Name: STEVEN BLEA.

MET 330 Fluid Mechanics
Dr. Orlando Ayala
Spring 2018
Test 3

Take home – Due Tuesday April 10th 2018 before class.

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. The other ninety (90) points will come from the problem solutions. FOR THE "OTHER" SYLLABUS STUDENTS: All hundred (100) points will come from the problem solutions. I will not require technical writing for this test. You could still do it following the attached rubric, however you are under no obligation to do so it as I will not grade it.

3. You will solve 5 problems, each worth the same amount of points. You will have to solve the very 1st problem. Then, solve 4 problems out of the other 5 problems. If you decide to solve them all, I will only grade the first 4 problems I find (in addition to the 1st one).

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.

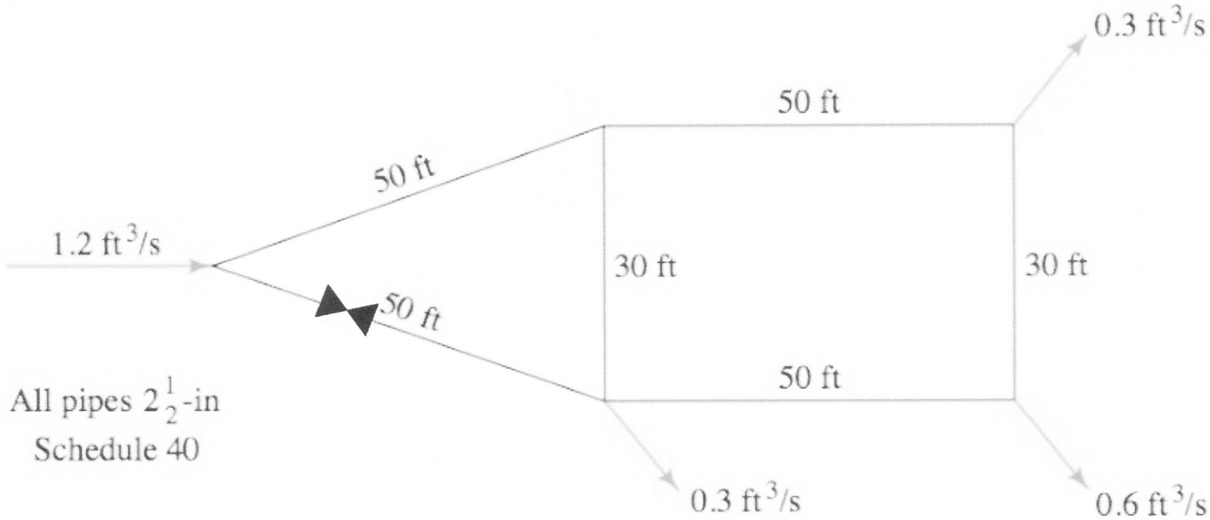
7. Do not start at the last minute so you can handle anything that could happen. Late tests will not be accepted. Test submitted through email will not be accepted either.

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:

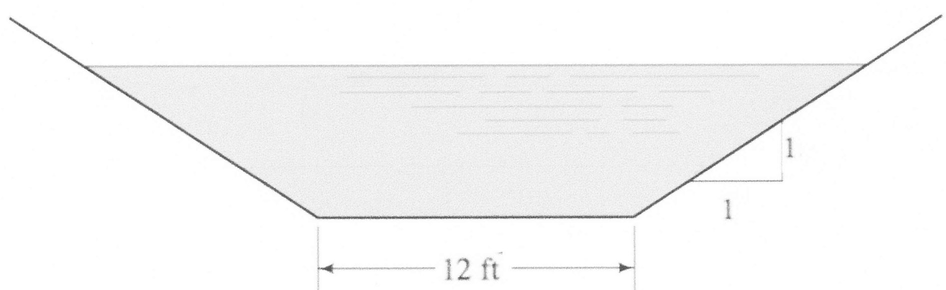
    IX. PROHIBITED CONDUCT
    A. Academic Integrity violations, including:
    1. *Cheating*: Using unauthorized assistance, materials, study aids, or other information in any academic exercise (Examples of cheating include, but are not limited to, the following: using unapproved resources or assistance 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. Find the flow rate of water at 60F in each pipe. Please note the valve shown is completely closed. Neglect the minor losses.



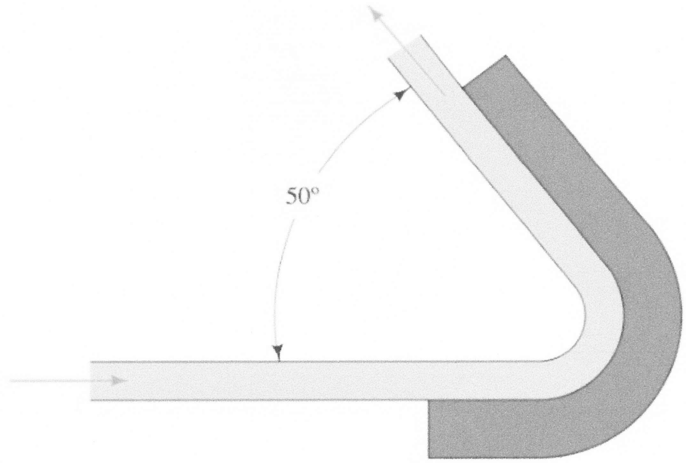
2. The channel shown has a Manning's n value of 0.04. If the average slope is 0.00015, determine the water depth when the flow rate is 34.7 ft^3/s.



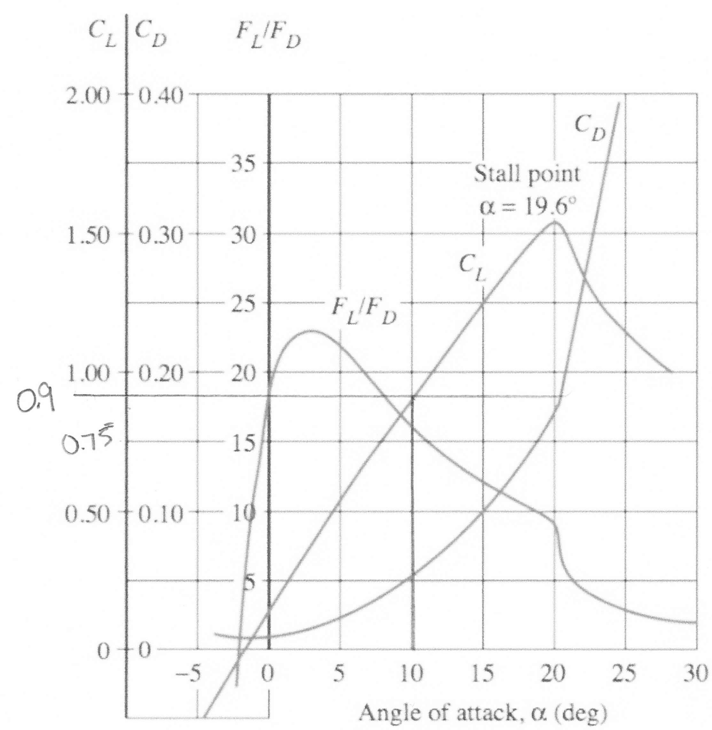
3. A 3.741-in flow nozzle is to be installed in a 4-in Type K copper tube carrying linseed oil at 77 F. The expected range of the flow rate is from 700 gpm to 1000 gpm. A mercury manometer is to be used to measure the pressure difference across the nozzle. What is the appropriate manometer scale range to be used?

4. At the end of a steel pipe ($E=2x10^7$ N/cm^2) of internal diameter 600 mm, and thickness δ=10mm, there is a valve. The water velocity in the pipe is 2.5 m/s and its compressibility module is E_o=2.03 x 10^5 N/cm^2. What would be the required minimum pipe thickness so the pipe does not fail after the pressure increment when the valve closes all of the sudden. The operating pressure before closing the valve is 600 psi. Does the pipe fail? For the pipe thickness, use the equation in the last section of chapter 11 in our book (make any appropriate assumption when using this equation).

5. What would be the water stream velocity if the horizontal force acting upon the stationary vane shown in the figure is 30.8 lbf? The water is at 180 F. The cross-sectional area of the stream is constant at 2.95 in^2 throughout the system. What is the vertical force?



6. An airplane moves at a speed of 200 km/h in the standard atmosphere at 200 m. The airfoil of the airplane is one with the performance characteristics shown in the figure, a chord length of 1.4 m and a span of 6.8 m. If the airplane weight is 19.875 kN, what should be the angle of attack of the airfoil? What is the minimum engine power to move the airplane for such angle of attack? Remember that the engine will be basically used to work againts the drag force and maintain the airplane velocity.

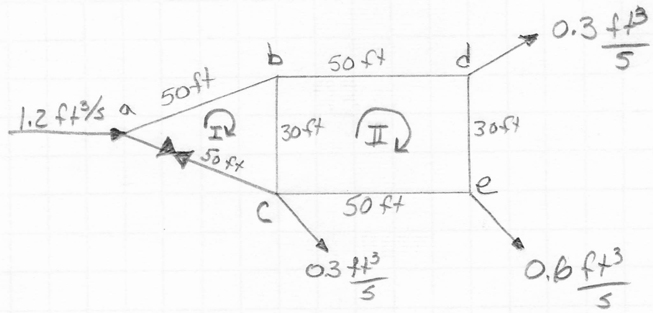


EXAM #3 | MET 330 | STEVEN BLEA | A

PROBLEM #1

PURPOSE: DETERMINE THE FLOW RATE OF WATER IN EACH PIPE OF THE SYSTEM.

DIAGRAM:



SOURCES: MOTT & UNTENER. APPLIED FLUID MECHANICS. 7^{th} ED. PEARSON 2015

DESIGN CONSIDERATIONS:

1) INCOMPRESSIBLE FLUIDS
2) ISOTHERMAL, $T = 60°F$
3) SYSTEM IS HORIZONTAL
4) NO MINOR LOSSES
5) FRICTION FACTOR DEPENDS ONLY ON ROUGHNESS
6) VALUE IS COMPLETELY CLOSED

DATA & VARIABLES:

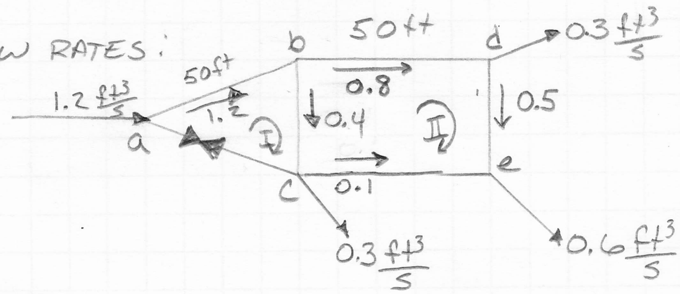
- PIPES ARE MADE OF 2½ SCHED 40 COMMERCIAL STEEL PIPE.

$\varepsilon = 4.92126 \times 10^{-6}$ ft $\quad D = 0.2058$ ft $\quad A = 0.03326\ ft^2$

Kinematic Viscosity (ν) = $1.21 \times 10^{-5}\ ft^2/s$

PROCEDURE: AN INITIAL ASSUMPTION OF FLOWS THROUGH EACH BRANCH NEEDS TO BE MADE FOR TRIAL #1. ONCE THE INITIAL FLOWS ARE INPUT, EACH TRIAL CAN THEN BE CONDUCTED UNTIL AN ACCEPTABLE PERCENT CHANGE IS ACHIEVED. USING AN EXCEL SPREADSHEET.

INITIAL FLOW RATES:



CALCULATIONS:

MY SPREADSHEET WAS CREATED USING THE FOLLOWING EQUATIONS:

$$N_R = \frac{QD}{A\nu} \quad ; \quad h = KQ^2 \quad ; \quad K = \frac{fL}{D2gA^2} \quad ; \quad f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{(N_R)^{0.9}}\right)\right]^2}$$

B

Kinematic Viscosity=	0.00000121 ft2/s

Circuit I						
	L (ft)	Le (ft)	D (ft)	e (ft)	e/D	Q_initial (ft^3/s)
a-b	50	0	0.2058	4.92126E-06	2.39E-05	1.20
b-c	30	0	0.2058	4.92126E-06	2.39E-05	0.40

Circuit II						
	L (ft)	Le (ft)	D (ft)	e (ft)	e/D	Q_initial (ft^3/s)
b-d	50	0	0.2058	4.92126E-06	2.39E-05	0.80
b-c	30	0	0.2058	4.92126E-06	2.39E-05	-0.40
c-e	50	0	0.2058	4.92126E-06	2.39E-05	-0.10
d-e	30	0	0.2058	4.92126E-06	2.39E-05	0.50

TRIAL 1

Circuit I								
	Q (ft3/s)	Re	f	k	h=kQ^2	2kQ	deltaQ	%change
a-b	1.20	6135650.65	0.010155978	113.654	163.6623	272.7705		44.00%
b-c	0.40	2045216.88	0.011156974	74.914	11.986214	59.9311		131.99%
					175.64851	332.7016	0.527946	

Circuit II								
	Q (ft3/s)	Re	f	k	h=kQ^2	2kQ	deltaQ	%change
b-d	0.80	4090433.77	0.010456693	117.020	74.8926	187.2314		28.43%
b-c	-0.40	2045216.88	0.011156974	74.914	-11.9862	59.9311		56.87%
c-e	-0.10	511304.221	0.01341795	150.159	-1.5016	30.0317		227.47%
d-e	0.50	2556521.1	0.010903703	73.213	18.3033	73.2132		45.49%
					79.7081	350.4075	0.227473	

TRIAL 2

Circuit I								
	Q (ft3/s)	Re	f	k	h=kQ^2	2kQ	deltaQ	%change
a-b	1.2000	124332375	0.009353126	104.670	150.72443	251.2074		44.27%
b-c	0.6275	59179738.5	0.009417899	63.237	24.897692	79.3587		84.67%
					175.62213	330.5661	0.531277	

Circuit II								
	Q (ft3/s)	Re	f	k	h=kQ^2	2kQ	deltaQ	%change
b-d	0.57	57613828.7	0.009421094	105.430	34.5588	120.7236		1.69%
b-c	-0.63	59179738.5	0.009417899	63.237	-24.8977	79.3587		1.54%
c-e	-0.33	25681089.8	0.009559689	106.981	-11.4725	70.0669		2.96%
d-e	0.27	26300320.1	0.00955417	64.152	4.7646	34.9662		3.55%
					2.9532	305.1154	0.009679	

TRIAL 3

Circuit I								
	Q (ft3/s)	Re	f	k	h=kQ^2	2kQ	deltaQ	%change
a-b	1.2000	135004801	0.009348177	104.614	150.64468	251.0745		44.31%
b-c	0.6372	71189096	0.009397751	63.101	25.61681	80.4104		83.45%
					176.26149	331.4849	0.531733	

Circuit II								
	Q (ft3/s)	Re	f	k	h=kQ^2	2kQ	deltaQ	%change
b-d	0.56	62865861.7	0.009410959	105.317	33.3642	118.5550		0.06%
b-c	-0.64	71189096	0.009397751	63.101	-25.6168	80.4104		0.05%
c-e	-0.34	37111300.3	0.00948515	106.147	-12.0659	71.5754		0.10%
d-e	0.26	28949240.6	0.009532974	64.009	4.4224	33.6496		0.13%
					0.1039	304.1903	0.000342	

EXAM #3 | MET 330 | STEVEN BLEA | C

SUMMARY: FINAL FLOW RATES ARE AS FOLLOWS:

CIRCUIT I

$a-b = 1.2 \frac{ft^3}{s}$

$a-c = 0.0 \frac{ft^3}{s}$

$b-c = 0.64 \frac{ft^3}{s}$

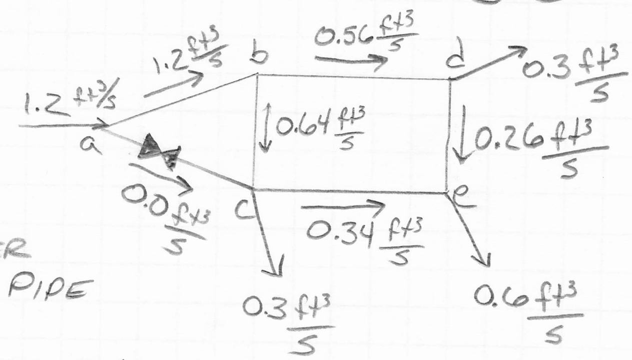
CIRCUIT II

$b-d = 0.56 \frac{ft^3}{s}$

$b-c = -0.64 \frac{ft^3}{s}$

$c-e = -0.34 \frac{ft^3}{s}$

$d-e = 0.26 \frac{ft^3}{s}$



MATERIALS: • WATER
• STEEL PIPE

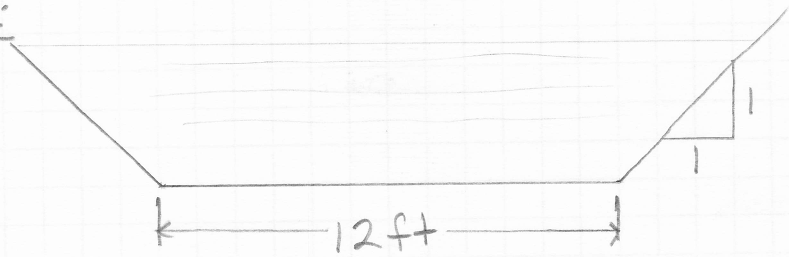
ANALYSIS: WHEN EXAMINING THE RESULTS IT CAN BE SEEN THAT THE LAW OF NODES CAN BE VERIFIED. ALL PIPE FLOW OUTPUTS EQUAL FLOW INPUT.

EXAM #3	MET 330	STEVEN BLEA	D

PROBLEM #2:

PURPOSE: DETERMINE WATER DEPTH WHEN THE FLOW RATE IN THE SYSTEM IS $34.7\ \frac{ft^3}{s}$

DIAGRAM:



SOURCES: MOTT & UNTENER APPLIED FLUID MECHANICS. 7th ED. PEARSON 2015

DESIGN CONSIDERATIONS:
1) INCOMPRESSIBLE FLUID
2) OPEN CHANNEL FLOW (TRAPEZOID)

DATA & VARIABLES:
1) MANNINGS n VALUE IS 0.04
2) AVERAGE SLOPE 0.00015
3) FLOW RATE IS $34.7\ \frac{ft^3}{s}$
4) BASE IS 12 ft

MATERIALS:
- WATER
- OPEN CHANNEL

PROCEDURE: SINCE WE KNOW $Q = 34.7\ \frac{ft^3}{s}$, WE WILL NEED TO WORK BACKWARDS FROM Q TO FIND THE AREA, WETTED PERIMETER, AND HYDRAULIC RADIUS. WE CAN USE EQUATIONS FOR OPEN-CHANNEL SECTIONS SHOWN BELOW:

CALCULATIONS:

$$A = (b+zy)y \quad ; \quad WP = b + 2y\sqrt{1+z^2} \quad ; \quad R = \frac{(b+zy)y}{b+2y\sqrt{1+z^2}}$$

$$A = Wy + Xy$$

$$Q = \left(\frac{1.49}{n}\right) A R^{2/3} S^{1/2} = 34.7\ \frac{ft^3}{s}$$

$$34.7\ \frac{ft^3}{s} = \left(\frac{1.49}{0.04}\right) A R^{2/3} (0.00015)^{1/2} \Rightarrow AR^{2/3} = 76.0602$$

$$A = 12y + y^2 \qquad WP = 12 + 2y\sqrt{1+1^2} \qquad R = \frac{12y + y^2}{12 + 2y\sqrt{1+1^2}} = \frac{A}{WP}$$

PROBLEM #2, PROCEDURE & CALCULATIONS CONT'D

SINCE WE CANNOT SOLVE FOR Y EASILY, WE WILL HAVE TO SOLVE USING MULTIPLE TRIALS.

DEPTH (Y) ft	WETTED PERIMETER (WP), ft	AREA (A) ft^2	HYDRAULIC RADIUS (R) ft	$R^{2/3}$	$AR^{2/3}$	COMPARE TO 76.06
2	17.657	28	1.586	1.3597	38.076	LOW
4	23.314	64	2.745	1.9606	125.476	HIGH
3.2	21.05	48.64	2.31	1.748	85.01	HIGH
3.1	20.768	46.81	2.254	1.719	80.47	HIGH
3.0	20.485	45	2.197	1.69	76.05	GOOD

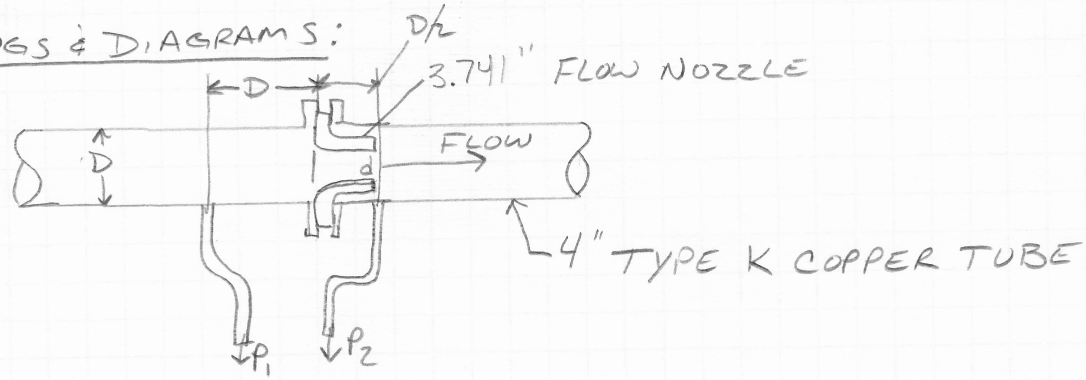
SUMMARY: THE DEPTH OF AN OPEN CHANNEL TRAPEZOID WITH A FLOW RATE OF 34.7 $\frac{ft^3}{s}$ IS **3 ft**

ANALYSIS: BY USING A TRIAL AND ERROR METHOD, WE WERE ABLE TO SOLVE FOR AN UNKNOWN DEPTH OF THE CHANNEL. THIS COULD ALSO BE EASILY DONE USING AN EXCEL SPREAD SHEET TO QUICKLY SOLVE EACH FORMULA.

PROBLEM #3:

PURPOSE: DETERMINE THE APPROPRIATE MANOMETER SCALE RANGE FOR THE DESCRIBED SYSTEM.

DRAWINGS & DIAGRAMS:



SOURCES: MOTT & UNTENER. APPLIED FLUID MECHANICS 7th ED. PEARSON 2015

DESIGN CONSIDERATIONS:

1) INCOMPRESSIBLE FLUIDS
2) ISOTHERMAL @ 77°F
3) SYSTEM IS HORIZONTAL
3) NO MINOR LOSSES

DATA & VARIABLES:

- PIPE IS 4-in TYPE K COPPER $D_1 = 3.857''$ (0.3214 ft)

  $A_1 = 8.114 \times 10^{-2}\ ft^2 = (0.08114\ ft^2)$

- NOZZLE THROAT DIAMETER: $d_1 = 3.741''$ (0.31175 ft)
- NOZZLE AREA: $A_2 = 0.076\ ft^2$
- LINSEED OIL FROM TABLE B.2 @ 77°F IS 58.00 lb/ft³
- Kinematic Viscosity $(\nu) = 0.000384\ ft^2/s$

- RANGE OF FLOW RATE: $Q_{min} = 700\ gpm = 1.559\ ft^3/s$

  $Q_{max} = 1000\ gpm = 2.227\ ft^3/s$

- PIPE VELOCITIES: $V_{min} = \dfrac{Q_{min}}{A_1} = \dfrac{1.559\ ft^3/s}{0.08114\ ft^2} = 19.21\ ft/s$

  $V_{max} = \dfrac{Q_{max}}{A_1} = \dfrac{2.227\ ft^3/s}{0.08114\ ft^2} = 27.45\ ft/s$

C = NOZZLE DISCHARGE COEFFICIENT

MATERIALS:

- MERCURY MANOMETER
- LINSEED OIL
- TYPE K COPPER TUBING
- FLOW NOZZLE

PROCEDURE & CALCULATIONS: FIRST WE WILL FIND THE REYNOLDS NUMBER AT THE MINIMUM AND MAXIMUM FLOW RATES. THIS WILL ALLOW ME TO USE FIGURE 15.5 TO FIND THE NOZZLE DISCHARGE COEFFICIENT. USING THE NOZZLE COEFFICIENTS I CAN THEN REARRANGE EQUATION 15-6 TO SOLVE FOR h (height of manometer needed).

$$N_{R_{min}} = \frac{v_{min} D}{\nu} = \frac{19.21\ ft/s \cdot 0.3214\ ft}{0.000384\ ft^2/s} = 16078.37$$

$$C_{min} = 0.958$$

$$N_{R_{MAX}} = \frac{v_{max} D}{\nu} = \frac{27.45\ ft/s \cdot 0.3214\ ft}{0.000384\ ft^2/s} = 22975.08$$

$$C_{MAX} = 0.965$$

NOW WE CAN USE EQ 15-6 TO FIND h:

$$v_{max} = C_{MAX}\sqrt{\frac{2gh[(\gamma_m/\gamma_f)-1]}{(A_1/A_2)^2-1}}$$

$v_{max} = 27.45\ ft/s$
$C_{MAX} = 0.965$
$g = 32.2\ ft/s^2$
$\gamma_m = 844.9\ lb/ft^3$
$\gamma_f = 58.00\ lb/ft^3$
$A_1 = 0.08114\ ft^2$
$A_2 = 0.076\ ft^2$
h = unknown

SUBSTITUTE KNOWN VALUES:

$$27.45 = 0.965\sqrt{\frac{2(32.2)h[(844.9/58.00)-1]}{(0.08114/0.076)^2-1}}$$

$$(28.4456) = \left[\sqrt{\frac{64.4(h)(13.5672)}{0.139837}}\right]^2$$

$$809.1522 = \frac{873.72768h}{0.139837}$$

$$\boxed{h = 0.1295\ ft = 1.55\ \text{INCHES}}$$

SUMMARY: THE APPROPRIATE MANOMETER RANGE WOULD NEED TO BE 0 TO 1.55 INCHES.

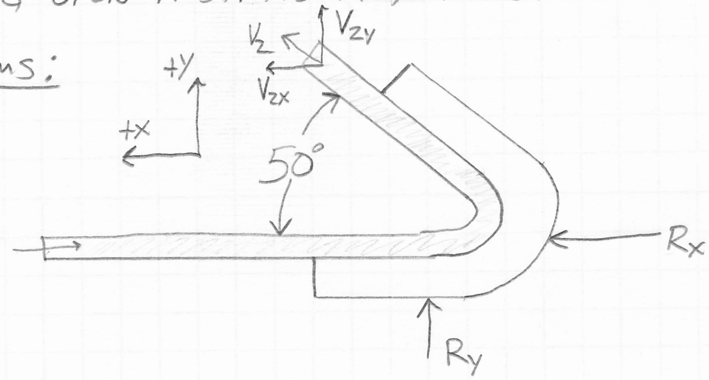
ANALYSIS: A MANOMETER OF SLIGHTLY MORE THAN 1.55 INCHES WOULD LIKELY BE A BETTER CHOICE. A Ø TO 2 OR 3 INCHES RANGE WOULD BE BETTER TO ALLOW FOR READINGS IF THE FLOW RATES WENT ABOVE 1000 gpm. ADDITIONALLY YOU WOULD WANT TO SELECT A MANOMETER THAT WOULD BE IN THE MIDDLE OF ITS RANGE.

EXAM #3 | MET 330 | STEVEN BLEA | H

PROBLEM #5

PURPOSE: DETERMINE WATER STREAM VELOCITY AND VERTICAL FORCE ACTING UPON A STATIONARY VANE.

DRAWINGS & DIAGRAMS:



SOURCES: MOTT & UNTENER. APPLIED FLUID MECHANICS 7th ED. PEARSON 2015

DESIGN CONSIDERATIONS:
1) INCOMPRESSIBLE FLUID
2) ISOTHERMAL @ 180° F
3) SYSTEM IS HORIZONTAL
4) VELOCITY IN IS SAME AS VELOCITY OUT
5) VANE IS STATIONARY

DATA & VARIABLES:

- $R_x = 30.8$ lbf, WATER TEMP IS 180°F
- DEFLECTION ANGLE = 180° − 50° = 130°
- WATER DENSITY (ρ) @ 180°F IS 1.883 $\frac{slugs}{ft^3}$
- AREA (A) = 2.95 in^2 = 0.020 ft^2

PROCEDURE: SINCE WE KNOW THE HORIZONTAL FORCE, WE CAN USE THAT INFORMATION ALONG WITH EQUATION 16-8 TO SOLVE FOR VELOCITY OF THE WATER STREAM.

CALCULATIONS:

Eq. 16-5: $R_x = \rho Q \Delta V_x = \rho Q (V_{2x} - V_{1x})$

$R_x = \rho (AV) V (\cos 50° + 1)$

$R_x = 30.8$ lbf
$\rho = 1.883$ slugs/ft^3
$V_2 = V_1$

$30.8 \text{ lbf} = \left(1.883 \frac{slugs}{ft^3}\right) \cdot 0.020 V_1 \cdot V_1 (\cos 50° + 1)$

$Q = AV = 0.020\, V \frac{ft^3}{s}$

$30.8 = 0.06187\, V_1^2 \implies V_1^2 = 497.839$

$$\boxed{V_1 = 22.31 \frac{ft^2}{s} = V_2}$$

FLOW RATE CAN NOW BE FOUND:

$Q = AV_1 = 0.020\, ft^2 \left(22.31 \frac{ft^2}{s}\right) = 0.446 \frac{ft^3}{s}$

PROCEDURE & CALCULATIONS CONT'D:

NOW THAT WE HAVE THE FLOW RATE $Q = 0.446 \frac{ft^3}{s}$ AND VELOCITY $V_1 = 22.31 \frac{ft^2}{s}$, WE CAN FIND THE FORCE IN THE y-DIRECTION

USING : $R_y = \rho Q (V_2 \sin 50° - 0)$

$\rho = 1.883$ slugs/ft^3

$Q = 0.446 \frac{ft^3}{s}$

$V_2 = 22.31 \frac{ft^2}{s}$

$$R_y = 1.883 (0.446)(22.31 \cdot \sin 50°)$$

$$\boxed{R_y = 14.35 \text{ lb}}$$

SUMMARY: THE VELOCITY OF THE WATER STREAM IS $22.31 \frac{ft^2}{s}$, WITH A HORIZONTAL FORCE OF 30.8 lbf
THE VERTICAL FORCE WAS DETERMINED TO BE 14.35 lbf

MATERIALS:
- WATER STREAM
- STATIONARY VANE

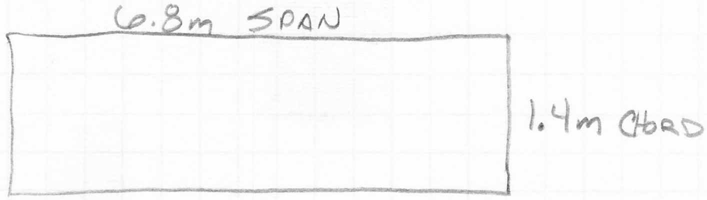
ANALYSIS: BY MANIPULATING EQ. 16-5 AND PUTTING IT INTO TERMS WERE ONLY ONE VARIABLE (V_1) WAS NEEDED WE WERE EASILY ABLE TO SOLVE FOR THE UNKNOWN VELOCITIES. USING THE VELOCITIES WE WERE THEN ABLE TO USE THE EQUATION FOR FORCE IN THE y-DIRECTION.

EXAM #3 | MET 330 | STEVEN BLEA | J

PROBLEM #6

PURPOSE: DETERMINE THE ANGLE OF ATTACK AND MINIMUM ENGINE POWER TO MOVE THE AIRPLANE FOR THAT ANGLE OF ATTACK.

DRAWINGS:



SOURCES: MOTT & UNTENER APPLIED FLUID MECHANICS, 7TH ED PEARSON 2015

DESIGN CONSIDERATIONS:
- STANDARD ATMOSPHERE @ 200m
- CONSTANT AIRSPEED OF 200 Km/h
- CONSTANT WEIGHT OF 19.875 KN
- ENGINE WILL WORK AGAINST DRAG FORCE & MAINTAIN VELOCITY

DATA & VARIABLES:
- VELOCITY $(V) = 200 \frac{Km}{h} = 55.56 \frac{m}{s}$
- CHORD LENGTH IS $C = 1.4m$
- SPAN OF AIRFOIL IS $b = 6.8m$
- DENSITY OF ATMOSPHERE @ 200 m IS $\rho = 1.202 \frac{kg}{m^3}$
- LIFT FORCE F_L IS 15.875 KN
- AREA OF AIRFOIL IS $Cb = 1.4m \times 6.8m = 9.52m^2$

PROCEDURE & CALCULATIONS: SINCE WE HAVE THE WEIGHT OF THE AIRPLANE (F_L), WE CAN USE EQ. 17-10 FOR LIFT FORCE TO SOLVE FOR LIFT COEFFICIENT (C_L). WE CAN USE C_L TO FIND THE ANGLE OF ATTACK, THIS SAME ANGLE OF ATTACK WILL ALLOW US TO FIND THE DRAG COEFFICIENT AND DRAG FORCE (EQ 17-14)

$$F_L = C_L\left(\frac{\rho V^2}{2}\right)A \Rightarrow \frac{F_L}{A\left(\frac{\rho V^2}{2}\right)} = C_L \Rightarrow C_L = \frac{15{,}875\ N}{(9.52m^2)(1.202)(55.56)^2(0.5)}$$

$$C_L = 0.8988 = 0.9$$

ACCORDING TO THE PERFORMANCE CHAR. OF AIR FOIL THE ANGLE OF ATTACK FOR C_L VALUE OF 0.9 IS $\boxed{\alpha \approx 10\,deg}$

PROBLEM #6, CONT'D

AT AN ANGLE OF ATTACK $\alpha = 10$ deg THE COEFFICENT OF DRAG IS ABOUT 0.055 ON THE C_D SLOPE.

USING THE VALUE OF C_D FOUND FROM THE CHART, WE CAN CALCULATE THE DRAG FORCE WHICH IS THE MINIMUM ENGINE POWER TO MOVE THE AIRPLANE.

EQ 17-14 ; $F_D = C_D(\rho V^2/2)A$

$C_D = 0.055$

$\rho = 1.202\ kg/m^3$

$V = 55.56\ m/s$

$A = 9.52\ m^2$

$F_D = 0.055(1.202)(55.56)^2(0.5)(9.52)$

$\boxed{F_D = 971.4\ N}$

SUMMARY: THE ANGLE OF ATTACK SHOULD BE APPROX 10 degrees. THE MINIMUM ENGINE POWER WOULD NEED TO BE 971.4 N TO OVER COME DRAG FORCES AND MAINTAIN A VELOCITY OF 200 $\frac{km}{h}$

MATERIALS:
- AIRPLANE
- ATMOSPHERE @ 200 m

ANALYSIS: ACCORDING TO THE AIR FOIL CHARACTERISTICS THE ANGLE OF ATTACK COULD BE INCREASED TO BETWEEN 15 and 19 degrees WHICH WOULD PROVIDE MUCH MORE LIFT WHILE THE DRAG COEFFICIENT CURVE STAYS RELATIVELY LOW. THE OPTIMUM ANGLE OF ATTACK SEEMS TO BE AROUND 15 degrees.