Test 2

Professors Solutions

Name: ____.

MET 330 Fluid Mechanics
Dr. Orlando Ayala
Fall 2024
Test 2

Take home – Due Wednesday October 30th, 2024, 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). 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 technical writing I will follow the attached rubric.
3. There are 3 main different parts, each one is worth 80/3 points.
4. What you turn in should be only your own work. You cannot discuss the exam with anyone, except me. Call 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 CANVAS. You must submit the test solution in only one file, and it has to be a pdf file. You must also submit the excel spreadsheet. For the ePortfolio (which is optional) you are supposed to upload this artifact to your Google drive. I will provide more instructions later.
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.

The company that hired you to start the design of the system in the figure is happy with your work (NOTE: THE FIGURE IS NOT TO SCALE). The want to hire you again to continue with the design. Let us remember that the system is to deliver 60 °F water from the lower open channel to the upper open channel at a rate of 3.387 ft^3/s. They want you to complete the following tasks:

a. Design the pumped pipeline system, for that:

- First select a pipe diameter from table F1 in the appendix of the book. The pipe diameter is such that the fluid flow velocity in the pipe is close to 3 m/s.
- Determine the required pump power (in HP), assuming a pump efficiency of 60%. The total suction pipe length is 11 ft, while the total discharge pipe length is 2500 ft. Neglect the losses due to all fittings.
- Compute the pressure at the pump inlet and at the pump outlet.
- You are required to perform all calculations by hand but must also create an Excel spreadsheet to automatically run the calculations. Ensure that the Excel results match your hand calculations.
- The company also wonders whether the selected pipe was a good choice. To facilitate the answer to this equation, use the spreadsheet to run the calculations for different commercial pipe diameters. Then, make a table with the different commercial pipe internal diameters , and the corresponding pump powers, and inlet and outlet pump pressures. Finally, plot pump power vs. pipe diameter and inlet and outlet pump pressures vs. pipe diameter.
- Review your results and provide comments in the "analysis" section of your solution. Why do the results make sense?

b. Your client also proposes to use a flow nozzle to measure the flow. For a nozzle diameter to pipe diameter ratio of 0.5:

- What is the pressure drop across the nozzle?
- With this addition to the system (which is an additional energy loss), by how much (show it in percentage) would the pump power increase?

  Please note that the equation for pressure drop you derived for the 1st question is the total pressure drop that includes the pressure drop due to the fluid acceleration and the pressure drop due to energy losses. To get the portion of the energy loss you could use this equation:

  $$\Delta p_{loss} = (1 - C^2)\Delta p_{total}$$

  where Δp_{total} is what you calculated for the 1st question.

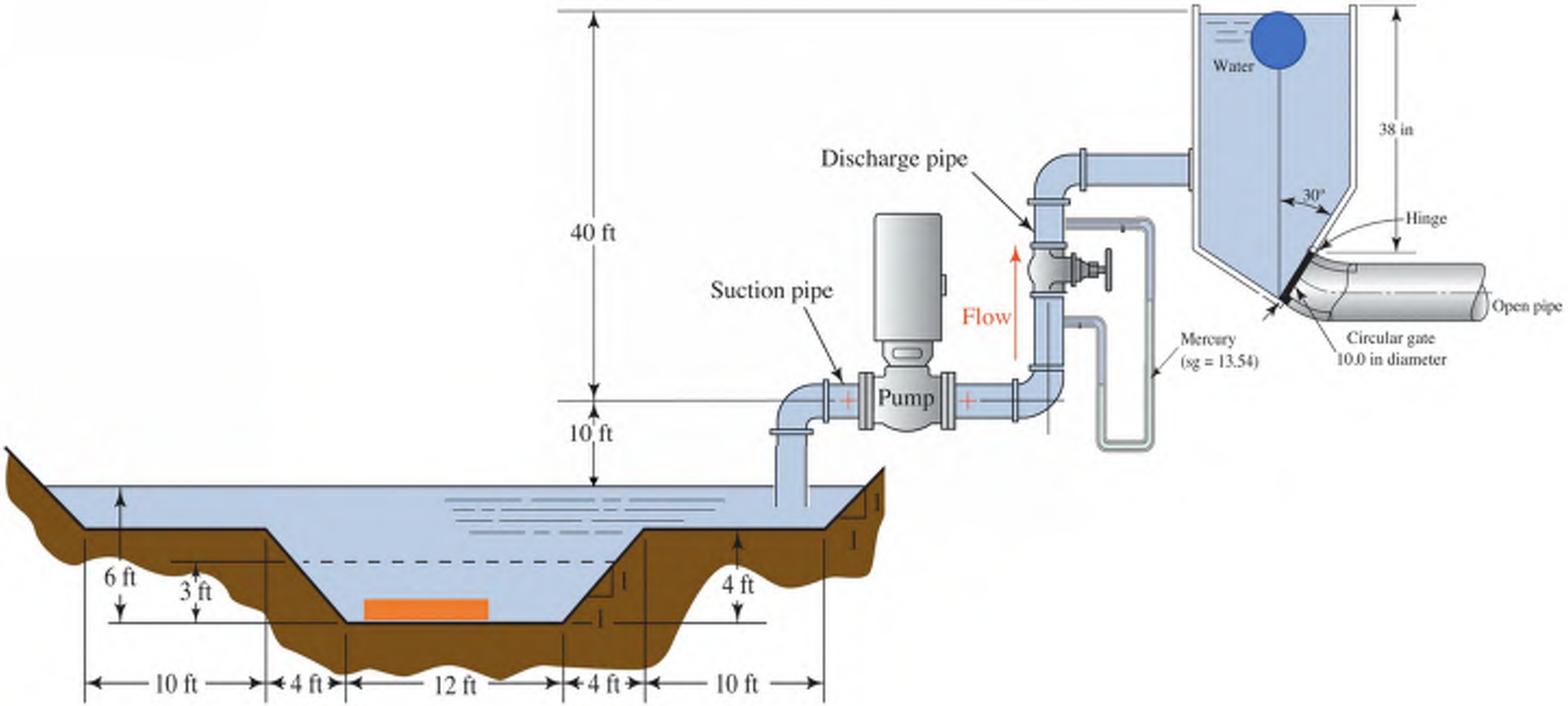
  <u>*NOTE*</u>*: If you derive this equation for Δp_{loss}, I will give you 5 extra points.*

- You are required to perform all calculations by hand but must also create an Excel spreadsheet to automatically run the calculations. Ensure that the Excel results match your hand calculations.
- Use the spreadsheet, with it run the calculations for different nozzle diameter to pipe diameter ratio and make a table with the different nozzle diameter to pipe diameter

ratios and the corresponding pressure drop across the nozzle. Finally, plot pressure drop across the nozzle vs. nozzle diameter to pipe diameter ratio.
- Review your results and provide comments in the "analysis" section of your solution. Why do the results make sense?

c. For a good working system, the amount of pumped water should not be too much to dry the lower open channel. The company wants to know whether the amount of pumped water is negligible compared to the total flow rate running through the lower open channel. Please note that this is a natural channel with light brush and its average slope is 0.00015.

- Compute the flow rate running through the lower open channel.
- Compute the percentage of pumped water flow with respect to the lower open channel flow.
- You are required to perform all calculations by hand but must also create an Excel spreadsheet to automatically run the calculations. Ensure that the Excel results match your hand calculations.
- Use the spreadsheet, with it run the calculations for different total water elevation in the lower open channel (go from 4 ft to 8 ft) and make a table with the different total water elevations and the corresponding percentage of pumped water flow. Finally, plot percentage of pumped water flow vs. water elevation.
- Review your results and provide comments in the "analysis" section of your solution. Why do the results make sense?


Water
38 in
30°
Hinge
Open pipe
Circular gate
10.0 in diameter
Mercury
(sg = 13.54)
Discharge pipe
Suction pipe
Flow
Pump
40 ft
10 ft
1
1
1
1
6 ft
3 ft
4 ft
10 ft
4 ft
12 ft
4 ft
10 ft

Problem solution rubric

	Exceeds Standard	Meets Standard	Approaches Standard	Needs Attention
	4	3	2	1
	10 points	7 points	4 points	0 points
1. **Purpose** 5%	The purpose of the section to be answered is clearly identified and stated.	The purpose of the section to be answered is identified, but is stated in a somewhat unclear manner.	The purpose of the section to be answered is partially identified, and is stated in a somewhat unclear manner.	The purpose of the section to be answered is erroneous or irrelevant.
2. **Drawings & Diagrams** 10%	Clear and accurate diagrams are included and make the section easier to understand. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled neatly and accurately.	Diagrams are included and are labeled.	Needed diagrams are missing OR are missing important labels.
3. **Sources** 5%	Several reputable background sources were used and cited correctly.	A few reputable background sources are used and cited correctly.	A few background sources are used and cited correctly, but some are not reputable sources.	Background sources are cited incorrectly.
4. **Design considerations (assumptions, safety, cost, etc)** 10%	Design is carried out with applicable assumptions and full attention to safety and cost, etc.	Design is generally carried out with assumptions and attention to safety, cost, etc.	Design is carried out with some assumptions and some attention to safety, cost, etc.	Assumptions, safety and cost were ignored in the design.
5. **Data and variables** 5%	All data and variables are clearly described with all relevant details.	All data and variables are clearly described with most relevant details.	Most data and variables are clearly described with most relevant details.	Data and variables are not described OR the majority lack sufficient detail.
6. **Procedure** 25%	Procedure is described in clear steps. The step description is in a complete and easy to understand short paragraph.	Procedure is described in clear steps but the step description is not in a complete short paragraph.	Procedure is described in clear steps. The step description is in a complete short paragraph but it is difficult to understand.	Procedure is not described in clear steps at all.
7. **Calculations** 20%	All calculations are shown and the results are correct and labeled appropriately. The units of all values are shown.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
8. **Summary** 5%	Summary describes the design, the relevant information and some future implications.	Summary describes the design and some relevant information.	Summary describes the design.	No summary is written.
9. **Materials** 5%	All materials used in the design are clearly and accurately described.	Almost all materials used in the design are clearly and accurately described.	Most of the materials used in the design are clearly and accurately described.	Many materials are described inaccurately OR are not described at all.
10. **Analysis** 10%	The design is discussed and analyzed. Argumentative predictions are made about what might happen in case of change in the operation and how the design could be change.	The design is discussed and analyzed. Argumentative predictions are made about what might happen in case of change in the operation.	The design is discussed and analyzed. No argumentative predictions are made about what might happen in case of change in the operation and how the design could be change.	The design is not discussed and analyzed.

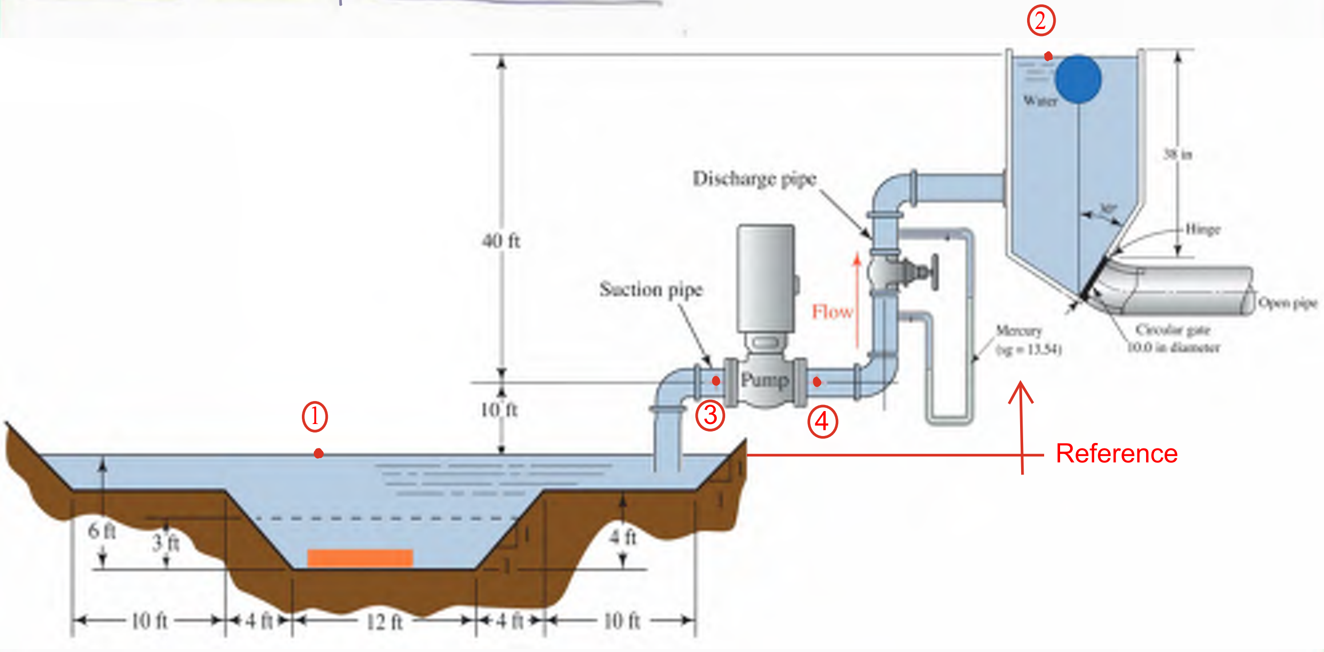
A

PURPOSE

Design a pumped system to deliver water from a lower open channel to an elevated open channel. The design includes:

a) Pump power requirement to pump 3.387 ft³/s
b) Compute the pressure drop across a flow-nozzle meter to be possibly installed & determine the pump power increment that it will require.
c) Check that the amount of pumped water is negligible with respect to the flow running through the lower open channel.

DRAWINGS & DIAGRAMS



SOURCES

Mott, R., Untener, J.A., "Applied Fluid Mechanics" 8th edition, Pearson Education Inc (2023)

B

DESIGN CONSIDERATIONS

- Constant properties
- Incompressible fluid
- Isothermal conditions
- Steady state
- Newtonian fluid

MATERIALS

- Water at 60°F
- Steel pipe

DATA & VARIABLES

- $n = 0.05$
- $S = 0.00015$

Open Channel Info

- $L_{discharge} = 2{,}500\ ft$
- $L_{suction} = 11\ ft$
- $\varepsilon = 1.5 \times 10^{-4}\ ft$
- All dimensions in drawing

Pipe Info

- $Q_{pump} = 3.387\ ft^3/s$
- $\eta_{pump} = 0.6$

Pump Info

- $\nu = 1.21 \times 10^{-5}\ ft^2/s$
- $\gamma = 62.4\ lb/ft^3$

Fluid Info

- $\beta = 0.5$

Flowmeter Info

PROCEDURE

For the three parts, I will do the following:

a) Use the given flow and the 3 m/s criteria with $Q = V \times A$ equation to get the pipe diameter. Then pick a commercial diameter from table F1. Next, I compute the pump head using Bernoulli's equation. With h_A & Q, I will get the pump power

C

b) Use the equation for flow rate crossing a flow meter and solve for ΔP.

c) Compute the flow rate in the lower open channel using the open channel equation (Manning's eq). Then compute the percentage of pumped flow with respect to the open channel flow.

CALCULATIONS

a) Let us start selecting the pipe diameter using $Q = V\times A$:

$$Q = V\times A = V\frac{\pi}{4}D^2 \longrightarrow D = \sqrt{\frac{4Q}{\pi V_{criteria}}}$$

$$V_{crit} = 3\ m/s = 9.842\ ft/s$$

$$D = \sqrt{\frac{4\times 3.387\ ft^3/s}{\pi \times 9.842\ ft/s}}$$

$$D = 0.662\ ft = 7.94\ in$$

From table F1, I pick an 8" Sch 40 pipe. The inside diameter is 7.981 in (0.6651 ft) and the area is $0.3472\ ft^2$.

Now, I need the pump head. I put the Bernoulli points on the water surfaces of the open channels.

$\boxed{D}$

$$h_A + \frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L_{1-2}}$$

I will assume that both open channels have similar velocities, and since they are open to the atmosphere, I get:

$$h_A = (z_2 - z_1) + h_{L_{1-2}}$$

The change of elevation is 50 ft. For the energy losses I compute the one due to the pipe, while ignoring the losses due to the elbows, valve, and exit (top open channel), per test instructions:

$$h_{pipe} = f \frac{L}{D} \frac{V^2}{2g}$$

$$V = \frac{Q}{A} = \frac{3.387\ ft^3/s}{0.3472\ ft^2} = 9.755\ ft/s$$

$$Re = \frac{VD}{\nu} = \frac{9.755\ ft/s \times 0.6651\ ft}{1.21 \times 10^5\ ft^2/s} = 5.36 \times 10^5$$

$$D/\epsilon = \frac{0.6651\ ft}{1.5 \times 10^4\ ft} = 4434$$

From Moody chart: $f \cong 0.01566$

$\boxed{E}$

$$h_{L_{\substack{pipe\\suction}}} = 0.01557 \frac{11\,ft}{0.6651\,ft} \frac{(9.755\,ft/s)^2}{2 \times 32.2\,ft/s^2}$$

$$h_{L_{\substack{pipe\\suction}}} = 0.383\,ft$$

$$h_{L_{\substack{pipe\\discharg}}} = 0.01557 \frac{2500\,ft}{0.6651\,ft} \frac{(9.755\,ft/s)^2}{2 \times 32.2\,ft/s^2}$$

$$h_{L_{\substack{pipe\\discharg}}} = 86.357\,ft$$

So, $h_{L_{1-2}} = 0.383\,ft + 86.357\,ft = 87.357\,ft$

Therefore, plugging this into Bernoulli's eq:

$$h_A = 50\,ft + 87.357\,ft$$

$$h_A = 137.357\,ft$$

Now the pump power

$$P = \frac{\gamma Q h_A}{\eta} = \frac{62.4\,lb/ft^3 \times 3.387\,ft^3/s \times 137.357\,ft}{0.6}$$

$$P = 48{,}345.18\ \frac{lb \cdot ft}{s}$$

converting (table k1)

$$\boxed{\cancel{P = 87.90\ HP}}$$

For the pressure at the inlet, I will use $\boxed{F}$ points ① & ③:

$$\overset{0\,(\text{gage})}{\cancel{\frac{P_1}{\gamma}}}+\overset{\text{neglect}}{\cancel{\frac{V_1^2}{2g}}}+\overset{0\,(\text{ref})}{\cancel{Z_1}}=\frac{P_3}{\gamma}+\frac{V_3^2}{2g}+Z_3+h_{L_{1-3}}$$

Note I do not include h_A because there is no pump between ① & ③. Solving for P_3:

$$P_3=\gamma\left(\frac{V_3^2}{2g}+Z_3-h_{L_{1-3}}\right)$$

$$h_{L_{1-3}}=h_{\text{pipe suction}}$$

$$P_3=-62.4\,\frac{\text{lb}}{\text{ft}^3}\left(\frac{(9.785\,\text{ft/s})^2}{2\times 32.2\,\frac{\text{ft}}{\text{s}^2}}+10\,\text{ft}+0.383\,\text{f}\right)$$

$$\boxed{P_3=-739.937\,\frac{\text{lb}}{\text{ft}^2}=-5.138\,\text{psi}}$$

For the pressure at the outlet, I use points ③ & ④:

$$h_A+\frac{P_3}{\gamma}+\overset{\text{same velocity}}{\cancel{\frac{V_3^2}{2g}}}+\overset{\text{same elevation}}{\cancel{Z_3}}=\frac{P_4}{\gamma}+\overset{\text{same velocity}}{\cancel{\frac{V_4^2}{2g}}}+\overset{\text{same elevation}}{\cancel{Z_4}}+\overset{0\,(\text{there are no losses})}{\cancel{h_{L_{3-4}}}}$$

So,

$$P_4=\gamma\left(h_A+\frac{P_3}{\gamma}\right)=\left(137.357\,\text{ft}+\frac{(-739.937\,\frac{\text{lb}}{\text{ft}^2})}{62.4\,\text{lb/ft}^3}\right)\times 62.4\,\frac{\text{lb}}{\text{ft}^3}$$

$$\boxed{P_4=7{,}824.31\,\frac{\text{lb}\times\text{ft}}{\text{s}}=54.335\,\text{psi}}$$

See excel for automated calculations & plots

Open Channel Info

n= 0.05
S= 0.00015
L_lower trapezoid= 12 ft
H_lower trapezoid= 4 ft
L_upper trapezoid= 40 ft
H_lower trapezoid= 6 ft

Pipe Info

Ldisch= 2500 ft
Lsuct= 11 ft
ε= 1.50E-04 ft
z2= 50 ft
z1= 0 ft
z3=z4= 10 ft

Pump Info

Q= 3.387 ft3/s
η= 0.6

Fluid Info

ν= 1.21E-05 ft2/s
γ= 62.4 lb/ft3

Flowmeter Info

β= 0.5 ft

SELECTING -> 8 in Schedule 40 Stee
7.943 in D= 0.6651 ft
A= 0.3474 ft2

PIPE SELECTION
D= 0.662
ft/s

ENERGY LOSSES
v= 9.749
Re= 5.36E+05
D/e= 4.43E+03
f= 0.01566

h_suction= 0.382 ft
h_discharge= 86.865 ft

h_1-2= 87.248 ft

PUMP HEAD hA= 137.248 ft

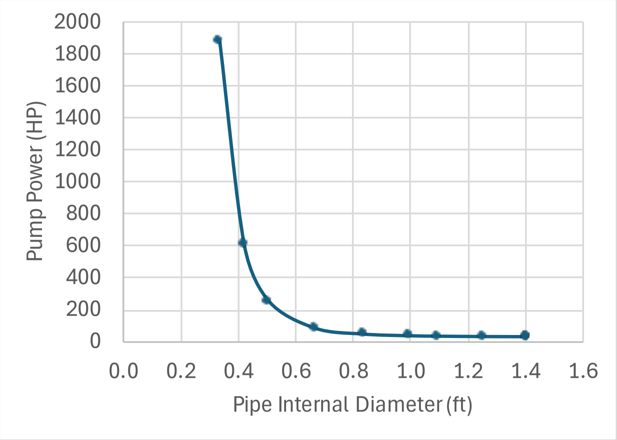
PUMP POWER P= 48345.1842 lb x ft/s
P= 87.90 HP

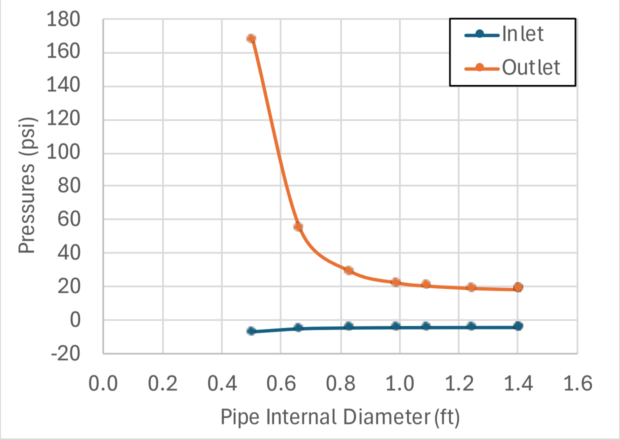
PRESSURE AT INLET p3= -739.937 lb/ft2
p3= -5.138 psi

PRESSURE AT OUTLET p4= 7824.311 lb/ft2
p4= 54.335 psi

MAKE A TABLE BY CHANGING THE DIAMENTER VALUES

Dnominal (in)	D (ft)	Pump Power (HP)	Inlet Pressure (psi)	Outlet Pressure (psi)
4	0.3355	1878.31	-19.683	1251.194
5	0.4206	608.85	-10.042	401.912
6	0.5054	257.38	-6.919	167.226
8	0.6651	87.900	-5.138	54.335
10	0.8350	49.81	-4.643	29.058
12	0.9948	39.44	-4.483	22.204
14	1.0940	36.65	-4.434	20.364
16	1.2500	34.42	-4.392	18.895
18	1.4060	33.36	-4.369	18.205
20	1.4060	33.36	-4.369	18.205





b) The equation for flowmeters is:

G

$$Q = CA_1\sqrt{\frac{2g\frac{\Delta p}{\gamma}}{(A_1/A_2)^2-1}}$$

$$\beta = \frac{d_2}{d_1}$$

$$\frac{A_1}{A_2} = \frac{d_1^2}{d_2^2} = \left(\frac{d_1}{d_2}\right)^2 = 4$$

and the equation for C for a flow nozzle is:

$$C = 0.9975 - 6.55\sqrt{\frac{\beta}{Re}}$$

Solving for Δp:

$$\Delta p = \frac{\gamma}{2g}\frac{Q^2}{C^2A_1^2}\left[(A_1/A_2)^2-1\right]$$

with $Re = 5.36 \times 10^5$ (from previous part)

$$C = 0.991$$

$$\Delta p = \frac{62.4\,\frac{lb}{ft^3}}{2 \times 32.2\,\frac{ft}{s^2}} \times \frac{(3.387\,ft^3/s)^2}{(0.991)^2(0.3472\,ft^2)^2}\left[4^2-1\right]$$

$$\boxed{\Delta p = 1{,}406.028\,\frac{lb}{ft^2} = 9.764\,psi}$$

Now, a portion of that pressure drop is due to energy losses, and this portion is: $\boxed{H}$

$$\Delta P_{loss} = (1-C^2)\Delta P_{total}$$

$$= (1-0.991^2)\times 1{,}406.028 \frac{lb}{ft^2}$$

$$\Delta P_{loss} = 24.713 \frac{lb}{ft^3}$$

This ΔP_{loss} is an additional energy loss:

$$h_{L_{additional}} = \frac{\Delta P_{loss}}{\gamma} = \frac{24.713\ lb/ft^3}{62.4\ lb/ft^3} = 0.396\ ft$$

The previous energy loss is 87.248 ft, adding the loss due to the flow-nozzle, we get 87.644 ft. Thus, the new pump head:

$$h_A = 50\ ft + 87.644\ ft = 137.644\ ft$$

And the new pump power is

$$P = \frac{\gamma Q h_A}{\eta} = \frac{62.4\ lb/ft^3 \times 3.387\ ft^3/s \times 137.644\ ft}{0.6} = 48{,}484.69 \frac{lbft}{s}$$

$$\boxed{P = 88.15\ HP}$$

This represents a percentage increment of: $\boxed{I}$

$$\%HP_{increment} = \frac{88.15\,HP - 87.90\,HP}{87.90\,HP} \times 100$$

$$\boxed{\%HP_{increment} = 0.29\%}$$

See excel for automated calculations & plot

c) Need the lower open channel flow rate first:

$$Q = \frac{1.49}{n} S^{1/2} R^{2/3} A$$

$$A = (12ft \times 4ft) + 2\frac{1}{2}(4ft \times 4ft) \leftarrow \text{lower trapezoid}$$

$$+ (10ft + 4ft + 12ft + 4ft + 10ft) \times 2ft + 2\frac{1}{2}(2ft \times 2ft)$$

Upper trapezoid

Note: for excel, the highlighted 2ft will vary. And note that this 2ft comes from (6ft − 4ft)...

$$\underline{A = 148\,ft^2}$$

$$R = \frac{A}{WP}$$

Open Channel Info		
n=	0.05	
S=	0.00015	
L_lower trapezoid=	12	ft
H_lower trapezoid=	4	ft
L_upper trapezoid=	40	ft
H_lower trapezoid=	6	ft
Pipe Info		
Ldisch=	2500	ft
Lsuct=	11	ft
ε=	1.50E-04	ft
z2=	50	ft
z1=	0	ft
z3=z4=	10	ft
Pump Info		
Q=	3.387	ft3/s
η=	0.6	
Fluid Info		
ν=	1.21E-05	ft2/s
γ=	62.4	lb/ft3
Flowmeter Info		
β=	0.5	ft/s

8 in Schedule 40 Steel Pipe

D= 0.6651 ft

A= 0.3474 ft2

DISCHARGE COEEFICIENT

v=	9.749
Re=	5.36E+05
C=	0.991

PRESSURE DROP

Δp=	1406.028	lb/ft2
Δp=	9.764	psi

ADDITIONAL LOSS

Δp_loss=	24.713	lb/ft2
Δp_loss=	0.172	psi
hl=	0.396	ft
h_1-2=	87.644	ft

PUMP HEAD hA= 137.644 ft

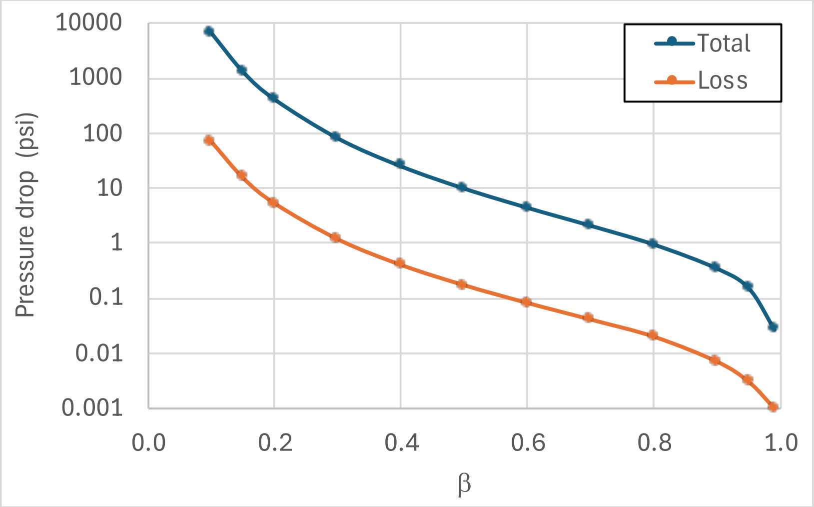
PUMP POWER P= 48484.69 lb x ft/s

P= 88.15 HP

%diff= 0.29%

MAKE A TABLE BY CHANGING β

β	Δp (psi)	$\Delta p_{acceleration}$ (psi)	Δp_{loss} (psi)
0.10	6463.045	6394.339	68.706
0.15	1277.766	1262.567	15.199
0.20	404.287	399.047	5.24
0.30	79.483	78.311	1.172
0.40	24.743	24.341	0.402
0.50	9.764	9.592	0.172
0.60	4.377	4.295	0.082
0.70	2.065	2.024	0.041
0.80	0.941	0.921	0.02
0.90	0.343	0.336	0.007
0.95	0.149	0.146	0.003
0.99	0.027	0.026	0.001



$\boxed{J}$

$$WP = 10ft + 12ft + 10ft + 2\left(\sqrt{4^2+4^2} + \sqrt{2^2+2^2}\right) ft$$

Note: for excel, the highlighted 2 ft will vary. Also 10 ft will disappear if the height of the water level is a total of 4 ft

$$WP = 48.97\ ft$$

$$R = \frac{148\ ft^2}{48.97\ ft} \rightarrow \boxed{R = 3.02\ ft}$$

$$Q = \frac{1.49}{0.05}(0.00015)^{1/2}(3.02ft)^{2/3}(148ft^2)$$

$$Q = 112.91\ ft^3/s$$

Now the percentage of pumped water:

$$\%Q_{pumped} = \frac{Q_{pump}}{Q} \times 100 = \frac{3.387\ ft^3/s}{112.91\ ft^3/s} \times 100$$

$$\boxed{\%Q_{pumped} = 2.99\%}$$

This is less than 5%, thus it is negligible.

See excel for automated calculations & plot

Open Channel Info

n= 0.05
S= 0.00015
L_lower trapezoid= 12 ft
H_lower trapezoid= 4 ft
L_upper trapezoid= 40 ft
H_total= 6 ft

Pipe Info

Ldisch= 2500 ft
Lsuct= 11 ft
ε= 1.50E-04 ft
z2= 50 ft
z1= 0 ft
z3=z4= 10 ft

Pump Info

Q= 3.387 ft3/s
η= 0.6

Fluid Info

ν= 1.21E-05 ft2/s
γ= 62.4 lb/ft3

Flowmeter Info

β= 0.5

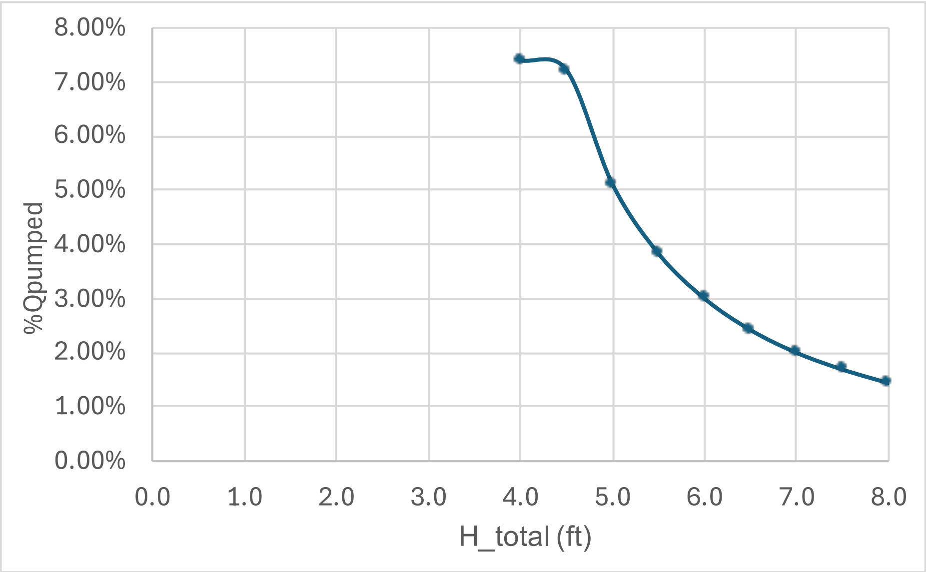
AREA A= 148.000 ft2
WETTED PERIMETER WP= 48.971 ft
HYDRAULIC RADIUS R= 3.022 ft

FLOW RATE Q= 112.912 ft3/s

%Qpumped= 3.00%

MAKE A TABLE BY CHANGING H_total

H_total (ft)	%Qpumped
4.00	7.40%
4.50	7.22%
5.00	5.11%
5.50	3.83%
6.00	3.00%
6.50	2.42%
7.00	2.00%
7.50	1.69%
8.00	1.44%



K

SUMMARY

To deliver water from the lower open channel to the higher open channel, at a rate of 3.387 ft^3/s, we will need a pump of **87.90** HP, assuming its efficiency is 60%. The pipe diameter for the system should be 8" Sch 40 steel pipe. The pressure at the inlet of the pump is -5.138 psi, and 54.335 psi at the outlet of the pump.

The pressure drop due to the nozzle flowmeter with size ratio of 0.5 will be 9.8 psi, and it will produce an increment in pump power of 0.29%

The amount of pumped water is negligible (~3%) of the total flow running through the lower open channel. The system will work fine.

ANALYSIS

The procedure on this test is exactly the procedure you will follow to start a pump selection. Note that the the energy losses head is larger than the elevation head. The energy losses got dramatically reduce when increasing the pipe diameter, and thus the pump power reduces to a point where the pump power is solely used to elevate the water. You might think that this is better, it is better to use larger pipes, but the problem is that larger pipes are more expensive.

L

With the same reasoning, the pressure at the outlet of the pump reduces because the energy losses reduce with increasing pipe diameter

The additions of a flow meter does not represent a considerable increase in pump power. And the pressure drop across the flow meter reduces with size ratio.

The pumped water flow is negligible with respect to the flow of water running through the lower open channel. And it keeps reducing as the total water level height increases.