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Exam 1

CM3110 Spring

Thursday 21 January 2021

Name:

Rules:

- Closed book, closed notes.
- Two-page 8.5” by 11” study sheet allowed, double sided; you may use a calculator; you may not search the internet or receive help from anyone.
- Please text clarification questions to Dr. Morrison 906-487-9703. I will respond if I am able.
- All work submitted for the exam must be your own.
- Do not discuss the contents of the exam with anyone before 11:59pm Thursday, 21 January 2021.
- *Please copy the following Honors Pledge onto the first page of your exam submission and sign and date your agreement to it.*

Honor’s Pledge:

On my honor, I agree to abide by the rules stated on the exam sheet.

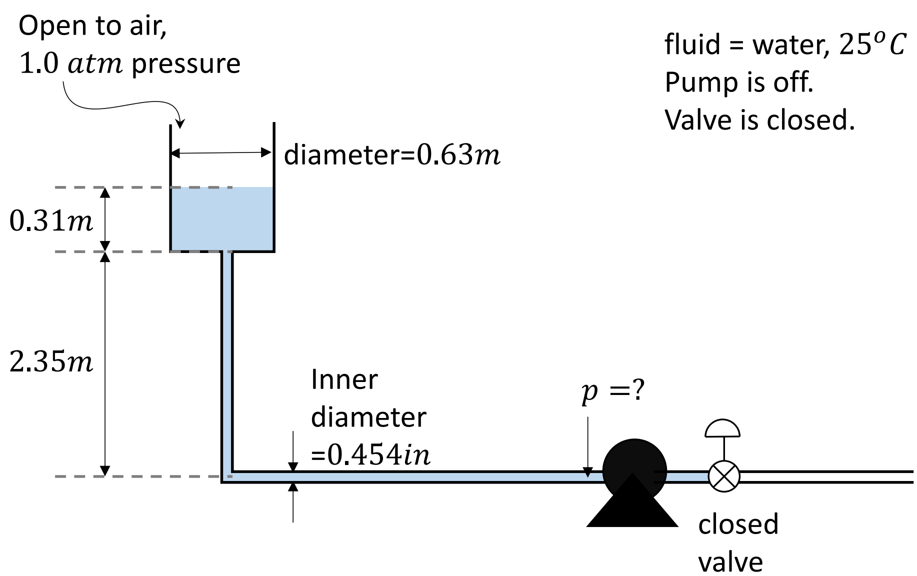
Signature ________________________________

Date _____________________

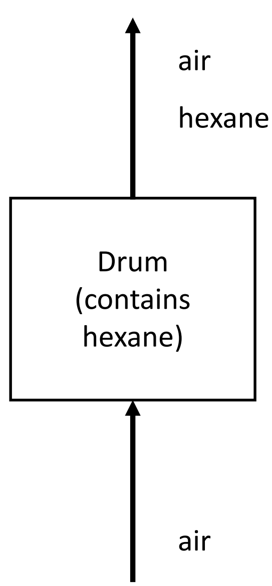
Exam Instructions:

i. You may work on the exam for up to two hours and 15 minutes (135 minutes).
ii. Please submit your exam work within 135 minutes of downloading the exam.
iii. Please be neat. Only neat answers will be granted partial credit. Please use a dark pencil or pen so that your work is readable once scanned.
iv. Significant figures always count.
v. Please box your final answers.
vi. Submit your work as a single PDF file; put your name on every page. (Genius Scan is a free app that can create a PDF from photos taken by your phone)
vii. Submit your exam study sheet as a separate PDF file; put your name on the first page (at a minimum)

1. (20 points) What is the absolute pressure in the fluid at the point p indicated in the figure below (just upstream of the pump)? The pump is <u>off</u>, and the fluid (water, 25^oC) is not moving. Give your answer in Pa.

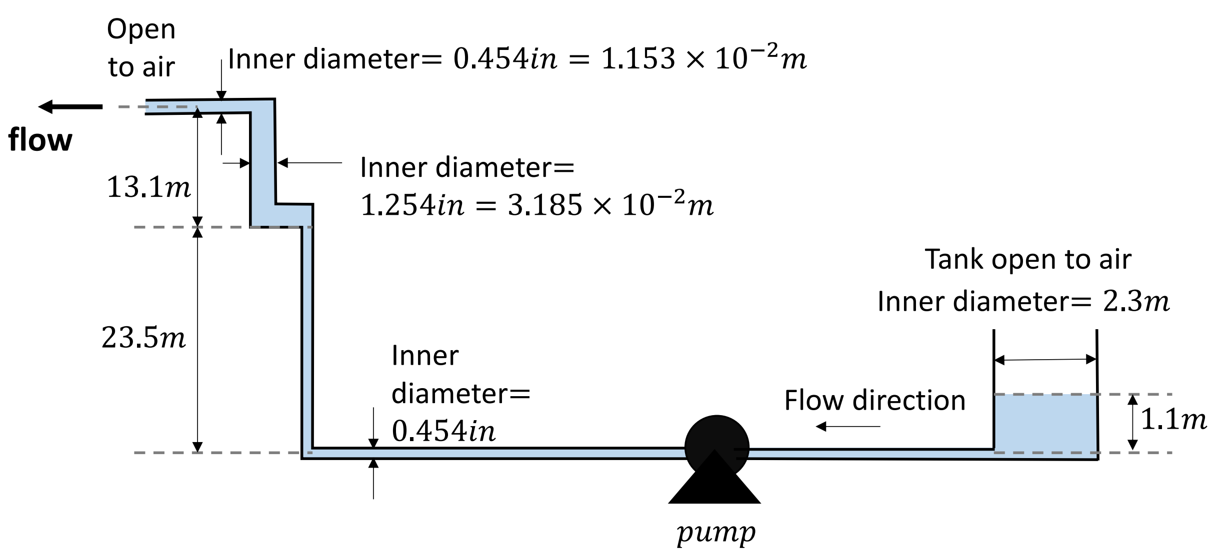


2. (20 points) Air is bubbled through a drum of liquid hexane (density $= 0.659\ g/cm^3$, molecular weight $86.17\ g/mol$) at a rate of $0.105\ kmol/min$. The gas stream leaving the drum contains 0.090 mole fraction hexane and the rest is air. Air is insoluble in hexane. How long will it take to vaporize $8.0\ m^3$ of the liquid hexane? Give your answer in minutes.



3. (20 points) Carry out the following calculations. The quantities x, y, and z are the position variables of a cartesian coordinate system.
   a. $\frac{\partial}{\partial x}(3x^4 + 2x) =$
   b. $\frac{\partial}{\partial z}\left(\frac{4xz}{y}\right) =$
   c. $(1 \quad 0 \quad 2x)_{xyz} \cdot \begin{pmatrix} 3x \\ 1 \\ 1 \end{pmatrix}_{xyz} =$
   d. $(1 \quad 0 \quad 2x)_{xyz} \cdot \begin{pmatrix} 1 & 0 & x \\ 1 & -1 & 3x \\ x & 0 & 1 \end{pmatrix}_{xyz} =$

4. (20 points) Water (25^oC) flows at 4.5 gpm (gpm is gallons per minute) in the pumping/piping system shown below. Answer the following questions:
   a. What is the average fluid velocity at the exit of the pipe? Give your answer in m/s.
   b. With friction neglected, what is the required shaft work of the pump needed to maintain this flow? Give your answer in Watts.



fluid = water, 25^oC

5. (20 points) For the flow shown below we can calculate the volumetric flow rate Q by carrying out the double integral shown below (xyz coordinate system). Calculate Q by carrying out this integral, showing your steps. If you use a calculator to perform any steps, explain what you did.

$$\underline{v} = \begin{pmatrix} v_x \\ v_y \\ v_z \end{pmatrix}_{xyz} = \begin{pmatrix} v_x(y) \\ 0 \\ 0 \end{pmatrix}_{xyz}$$

$$v_x(y) = \left(\frac{P_L - P_0}{2\mu L}\right)(y^2 - Hy) + \frac{V}{H}y$$

$$Q = \int_{-W}^{0}\int_{0}^{H} v_x(y)\, dydz$$

where the following are <u>constants</u>:

P_L, P_0 = downstream and upstream pressures, respectively
μ = viscosity
L = length of slit
H = height of slit
W = width of slit
V = velocity of the top plate of the slit