**
	$\frac{0.25}{[\frac{5.74}{Re^{0.9}})]^{\wedge}2} = f$ Note: roughness of PVC=zero	f= 0.316 (Re^-0.25) Note: This is a formula of Colebrook equ.
Section(A)	Valve1→0.02062	Valve1→0.02098
Section(A)	Valve2→0.02608	Valve2→0.02684
Section(A)	Parallel→0.020081	Parallel→0.02036
Section(B)	Valve1→0.02085	Valve1→0.02124
Section(B)	Valve2→0.026207	Valve2→0.02697
Section(B)	Parallel→0.01985	Parallel→0.020091
Section(C)	Valve1→0.01924	Valve1→0.01939
Section(C)	Valve2→0.02559	Valve2→0.02635
Section(C)	Parallel→0.01952	Parallel→0.01971
Section(D)	Valve1→0.02076	Valve1→0.02114
Section(D)	Valve2→0.0265	Valve2→0.0273
Section(D)	Parallel→0.01997	Parallel→0.02023
Section(E)	Valve1→0.020919	Valve1→0.02131
Section(E)	Valve2→0.02576	Valve2→0.02652

Section(E)	Parallel→0.020.4	Parallel→0.02066

	Bernoulli	Swamee-Jain	Moody chart	Blasius
Section(A)	Valve1→0.05	Valve1→0.02062	0.020755	Valve1→0.02098
Section(A)	Valve1→0.153	Valve2→0.02608	0.026144	Valve2→0.02684
Section(A)	Parallel→0.0982	Parallel→0.020081	0.0202135	Parallel→0.02036
Section(B)	Valve1→0.038	Valve1→0.02085	0.020987	Valve1→0.02124
Section(B)	Valve1→0.25	Valve2→0.026207	0.026267	Valve2→0.02697
Section(B)	Parallel→0.0207	Parallel→0.01985	0.01998	Parallel→0.020091
Section(C)	Valve1→0.0102	Valve1→0.01924	0.01937	Valve1→0.01939
Section(C)	Valve1→0.158	Valve2→0.02559	0.02567	Valve2→0.02635
Section(C)	Parallel→0.0436	Parallel→0.01952	0.019651	Parallel→0.01971
Section(D)	Valve1→0.0667	Valve1→0.02076	0.020897	Valve1→0.02114
Section(D)	Valve1→0.192	Valve2→0.0265	0.02656	Valve2→0.0273
Section(D)	Parallel→0.0695	Parallel→0.01997	0.0201072	Parallel→0.02023
Section(E)	Valve1→0.0281	Valve1→0.020919	0.0210497	Valve1→0.02131
Section(E)	Valve1→0.121	Valve2→0.02576	0.02583	Valve2→0.02652
Section(E)	Parallel→0.0276	Parallel→0.020.4	0.020474	Parallel→0.02066

Notes:

1. Swami-Jain limits:
    - (Roughness / Re)) >2 * 10^-2) → (valid)
    - Re)< 3 * 10^3)→ (valid)

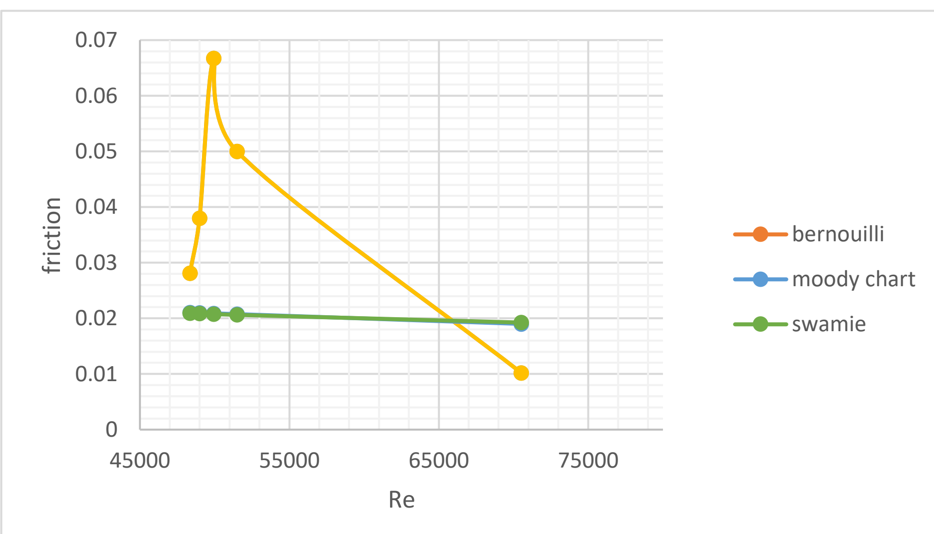
2. There is a (-ve) value of (f) because:
    - Wrong reading
    - Wrong timing reading as the pressure pointer didn't stop at a constant value (pointer still moving).

By using log scale:

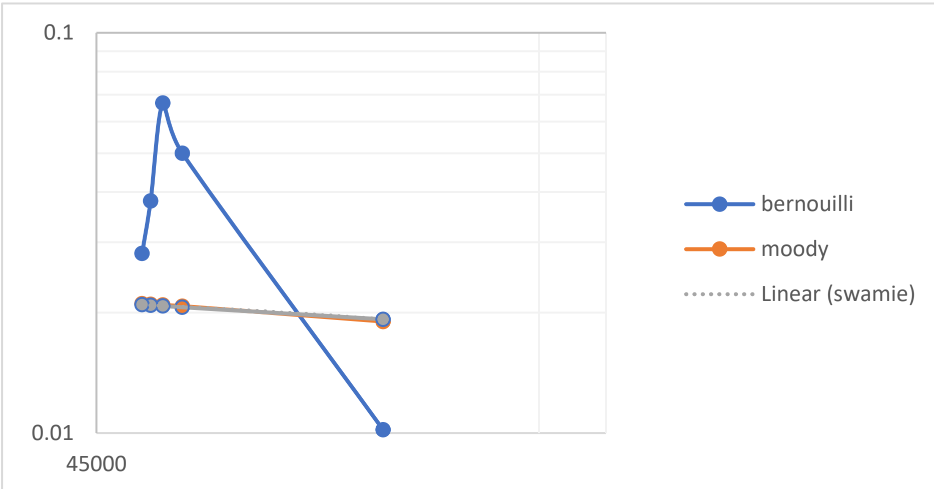
Valve 1:

bernouilli	Re	mody	swamee
0.0102	70521.21	0.019	0.01924
0.05	51490.9	0.020755	0.02062
0.0667	49940	0.020897	0.02077
0.038	48990	0.020987	0.02086
0.0281	48340	0.02105	0.02092

Note:without log scale



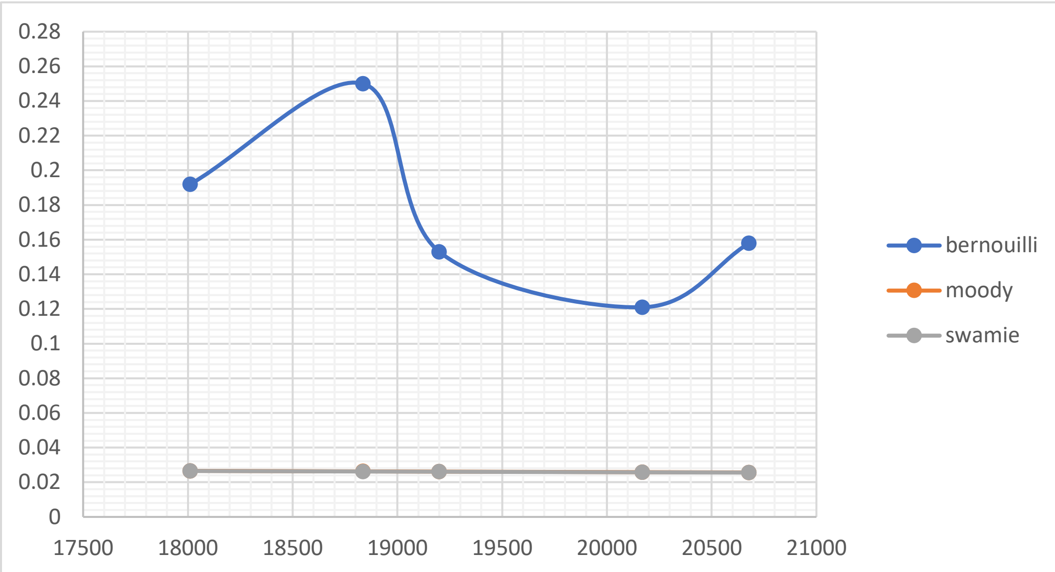
Note:with log scale



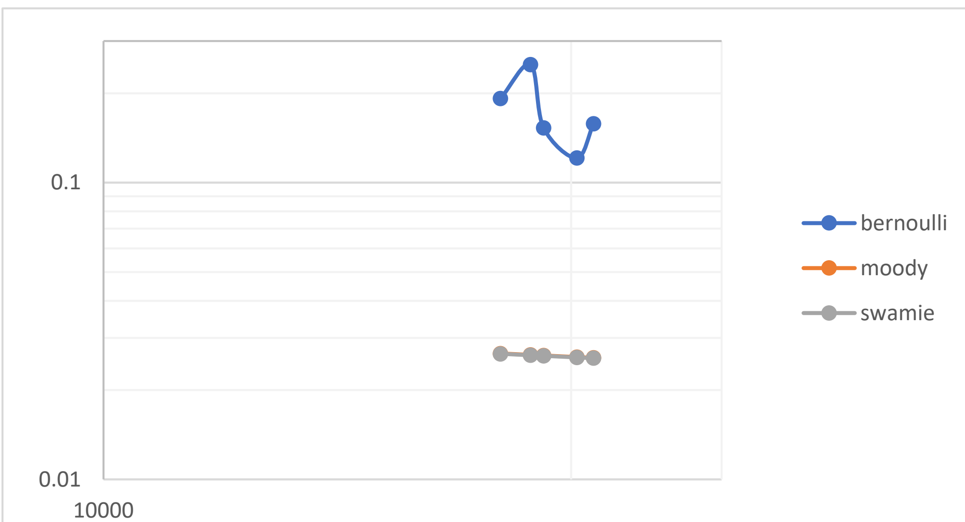
Valve 2:

Renould number	bernouilli	moody	swamei jain
20678.788	0.158	0.02567	0.0256
20169.697	0.121	0.02583	0.02576
19200	0.153	0.026144	0.02608
18836.4	0.25	0.026267	0.0262
18012.12	0.192	0.02656	0.0265

Note:without log scale

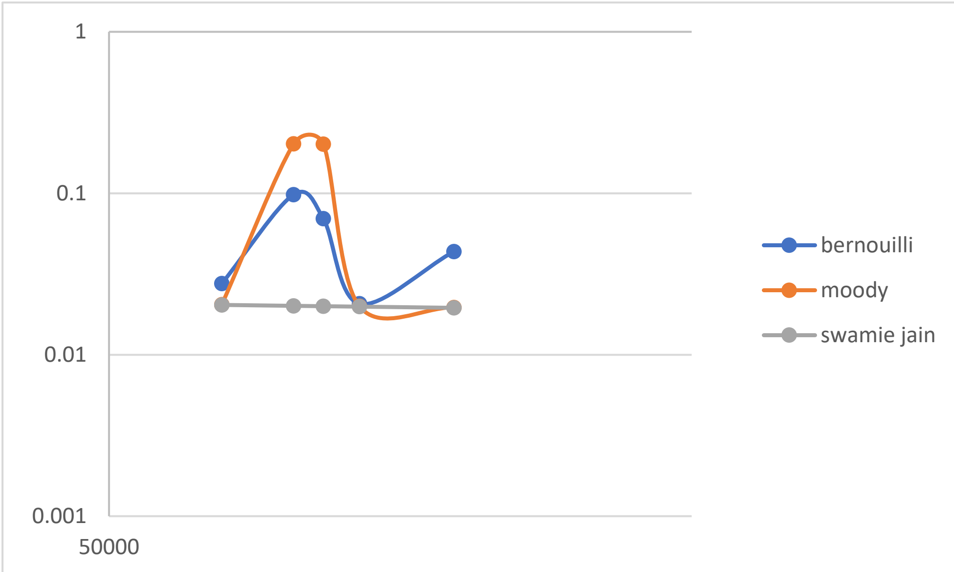


With log scale



Valve 3:

Note:without log scale



1
0.1
0.01
0.001
50000
bernouilli
moody
swamie jain

Watercad

We take the pressure , the pipe material and the flow rate and started to put it in the watercad software to find the pressure values at all joints in our network.

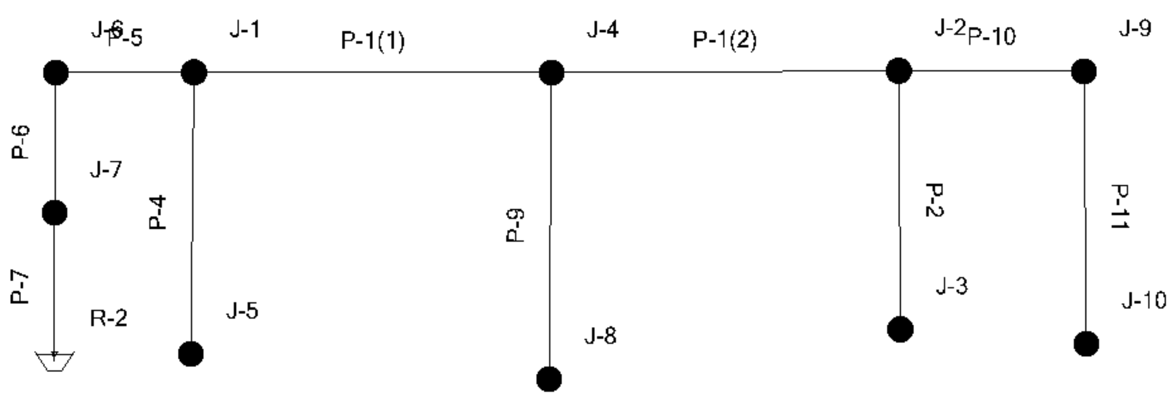
Case (1) : static

The main purpose of it is to make sure that our length are accurate because there is no flow .

$$p = \rho g h$$

$$h = (0.8*f*l*q^2)/(gd^5)$$

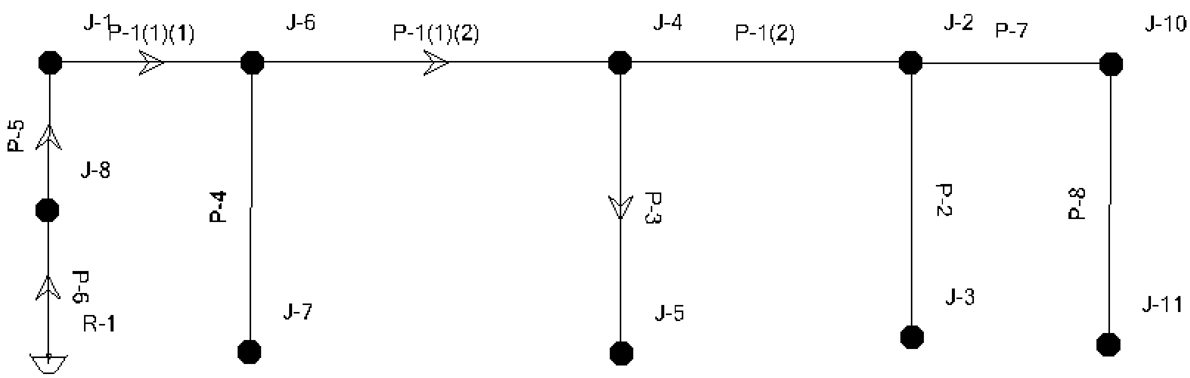
q : flow rate



	ID	Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/m)	Has User Defined Length?	Length (User Defined) (m)
4: P-2	34	P-2	J-2	J-3	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
6: P-1(1)	36	P-1(1)	J-1	J-4	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	40
7: P-1(2)	37	P-1(2)	J-4	J-2	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
1: P-4	41	P-4	J-1	J-5	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
3: P-5	43	P-5	J-1	J-6	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	23
5: P-6	45	P-6	J-6	J-7	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	5
7: P-7	47	P-7	J-7	R-2	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	2
1: P-9	51	P-9	J-4	J-8	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
3: P-10	53	P-10	J-2	J-9	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	17
5: P-11	55	P-11	J-9	J-10	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8

Case (2) : valve 1 is open

Here the flow started to have a value every joint will have a different pressure head.

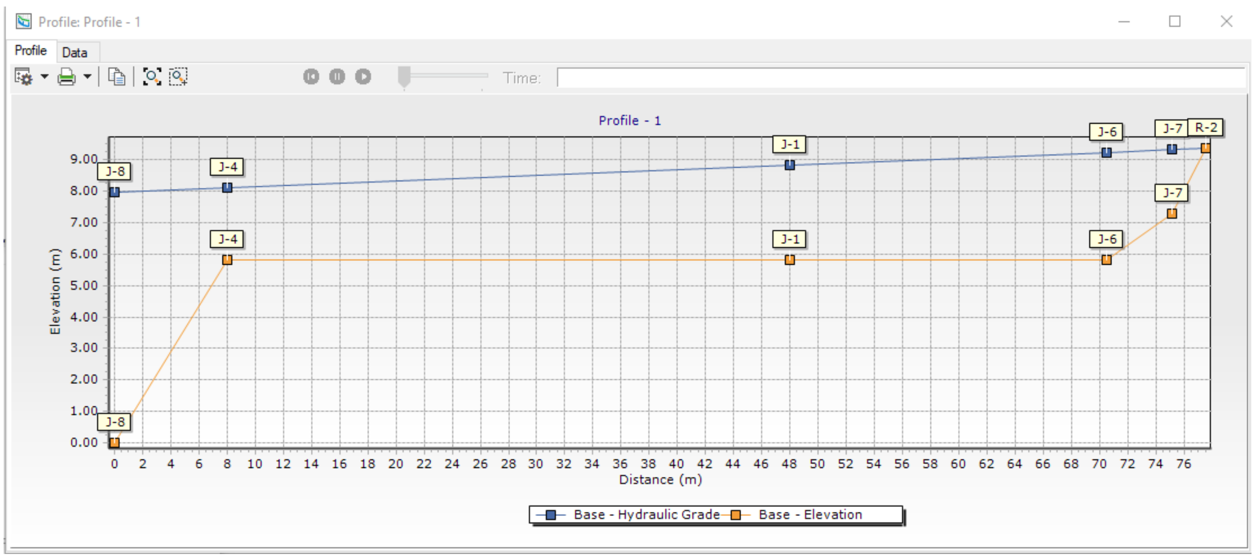


FlexTable: Junction Table (Current Time: 0.000 hours) (VALVE 2.wtg)

	ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
30: J-1	30	J-1	5.80	<None>	<Collection:	0	8.84	30
31: J-2	31	J-2	5.80	<None>	<Collection:	0	8.11	23
33: J-3	33	J-3	7.65	<None>	<Collection:	0	8.11	5
35: J-4	35	J-4	5.80	<None>	<Collection:	0	8.11	23
40: J-5	40	J-5	7.53	<None>	<Collection:	0	8.84	13
42: J-6	42	J-6	5.80	<None>	<Collection:	0	9.24	34
44: J-7	44	J-7	7.29	<None>	<Collection:	0	9.33	20
50: J-8	50	J-8	0.00	<None>	<Collection:	2	7.97	78
52: J-9	52	J-9	5.70	<None>	<Collection:	0	8.11	24
54: J-10	54	J-10	1.00	<None>	<Collection:	0	8.11	70

FlexTable: Pipe Table (Current Time: 0.000 hours) (VALVE 2.wtg)

	ID	Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/m)	Has User Defined Length?	Length (User Defined) (m)
34: P-2	34	P-2	J-2	J-3	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
36: P-1(1)	36	P-1(1)	J-1	J-4	52.5	PVC	150.0	☐	0.000	2	0.95	0.018	☑	40
37: P-1(2)	37	P-1(2)	J-4	J-2	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
41: P-4	41	P-4	J-1	J-5	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
43: P-5	43	P-5	J-1	J-6	52.5	PVC	150.0	☐	0.000	-2	0.95	0.018	☑	23
45: P-6	45	P-6	J-6	J-7	52.5	PVC	150.0	☐	0.000	-2	0.95	0.018	☑	5
47: P-7	47	P-7	J-7	R-2	52.5	PVC	150.0	☐	0.000	-2	0.95	0.018	☑	2
51: P-9	51	P-9	J-4	J-8	52.5	PVC	150.0	☐	0.000	2	0.95	0.018	☑	8
53: P-10	53	P-10	J-2	J-9	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	17
55: P-11	55	P-11	J-9	J-10	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8



As we see here the H.G.L height increases from the first joint to the last one and this is according to pressure value that is higher in the first of the flow

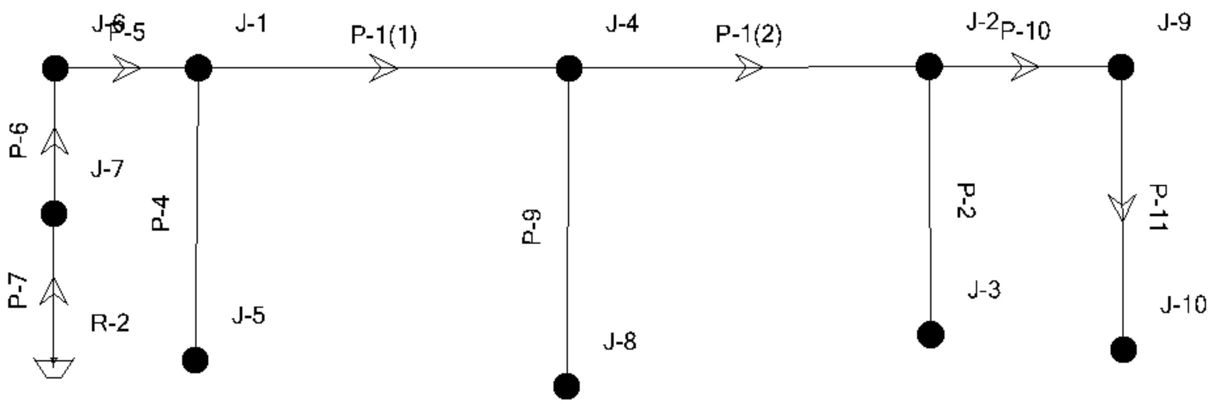
Notice: represents the sum of the elevation and pressure energies along the pipeline.

Flow rate is in inversely proportional to pressure.

The negative values of flow rate is because of wrong measurements.

Case (3) : valve 2 is open

The length of the pipe where the water will flow so will find a noticeable change in pressure.

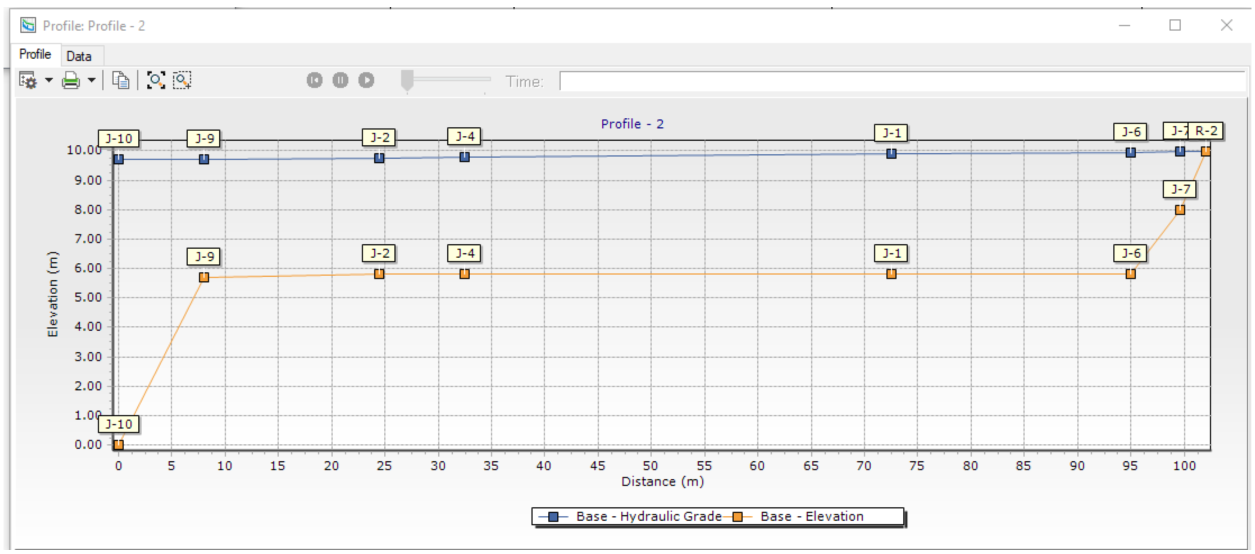


FlexTable: Junction Table (Current Time: 0.000 hours) (VALVE 2.wtg)

	ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
30: J-1	30	J-1	5.80	<None>	<Collection:	0	9.90	40
31: J-2	31	J-2	5.80	<None>	<Collection:	0	9.77	39
33: J-3	33	J-3	9.18	<None>	<Collection:	0	9.77	6
35: J-4	35	J-4	5.80	<None>	<Collection:	0	9.79	39
40: J-5	40	J-5	8.55	<None>	<Collection:	0	9.90	13
42: J-6	42	J-6	5.80	<None>	<Collection:	0	9.96	41
44: J-7	44	J-7	8.00	<None>	<Collection:	0	9.97	19
50: J-8	50	J-8	1.00	<None>	<Collection:	0	9.79	86
52: J-9	52	J-9	5.70	<None>	<Collection:	0	9.72	39
54: J-10	54	J-10	0.00	<None>	<Collection:	1	9.70	95

FlexTable: Pipe Table (Current Time: 0.000 hours) (VALVE 2.wtg)

	ID	Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/m)	Has User Defined Length?	Length (User Defined) (m)
34: P-2	34	P-2	J-2	J-3	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
36: P-1(1)	36	P-1(1)	J-1	J-4	52.5	PVC	150.0	☐	0.000	1	0.34	0.003	☑	40
37: P-1(2)	37	P-1(2)	J-4	J-2	52.5	PVC	150.0	☐	0.000	1	0.34	0.003	☑	8
41: P-4	41	P-4	J-1	J-5	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
43: P-5	43	P-5	J-1	J-6	52.5	PVC	150.0	☐	0.000	-1	0.34	0.003	☑	23
45: P-6	45	P-6	J-6	J-7	52.5	PVC	150.0	☐	0.000	-1	0.34	0.003	☑	5
47: P-7	47	P-7	J-7	R-2	52.5	PVC	150.0	☐	0.000	-1	0.34	0.003	☑	2
51: P-9	51	P-9	J-4	J-8	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
53: P-10	53	P-10	J-2	J-9	52.5	PVC	150.0	☐	0.000	1	0.34	0.003	☑	17
55: P-11	55	P-11	J-9	J-10	52.5	PVC	150.0	☐	0.000	1	0.34	0.003	☑	8

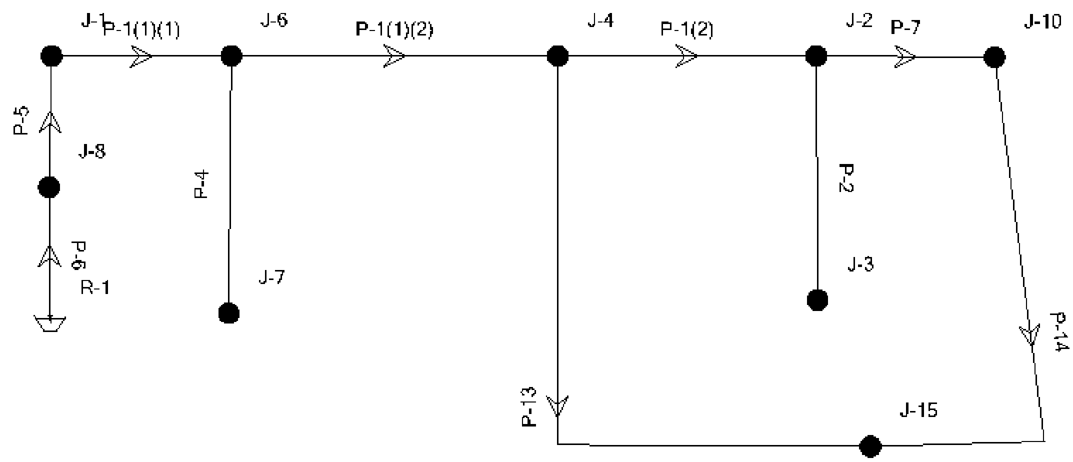


The pressure is quietly constant

The negative values of flow rate is because of wrong measurements.

Case (3) : parallel pipes

Here we will open valves in two pipes and we will see the change in flow rate and the head loss.

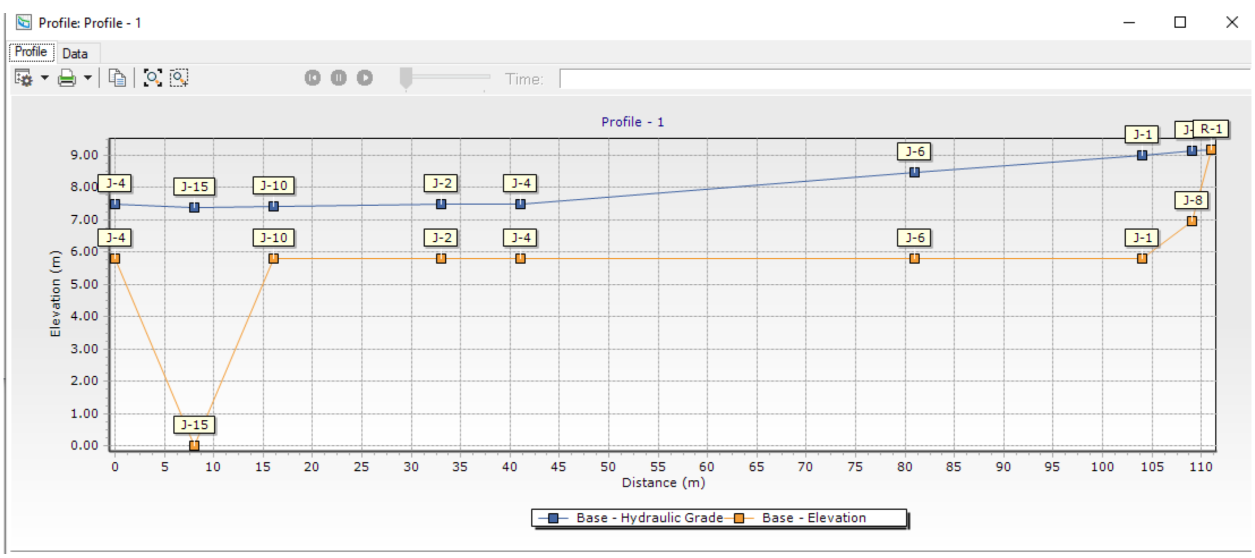


FlexTable: Pipe Table (Current Time: 0.000 hours) (Untitled1.wtg)

	ID	Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/m)	Has User Defined Length?	Length (User Defined) (m)
34: P-2	34	P-2	J-2	J-3	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
37: P-1(2)	37	P-1(2)	J-4	J-2	52.5	PVC	150.0	☐	0.000	1	0.35	0.003	☑	8
41: P-1(1)(1)	41	P-1(1)(1)	J-1	J-6	52.5	PVC	150.0	☐	0.000	2	1.11	0.024	☑	23
42: P-1(1)(2)	42	P-1(1)(2)	J-6	J-4	52.5	PVC	150.0	☐	0.000	2	1.11	0.024	☑	40
44: P-4	44	P-4	J-6	J-7	52.5	PVC	150.0	☐	0.000	0	0.00	0.000	☑	8
46: P-5	46	P-5	J-1	J-8	52.5	PVC	150.0	☐	0.000	-2	1.11	0.024	☑	5
48: P-6	48	P-6	J-8	R-1	52.5	PVC	150.0	☐	0.000	-2	1.11	0.024	☑	2
50: P-7	50	P-7	J-2	J-10	52.5	PVC	150.0	☐	0.000	1	0.35	0.003	☑	17
64: P-13	64	P-13	J-4	J-15	52.5	PVC	150.0	☐	0.000	2	0.76	0.012	☑	8
65: P-14	65	P-14	J-15	J-10	52.5	PVC	150.0	☐	0.000	-1	0.35	0.003	☑	8

FlexTable: Junction Table (Current Time: 0.000 hours) (Untitled1.wtg)

	ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
30: J-1	30	J-1	5.80	<None>	<Collection:	0	9.00	31
31: J-2	31	J-2	5.80	<None>	<Collection:	0	7.46	16
33: J-3	33	J-3	7.14	<None>	<Collection:	0	7.46	3
35: J-4	35	J-4	5.80	<None>	<Collection:	0	7.49	17
40: J-6	40	J-6	5.80	<None>	<Collection:	0	8.45	26
43: J-7	43	J-7	7.02	<None>	<Collection:	0	8.45	14
45: J-8	45	J-8	6.94	<None>	<Collection:	0	9.12	21
49: J-10	49	J-10	5.80	<None>	<Collection:	0	7.42	16
63: J-15	63	J-15	0.00	<None>	<Collection:	2	7.39	72



The negative values of flow rate is because of wrong measurements.