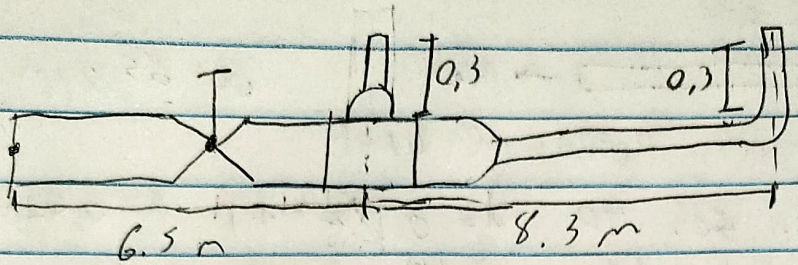
# Test 3 Robert Morris

1.




$P = 400$ kPA

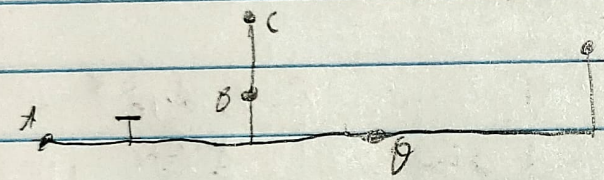
$K_{head} = 50$

Joint = 1 1/2 in schedule 40 pipe

Sprinkler head = 1 in Schedule 40 pipe

Class II Problem

Objective: find flow rate delivered to each head, determine if flow rates are the same, if not how can they? how does fluid velocity compare to 3 ft/s? if great difference, how would it be fixed?




$P_B = P_D$ $P = 400$ kPA = constant

$A_{main} = \frac{\pi \cdot 44.9^2}{4} = 1583.37\ mm = 1.5834\ m$

$A_{SPRK} = \frac{\pi \cdot 26.6^2}{4} = 555.7163\ mm = 0.5557\ m$

$\frac{400}{9.81} = 4.08\ m$ $\frac{D}{3} \frac{0.0449}{4.6 \cdot 10^{-5}} = 976.09$

$Q = -2.22(0.0449)^2 \sqrt{\frac{9.81(0.0449)(4.08)}{6.5}} \log\left(\frac{1}{3.7(976.09)} + \frac{1.784(1.15 \cdot 10^{-6})}{0.0449\sqrt{9.81(0.0449)(4.08)}}\right)$

$Q = 0.008\ m^3/s$

$V_{main} = \frac{0.008}{1.5834} = 0.005\ m/s$

$4.08 = 50\left(\frac{V_2^2}{2(9.81)}\right)$ $V_2 = 1.265\ m/s$

$1.265 \cdot 0.5557 = 0.703\ m^3/s$

Since pressure is said to be a constant, finding the rate of flow for the main would allow me to find $h_2$. With this, using the reduction formula allowed me to find the velocity of the sprinkler pipes. They should both have the same flow rates. The found velocity is below the critical velocity, to achieve 3 m/s either the flow rate would need to be increased or larger pipes.

2. $Q_{in}$ → 1500 ft → $Q_{out}$ $\quad Q = 65$ gpm

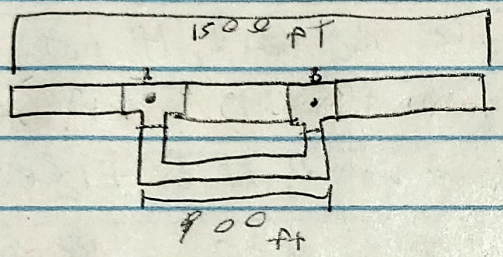
a. Determine pressure drop

Pipe = 2 in Sch 40 $\quad D = 0.1723$ ft $\quad A = 0.0233$

$65\ gpm = 0.130\ ft^3/s \quad \frac{0.130}{0.0233} = 5.58$ ft/s

$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g} \quad \frac{P_1 - P_2}{\gamma} = \frac{V_1^2}{2g} + (z_2 - z_1)$

$\frac{P_1 - P_2}{62.4} = \frac{5.58^2}{2(32.2)} + 1500 = 24.056$ psf $= 288.681$ psi




Pipe$_L$ = 1 1/2 in Sch 40

$D = 0.1342 \quad A = 0.01414$

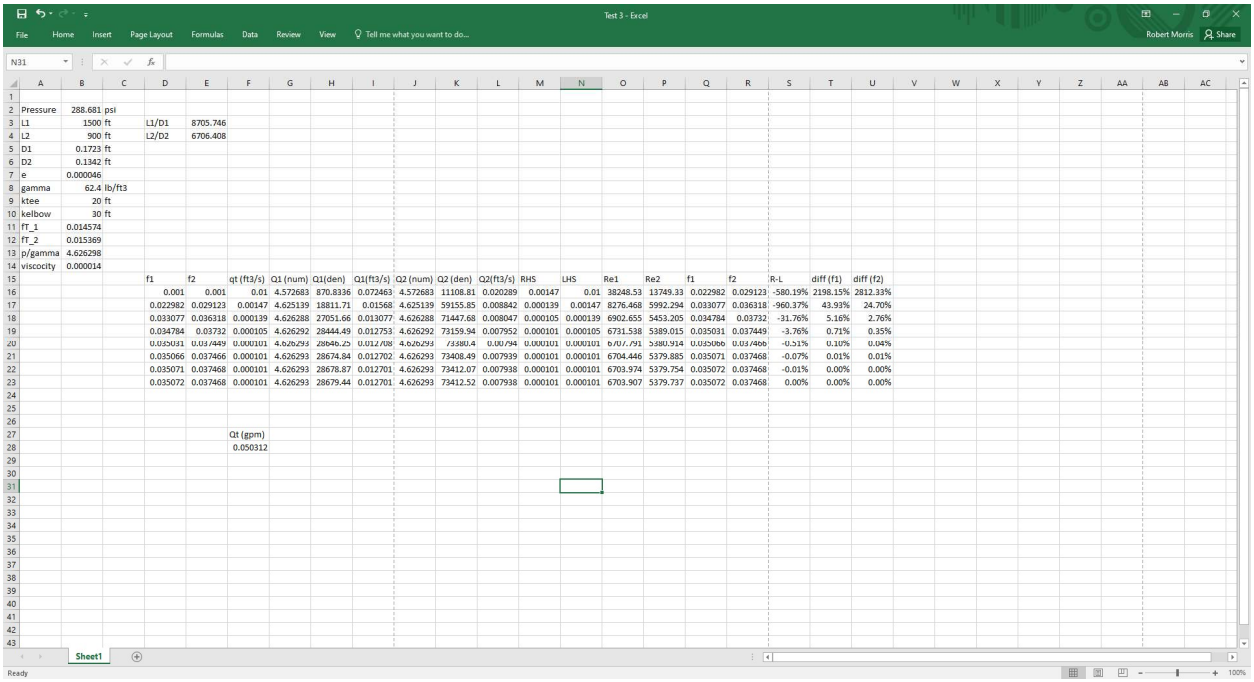
$\frac{L_e}{D}\ T_s = 20 \quad \frac{L_e}{D}\ g = 30 \quad \varepsilon = 4.6 \cdot 10^{-5}$

$$Q = 0.130 = \sqrt{\frac{\frac{288.681}{62.4}}{f_1\left(\frac{1500}{0.1723} + 2(20)\right)\frac{8}{32.2\pi^2(0.1723)^5}}}$$

$f = 0.0369$

$$Q_2 = \sqrt{\frac{\frac{288.681}{62.4}}{F\left(\frac{900}{0.1342} + 2(20) + 2(39)\right)\frac{8}{(32.2)\pi^2(0.1342)^5}}}$$

## Question 2 Excel sheet



Test 3 - Excel

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Pressure | 288.681 | psi | | | | | | | | | | | | | | | | | | |
| 3 | L1 | 1500 | ft | L1/D1 | 8705.746 | | | | | | | | | | | | | | | | |
| 4 | L2 | 900 | ft | L2/D2 | 6706.408 | | | | | | | | | | | | | | | | |
| 5 | D1 | 0.1723 | ft | | | | | | | | | | | | | | | | | | |
| 6 | D2 | 0.1342 | ft | | | | | | | | | | | | | | | | | | |
| 7 | e | 0.000046 | | | | | | | | | | | | | | | | | | | |
| 8 | gamma | 62.4 | lb/ft3 | | | | | | | | | | | | | | | | | | |
| 9 | ktee | 20 | ft | | | | | | | | | | | | | | | | | | |
| 10 | kelbow | 30 | ft | | | | | | | | | | | | | | | | | | |
| 11 | ff_1 | 0.014574 | | | | | | | | | | | | | | | | | | | |
| 12 | ff_2 | 0.015369 | | | | | | | | | | | | | | | | | | | |
| 13 | p/gamma | 4.626298 | | | | | | | | | | | | | | | | | | | |
| 14 | viscocity | 0.000014 | | | | | | | | | | | | | | | | | | | |
| 15 | | | | f1 | f2 | qt (ft3/s) | Q1 (num) | Q1(den) | Q1(ft3/s) | Q2 (num) | Q2 (den) | Q2(ft3/s) | RHS | LHS | Re1 | Re2 | f1 | f2 | R-L | diff (f1) | diff (f2) |
| 16 | | | | 0.001 | 0.001 | 0.01 | 4.572683 | 870.8336 | 0.072463 | 4.572683 | 11108.81 | 0.020289 | 0.00147 | 0.01 | 38248.53 | 13749.33 | 0.022982 | 0.029123 | -580.19% | 2198.15% | 2812.33% |
| 17 | | | | 0.022982 | 0.029123 | 0.00147 | 4.625139 | 18811.71 | 0.01568 | 4.625139 | 59155.85 | 0.008842 | 0.000139 | 0.00147 | 8276.468 | 5992.294 | 0.033077 | 0.036318 | -960.37% | 43.93% | 24.70% |
| 18 | | | | 0.033077 | 0.036318 | 0.000139 | 4.626288 | 27051.66 | 0.013077 | 4.626288 | 71447.68 | 0.008047 | 0.000105 | 0.000139 | 6902.655 | 5453.205 | 0.034784 | 0.03732 | -31.76% | 5.16% | 2.76% |
| 19 | | | | 0.034784 | 0.03732 | 0.000105 | 4.626292 | 28444.49 | 0.012753 | 4.626292 | 73159.94 | 0.007952 | 0.000101 | 0.000105 | 6731.538 | 5389.015 | 0.035031 | 0.037449 | -3.76% | 0.71% | 0.35% |
| 20 | | | | 0.035031 | 0.037449 | 0.000101 | 4.626293 | 28646.25 | 0.012708 | 4.626293 | 73380.4 | 0.00794 | 0.000101 | 0.000101 | 6707.791 | 5380.914 | 0.035066 | 0.037466 | -0.51% | 0.10% | 0.04% |
| 21 | | | | 0.035066 | 0.037466 | 0.000101 | 4.626293 | 28674.84 | 0.012702 | 4.626293 | 73408.49 | 0.007939 | 0.000101 | 0.000101 | 6704.446 | 5379.885 | 0.035071 | 0.037468 | -0.07% | 0.01% | 0.01% |
| 22 | | | | 0.035071 | 0.037468 | 0.000101 | 4.626293 | 28678.87 | 0.012701 | 4.626293 | 73412.07 | 0.007938 | 0.000101 | 0.000101 | 6703.974 | 5379.754 | 0.035072 | 0.037468 | -0.01% | 0.00% | 0.00% |
| 23 | | | | 0.035072 | 0.037468 | 0.000101 | 4.626293 | 28679.44 | 0.012701 | 4.626293 | 73412.52 | 0.007938 | 0.000101 | 0.000101 | 6703.907 | 5379.737 | 0.035072 | 0.037468 | 0.00% | 0.00% | 0.00% |
| 27 | | | | | | Qt (gpm) | | | | | | | | | | | | | | | |
| 28 | | | | | | 0.050312 | | | | | | | | | | | | | | | |

Sheet1

Ready

## Question two summary

The First part of this question asked what the pressure loss would be in a pipe 1500 ft. long. Using Bernoulli's equation the pressure loss was found to be 288.681 psi. The second part asked what the flow rate increase would need to be in order to keep the pressure found in the previous part. To do this integration through Excel was used. The second parallel pipe was 900 ft. long and had to elbows, and the loss from the two tee brackets had to be accounted for.

## Analysis

The first part seemed simple enough with just a straight pipe and no other fixtures. Bernoulli's was used to find the pressure of 288.681 psi. This seems slightly high, but not so extreme it is out of the possibility. Part B wanted to know how an addition that ran parallel for 900 ft. that then reconnected would increase the flow rate. To do this a modification of "Kyle's" method was used, accounting for the coefficient of both tees and elbows. The increase seems to be small, only 0.05gpm. This makes sense to me as the flow rate should not increase as only so much water can be moved through the main pipe at a given time.