Name: Frank Nguyen UIN: 00980645

MET 330 Fluid Mechanics
Dr. Orlando Ayala
Spring 2017
Test 2

Take home – Due Sunday March 19th 2017 before midnight.

READ FIRST

1. RELAX!!!! DO NOT OVERTHINK THE PROBLEMS!!!! There is nothing hidden. The test was designed for you to pass and get the maximum number of points, while learning at the same time. HINT: THINK BEFORE TRYING TO USE/FIND EQUATIONS (OR EVEN FIND SIMILAR PROBLEMS)

2. The total points on this test are one hundred (100). FOR THE "WORKFORCE" SYLLABUS STUDENTS: Ten (10) points are from your HW assignments, and ten (10) other points are based on the basis of technical writing. The other eighty (80) points will come from the problem solutions. FOR THE "OTHER" SYLLABUS STUDENTS: Ten (10) other points are based on the basis of technical writing. The other eighty (90) points will come from the problem solutions. For the technical writing I will follow the attached rubric.

3. There are 2 problems to solve, each worth (80/2) points for "Workforce" syllabus students and (90/2) for the "Other" syllabus students.

4. What you turn in should be only your own work. You cannot discuss the exam with anyone, except me. Call me, skype me, text me, email me, come to my office, if you have any question.

5. I do not read minds. You should be explicit and organized in your answers. Use drawings/figures. If you make a mistake, do not erase it. Rather use that opportunity to explain why you think it is a mistake and show the way to correct the problem.

6. You have to turn in your test ON TIME and ONLY through BLACKBOARD. You must submit only one file and it has to be a pdf file. For the ePortfolio you are also supposed to upload this artifact to your Google drive. When you are done solving the test, please go ahead and upload it now before you forget.

7. Do not start at the last minute so you can handle anything that could happen. Late tests will not be accepted. Test submitted through email will not be accepted either.

8. Cheating is completely wrong. The ODU Student Honor Pledge reads: "I pledge to support the honor system of Old Dominion University. I will refrain from any form of academic dishonesty or deception, such as cheating or plagiarism." By attending Old Dominion University you have accepted the responsibility to abide by this code. This is an institutional policy approved by the Board of Visitors. It is important to remind you the following part of the Honor Code:

> IX. PROHIBITED CONDUCT
>
> A. Academic Integrity violations, including:
>
> 1. *Cheating*: Using unauthorized assistance, materials, study aids, or other information in any academic exercise (Examples of cheating include, but are not limited to, the following: using unapproved resources or assistance to complete an assignment, paper, project, quiz or exam; collaborating in violation of a faculty member's instructions; and submitting the same, or substantially the same, paper to more than one course for academic credit without first obtaining the approval of faculty).

With that said, you are NOT authorized to use any online source of any type, unless is ODU related.

① Purpose

a) Determine the size of the pipe (steel pipe schedule 40) before and after the pump for the new pump system that needs 30 gpm for each machine exactly instead of 20 gpm and 10 gpm.

b) Determine the total head on the pump and the power delivered by the pump to the coolant with the new 30 gpm.

c) Determine the pressure at the inlet of the pump.

Sources

- Mott, R, Untener, J.A. "Applied Fluid Mechanics", 7th edition Pearson Education In (2015)
- Blackboard notes

Design Considerations

- Constant properties
- Constant temp.
- Pipe friction
- Incompressible fluid
- Steady state

Data and variables

$Q = 60$ gal/min $\approx .1336$ ft^3/s

$\gamma = .92$

$f_T = 1.85$

$\eta = 3.6 \times 10^{-5}$

$\varepsilon = 1.5 \times 10^{-4}$

$K_{globe\ valve} = 85_1$ } table 10.4

$K_{swing\ check\ valve} = 100 f_T$

$K_{entrance} = .5$ (fig 10.1)

$K_{exit} = 1$ (fig 10.4)

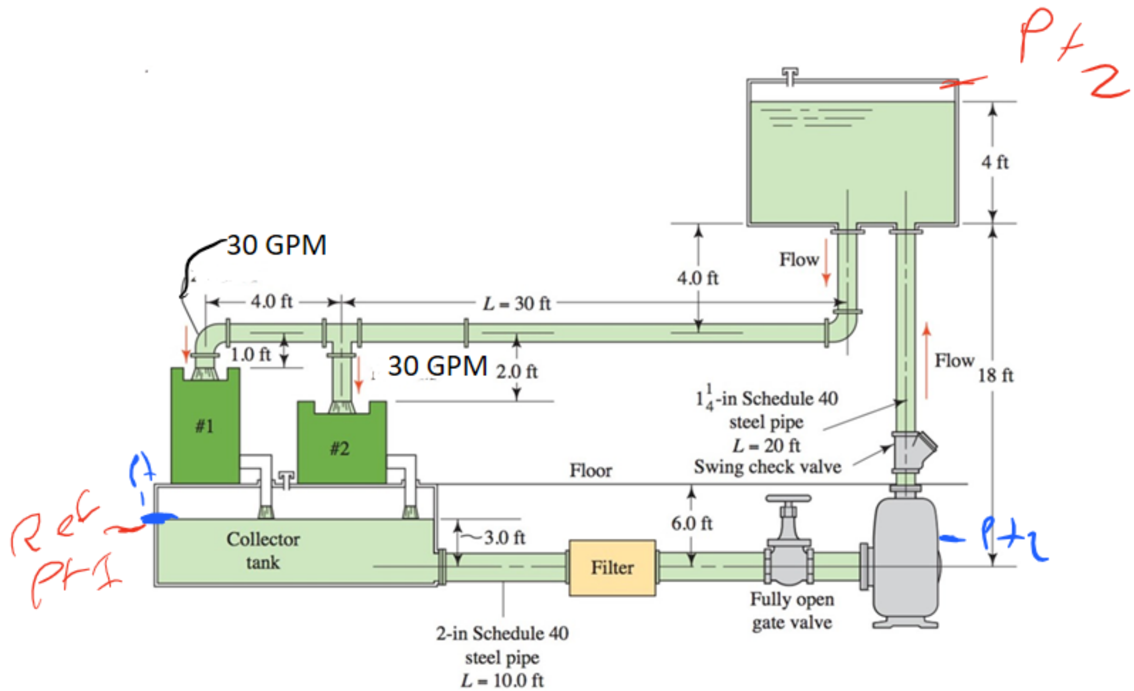
$V = 3$ m/s ≈ 9.84 ft/s (we use for our class)

$\frac{V_2^2}{2g} = 1.5$ ft

Materials

- Schedule 40 Steel
- Valve
- Coolant
- Pumps

Drawings and Diagrams



Red = Ref. points for
#1 part a) and b)

Blue = Ref points for
#1 part c

Procedure and Calculations

a) For this part I will apply Bernoulli's from the collector tank surface to the upper tank surface. That Bernoulli will lead to to find pipe size (D) by iterating equations. Then use the Class III equation to solve for D.

- Apply Bernoulli from 1 to 2, I get:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_{L,1-2} \qquad P_1 - P_2 = 0$$

$$\frac{P_1 - P_2}{\gamma} = h_{L_{1-2}}$$

now solve for head loss.

$$h_L = h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7$$

- h_1: entrance loss
- h_2: energy loss in pipe line
- h_3: energy loss in filter
- h_4: energy loss in fully open gate valve
- h_5: energy loss in swing check valve
- h_6: friction loss in delivery pipe
- h_7: exit loss

$$h_1 = K\left(\frac{V^2}{2g}\right) = (.5)(1.50) = .75\text{ft}$$

$$h_2 = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) = f\left(\frac{10}{D}\right)1.50\text{ ft} = f\left(\frac{10}{D}\right)1.50$$

$$h_3 = f_r\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) = (1.85)(1.50\text{ ft}) = 2.775\text{ft}$$

$$h_4 = f_{dt}\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) = f(8)(1.50\text{ft}) = f(8)(1.50) = 12f$$

$$h_5 = f_{dt}\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) = f(100)(1.50\text{ft}) = 150f$$

$$h_6 = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) = f\left(\frac{18}{D}\right)1.50\text{ ft} = f\left(\frac{18}{D}\right)1.50$$

$$h_7 = 1\left(\frac{V^2}{2g}\right) = 1(1.50\text{ft}) = 1.50\text{ft}$$

$$h_L = \underbrace{.75\text{ft}}_{h_1} + \underbrace{f\left(\frac{10}{D}\right)1.50}_{h_2} + \underbrace{2.775\text{ft}}_{h_3} + \underbrace{12f}_{h_4} + \underbrace{150f}_{h_5} + \underbrace{f\left(\frac{18}{D}\right)1.50}_{h_6} + \underbrace{1.50\text{ft}}_{h_7}$$

$$h_L = 5.025 + 162f + \frac{28f}{D}$$

- Put D on the other side.

$D = 5.025 + 162f + 28f$

1) assume f
2) Calculate D
3) Calculate R_e and $\frac{D}{\varepsilon}$
4) Calculate f
5) If f from 4) equals f from 1, Calculate D. hn

assume f	D	R_e	D/ε	f
.0261	9.84	4.61×10^6	62.6	.009 x
.015	7.875	3.78×10^6	48.5	.05 x
.052	15.665	7.53×10^6	100	.052 ✓

$D = 5.025 + 162(.052) + 28(.052)$

$D = 14.905$ ft

$h_L = 5.025 + 162(.052) + \frac{28(.052)}{14.905}$

$h_L = 13.55$ ft

Class III = $D = .66\left[\varepsilon^{1.25}\left(\frac{LQ}{gh_L}\right)^{4.75} + vQ^{9.4}\left(\frac{L}{gh_L}\right)^{5.2}\right]^{.04}$

$D = .66\left[(1.5\times10^{-4})^{1.25}\left(\frac{(30ft)(.1336 ft^3/s)}{(32.2 ft/s)(13.55ft)}\right)^{4.75} + (9.84 ft/s)(.1336 ft^3/s)^{9.4}\left(\frac{30ft}{(32.2ft/s)(13.54ft)}\right)^{5.2}\right]^{.04}$

$D = .66\left[2.47\times10^{-14} + 5.38\times10^{-14}\right]^{.04}$

$D = .66(.295)$

$D = .1947$ ft (inside)

- Next largest pipe size has an insit D = .2058 ft.

Pipe used is (2½ schedule 40 steel pipe)

b) use bernoulli's again to find total head on pump.

$$\frac{P_1}{\gamma} + z_1 + \frac{v_1^2}{2g} - h_L + h_A = \frac{P_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

$P_1 = P_2 = 0$

$$h_A = h_L + (z_2 - z_1)$$

$z_2 - z_1 = 19 ft$

- h_L similar to part a) but now we have 2½ in schedule 40 pipes to account for before and after the pump.

2½" schedule 40:

$D = .2058$ ft $A = .03326 ft^2$ (from Table F.1)

$V = \frac{.1336 \text{ ft}^3/s}{.03326 \text{ ft}^2}$ $V = 4.02$ ft/s , $\frac{v^2}{2g} = .251$ ft

- use N_R and D/ε to find f.

$$N_R = \frac{VD\rho}{\eta} = \frac{(4.02 \text{ ft/s})(.2058 \text{ ft})(.92)(1.94 \text{ slug/ft}^3)}{3.6 \times 10^{-5}}$$

$$\frac{D}{\varepsilon} = \frac{.2058 \text{ ft}}{1.5 \times 10^{-4}}$$

$N_R = 4.09 \times 10^4$

$D/\varepsilon = 1372$

$f = .024$ (from moody's diagram)

- h_L same as part a) and use same ref. points.

$h_1 = K\left(\frac{v^2}{2g}\right) = .5(.251 ft) = .1255$ ft

$h_2 = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) = (.024)\left(\frac{10 ft}{.2058 ft}\right)(.251 ft) = .293$ ft

$h_3 = f_T\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) = (1.85)(.251 ft) = .464$ ft

$h_4 = f_{dT}\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) = (.019)(8)(.251) = .038$ ft

$h_5 = f_{dT}\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) = (.022)(100)(.251) = .552$ ft

$h_6 = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) = (.024)\left(\frac{18 ft}{.2058 ft}\right)(.251) = .527$ ft

$h_7 = 1\left(\frac{v^2}{2g}\right) = .251$ ft

$h_L = .1255 + .293 + .464 + .038 + .552 + .527 + .251$ (h_1, h_2, h_3, h_4, h_5, h_6, h_7)

$h_L = 2.25$ ft

- Total head =

$$h_A = h_L + (z_2 - z_1)$$

$$= 2.25 + 19 ft$$

$$h_A = 21.25 ft$$

- Power of pump to coolant.

$$P = h_A \gamma Q$$

$$P = (21.25 ft)(.92 \frac{62.4 lb}{ft^3})(\frac{.1336 ft^3}{s}) \frac{1 hp}{550 \frac{ft \cdot lb}{s}}$$

$$P = .296 hp$$

c) again we manipulate bernoulis to find pressure at inlet pump.
- Reference points: point 1 at collector tank surface point 2 at pump inlet

$$\frac{P_1}{\gamma} + z_1 + \frac{v_1^2}{2g} - h_L = \frac{P_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

$$P_2 = \gamma(z_1 - z_2) - h_L - \frac{v_2^2}{2g}$$

- h_L for this part is just $h_1 - h_4$ because of Ref. points.
- h_L from previous part a and b

h_1 (entrance loss) $= .1255 ft$

h_2 (friction) $= .293 ft$

h_3 (filter) $= .464 ft$

h_4 (open gate valve) $= .038 ft$

$$h_L = .1255 + .293 + .464 + .038$$

$$h_L = .9205 ft$$

$$P_2 = .92\left(\frac{62.4 lb}{ft^3}\right)[3 ft - .9205 ft - .251 ft]\left(\frac{1 ft^2}{144 in^2}\right)$$

$$P_2 = .729 psig$$

Summary:

a) The new pipe siz 2½ schedule 40 before and after the pump is larger than the original one which was 2" before the pump and 1¼" after the pump.

b) The total head on the pump is 21.25ft and the power delivered by the pump to the coolant is .296 hp. after we put the new 2½" schedule 40 pipe on.

c) The pressure at inlet of the pump is now .729 psig after the new 2½" schedule 40 pipe.

Analysis

- Since our flow is now larger the piping has to be larger as well to keep up with flow.
- Not that much energy loss in pipes.
- Changing flow rate to 30 gpm in each machine affects our system.

② Purpose:

1) Determine the size of the pipe (steel pipe schedule 40), for the gravity driven system to deliver a flow rate of 30 gpm in each machine

Source(s):

- Mott, R. Untener, J.A "Applied Fluid Mechanics". 7th edition, Pearson education Inc (2015)
- Blackboard notes

Design Considerations

- Constant properties
- Constant temp
- Incompressible fluid
- Steady state
- Pipe friction

Materials

- Schedule 40 steel pipe
- Coolant
- Pipe

Data and Variables

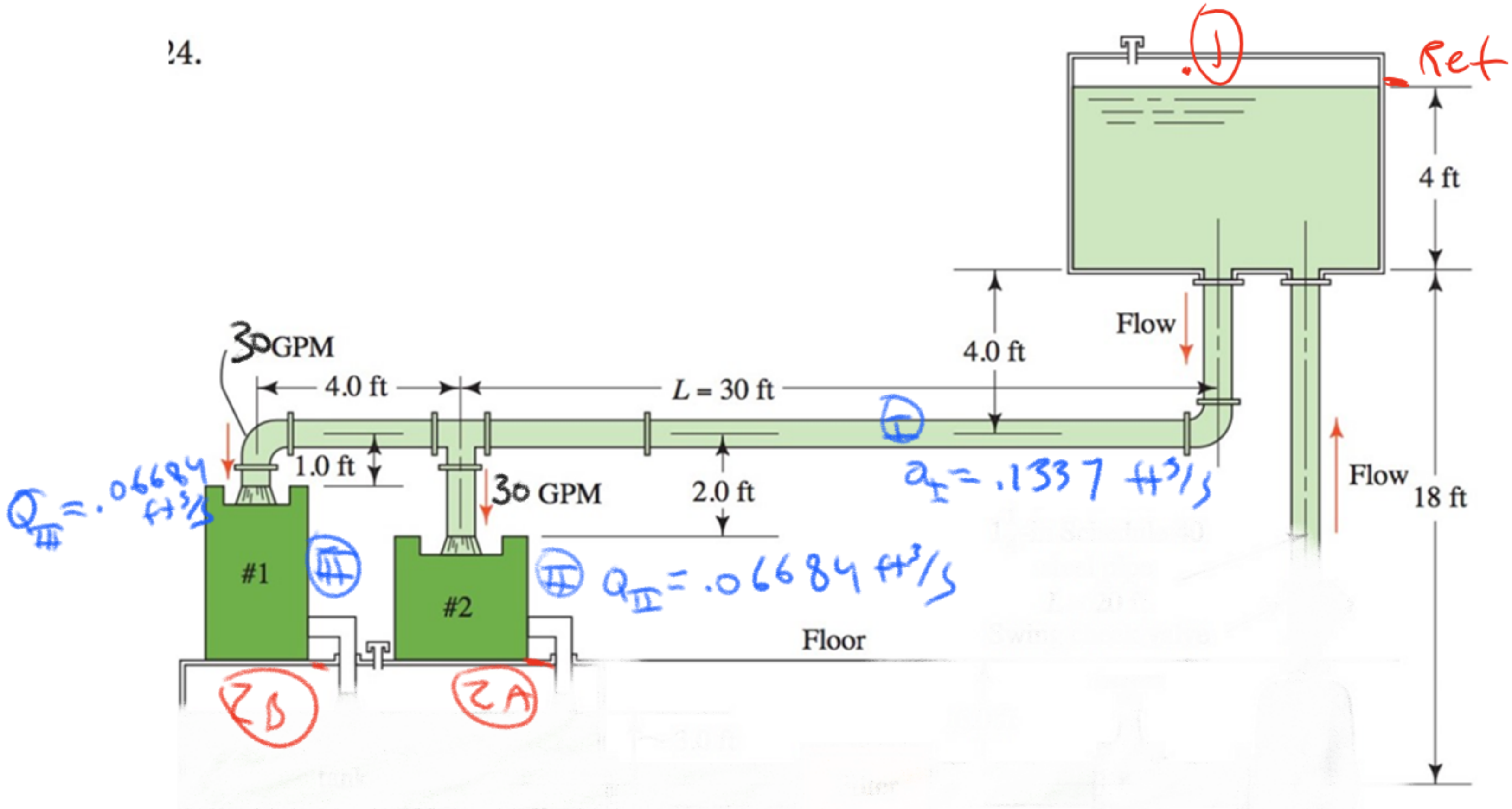
$Q_I = 60\,gpm = .1337\,ft^3/s$

$Q_{II} = 30\,gpm = .06684\,ft^3/s$

$Q_{III} = 30\,gpm = .06684\,ft^3/s$

$m = 3.6 \times 10^{-5}$

24.



1
Ref
4 ft
18 ft
Flow
Flow
4.0 ft
30GPM
4.0 ft
L = 30 ft
1.0 ft
30 GPM
2.0 ft
I
$Q_I = .1337$ ft³/s
$Q_{III} = .06684$ ft³/s
III
II $Q_{II} = .06684$ ft³/s
#1
#2
Floor
ZB
ZA

Procedure and Calculations

- manipulate bernoulli's equation between point 1 and 2A

$$\frac{P_1}{\gamma} + Z_1 + \frac{V_1^2}{2g} - h_{L_{1-2A}} = \frac{P_{2A}}{\gamma} + Z_{2A} + \frac{V_{2A}^2}{2g}$$

$$Z_1 = \frac{V_{2A}}{2g} + Z_{2A} + h_{L_{1-2A}}$$

$$Z_1 - Z_{2A} = \frac{V_{2A}}{2g} + h_{L_{1-2A}}$$

- $h_{L_{1-2A}}$: energy loss

$$h_{L_{1-2A}} = h_{ent} + h_{elbow} + h_{tee} + h_{L_I} + h_{L_{II}}$$

- Lets Call minor energy losses h_m

$$h_m = K\frac{V^2}{2g} \Rightarrow h_m = \frac{8K}{g\pi^2 D^4}Q^2$$

- Pipe energy losses $= h_L = f\frac{L}{D}\frac{V^2}{2g}$

or

$$h_L = \frac{8fL}{g\pi^2 D^5}Q^2$$

$$\frac{V^2}{2g} = \frac{8}{g\pi^2 D^4}Q^2$$

- Plug in Substitutions.

$$Z_1 - Z_{2A} = \frac{8}{g\pi^2 D_{II}^4}Q_{II}^2 + \frac{8K_{ent}}{g\pi^2 D_I^4}Q_I^2 + \frac{8K_{elbow}}{g\pi^2 D_I^4}Q_I^2 + \frac{8K_{tee}}{g\pi^2 D_I^4}Q_I^2 + \frac{8f_I L_I}{\pi^2 g D_I^5}Q_I^2 + \frac{8f_{II} L_{II}}{g\pi^2 D_{II}^5}Q^2$$

-Plug in numbers

$$10\text{ ft} = \frac{8}{\left(32.2\frac{ft}{s^2}\right)\pi^2 D_{II}^4}(.06684\text{ ft}^3/s)^2 + \frac{8(.5)}{\left(32.2\frac{ft}{s^2}\right)\pi^2 D_I^4}(.1337\text{ ft}^3/s)^2 + \frac{8\cdot 30 f_{T_I}}{\left(32.2\frac{ft}{s^2}\right)\pi^2 D_I^4}(.1337\text{ ft}^3/s)^2$$

$$+ \frac{8\cdot 60 f_{T_I}}{\left(32.2\frac{ft}{s^2}\right)\pi^2 D_I^4}(.1337\text{ ft}^3/s)^2 + \frac{8 f_I(34\text{ ft})}{\left(32.2\frac{ft}{s^2}\right)\pi^2 D_I^5}(.1337\text{ ft}^3/s)^2 + \frac{8f_{II}(2\text{ ft})}{\left(32.2\frac{ft}{s^2}\right)\pi^2 D_{II}^5}(.06684\text{ ft}^3/s)^2$$

$$10 = \frac{1.125\times10^{-4}}{D_{II}^4} + \frac{2.249\times10^{-4}}{D_I^4} + \frac{1.349\times10^{-2}(f_{T_I})}{D_I^4} + \frac{2.699\times10^{-2}(f_{T_I})}{D_I^4} + \frac{1.529\times10^{-2}(f_I)}{D_I^5} + \frac{2.249\times10^{-4}(f_{II})}{D_{II}^5}$$

A: $$1\times10^5 = (2.249 + 1349 f_{T_I} + 2699 f_{T_I})\frac{1}{D_I^4} + \frac{152.9 f_I}{D_1^5} + \frac{1.125}{D_{II}^4} + \frac{2.249 f_{II}}{D_{II}^5}$$

- Manipulate bernoulli's equation between points 1 and 2B

$$z_1 = \frac{V_B^2}{2g} + z_{2B} + h_{ent} + h_{el3} + h_{tee} + h_{L_I} + h_{elbow_{III}} + h_{L_{III}}$$

use $K = 20f_T$ and act

$$\frac{8.999\times10^{-3} f_{T_I}}{D_I^4}$$

$$\frac{V_{2B}^2}{2g} = \frac{8}{g\pi^2 D_{III}^4} Q_{III}^2 = \frac{8}{32.2\pi^2 D_{III}^4}\left(.06684 \frac{ft^3}{s}\right)^2 = \frac{1.125\times10^{-4}}{D_{III}^4}$$

$$h_{elbow_{III}} = \frac{8K_{elbow}}{g\pi^2 D_{III}^4} Q_{III}^2 = \frac{8(30 f_{T_{III}})}{32.2\pi^2 D_{III}^4}\left(.06684 \frac{ft^3}{s}\right)^2 = \frac{3.374\times10^{-3} f_{T_{III}}}{D_{III}^4}$$

$$h_{L_{III}} = \frac{8 f_{III} L_{III}}{g\pi^2 D_{III}^5} Q_{III}^2 = \frac{8 f_{III}\cdot 1}{32.2\pi^2 D_{III}^5}\left(.06684 \frac{ft^3}{s}\right)^2 = \frac{1.125\times10^{-4} f_{III}}{D_{III}^5}$$

$$B:\ 9\times10^4 = (2.249 + 134.9 f_{T_I} + 899.9 f_{T_I})\frac{1}{D_I^4} + \frac{152.9 f_I}{D_I^5} + (1125 + 33.74 f_{T_{III}})\frac{1}{D_{III}^4} + \frac{1.125 f_{III}}{D_{III}^5}$$

- Lets use $V_{max} = 3\,m/s$ (9.843 ft/s) because its the V we use for this class

$$V_I = \frac{4Q_I}{\pi D_I^2} = \frac{4(.1337\ ft^3/s)}{\pi D_I^2}$$

$$V_I = .170\frac{1}{D_I^2} \rightarrow D_I = \sqrt{\frac{.170\ ft^3/s}{9.843\ ft/s}}$$

$D_I = .131$ ft or 1.57 in

- From table F.1, I should use $1\tfrac{1}{2}$ inch nominal size

$D_I = 1\tfrac{1}{2}$ in nominal size Schedule 40

$D_{I_i} = .1342$ ft $\qquad A_i = .01414\ ft^2$

- Now Solve for D_{II}.

$$A:\ 1\times10^5 = (2.249 + 134.9 f_{T_I} + 269.9 f_{T_I})\frac{1}{D_I^4} + \frac{152.9 f_I}{D_I^5} + \frac{1.125}{D_{II}^4} + $$

$$\varepsilon/D_I = \frac{1.5\times10^{-4}\ ft\ (\text{for steel})}{.1342\ ft}$$

$$\frac{\varepsilon}{D_I} = 1.117\times10^{-3} \quad \text{or} \quad \frac{D_I}{\varepsilon} = 894.67\ ft$$

$$f_{T_I} = .021$$

- Now find f_I

$$R_e = \frac{V_I D_I}{\nu} = \frac{.170}{D_I^2} \cdot \frac{D_I}{\nu} = \frac{.170}{D_I \nu} = \frac{.170}{(.13492)(6.27\times10^{-7})} = 2.02\times10^6$$

- from moodys $f_I = .022$

- Now plug in numbers

$$1\times10^5 = [2.249 + 134.7(.021) + 269.9(.022)] \frac{1}{.13492^4} + \frac{152.9(.022)}{.13425} + \frac{1.125}{D_{II}^4} + \frac{2.249 f_{II}}{D_{II}^5}$$

$$1\times10^5 = (11.0197)\, 3093.1 + 77280.1 + \ldots$$

$$1\times10^5 = 3093 + 77280.1 + ?$$

$$19626.9 = \frac{1.125 f_{II}}{D_{II}^4} + \frac{2.249 f_{II}}{D_{II}^5}$$

- To solve equation we have to use trial and error. First guess is .041 ft

$$\frac{D_{II}}{\varepsilon} = \frac{.041}{1.5\times10^{-4}} = 273.3$$

$$R_e = \frac{V_{II} D_{II}}{\nu} = \frac{4 Q_{II}}{\pi D_{II}^2} \cdot \frac{D_{II}}{\nu} = \frac{4 Q_{II}}{\pi D_{II} \nu} = \frac{4(.06684)}{\pi(.041)(6.27\times10^{-7})}$$

$$R_e = 3.31\times10^6$$

from moodys $f_{II} = .0277$

$$D_{II}: \quad 19626.1 = \frac{1}{D_{II}^4}\left(1.125 + \frac{2.249 f_{II}}{D_{II}}\right)$$

$$\therefore D_{II} = \sqrt[4]{5.732\times10^{-4}\;\frac{1.146\times10^{-4}\, f_{II}}{D_{II}}}$$

- Now trial and error until $D_{II_{new}} = D_{II}$

D_{II} now (ft)	$D_{II}/2$	R_e	f_{II}	$D_{II} = \sqrt[4]{5.732\times10^{-4}\ \frac{1.146\times10^{-4} f_{II}}{(D_{II}\ \text{new})}}$	
.01723	1148.6	788159.2	.02	.156 ft	X
.167	1113.3	813172.6	.02	.1556 ft	X
.159	1060	854007	.02	.1557 ft	✓

$D_{II} = .159$ ft, now we go to table F and pick a diameter

D_{II} = 2 in nominal size Schedule 40 steel

$D_{II_i} = .1723$ ft $\qquad A_i = .02333\ ft^2$

- Plug in numbers and find D_{III} =

D_{III} =

$$9\times10^4 = [(2.249 + 134.9(.021) + 6999(.0041))]\frac{1}{.1342^4} + \frac{152.9(.022)}{.1342^5} + (1.125 + 33.74f_{T_{III}})\frac{1}{D_{III}^4} + \frac{1.125 f_{III}}{D_{III}^5}$$

$$9\times10^4 = 773932.5 + 77280.1 + (1.125 + 33.74f_{T_{III}})\frac{1}{D_{III}^4} + \frac{1.125f_{III}}{D_{III}^5}$$

OR,

$$761212.6 = (1.125 + 33.74f_{T_{III}})\frac{1}{D_{III}^4} + \frac{1.125f_{III}}{D_{III}^5}$$

$$761212.6 = \frac{1}{D_{III}^4}\left[1.125 + 33.74f_{T_{III}} + \frac{1.125f_{III}}{D_{III}}\right]$$

$$D_{III} = \sqrt[4]{1.478\times10^{-6} + 4.432\times10^{-5}f_{T_{III}} \frac{1.478\times10^{-6}f_{III}}{D_{III}}}$$

- Now trial and error just like before.

$D_{III,new}$ (ft)	$D_{III}/2$	R_e	f_{III}	$f_{4.1}$	$D_{III} = 1.476\times10^{-5} + 4.472\times10^{}$	
.159	1060	854087	.02	.02	.04625	X
.04625	308.3	213[illegible]12.6	.0256	.0256	.04304	X
.04304	286.9	315520	.0257	.0257	.04325	✓

$D_{III} = .04304$ ft

- Look up in table F.

$D_{III} = \frac{1}{2}$ in normal size, schedule 40 steel

$D_{III,i} = .0518$ ft

$A_i = .00211$ ft^2

- Summary
- Schedule 40 Steel

$D_I = 1\frac{1}{2}$ in	$D_{I,i} = .1342$ ft $A_I = .0144$ ft^2
$D_{II} = 2$ in	$D_{II,i} = .1723$ ft $A_i = .0233$ ft^2
$D_{III} = \frac{1}{2}$ in	$D_{III} = .0518$ ft $A_i = .00211$ ft^2

- Values are from table F.1

Analysis

To double check we was a flow rate of 30gpm or .06684 ft^3/s in machine 1 and 2. Less plug in the values of pipe sizes and check.

$$V = \frac{Q}{A} \Rightarrow Q = V \cdot A$$

$$Q_{II} = Q_{III} = .06684\ ft^3/s$$

- for the #1 machine

$$V = \frac{.06684\ ft^3/s}{.00211\ ft^2}$$

$$V = 31.67\ ft/s$$

$$Q_{III} = (31.67\ ft/s)(.00211\ ft^2)$$

$$Q_{III} = .06684\ ft^3/s \checkmark$$

- for the #2 machine

$$V = \frac{.06684\ ft^3/s}{.02333\ ft^2}$$

$$V = 2.864\ ft/s$$

$$Q_{II} = (2.864\ ft/s)(.02333\ ft^2)$$

$$Q_{II} = .06684\ ft^3/s \checkmark$$

- This means the pipe size for the system needs to be 2in for machine #2 and $\frac{1}{2}$ inch for machine #1. to get a 30gpm flow rate. We do not want to always increase pipe diameter because of energy loses.