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Exam 2

CM3110

Tuesday 20 October 2020

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 10pm Tuesday 19 October 2020.
- *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.

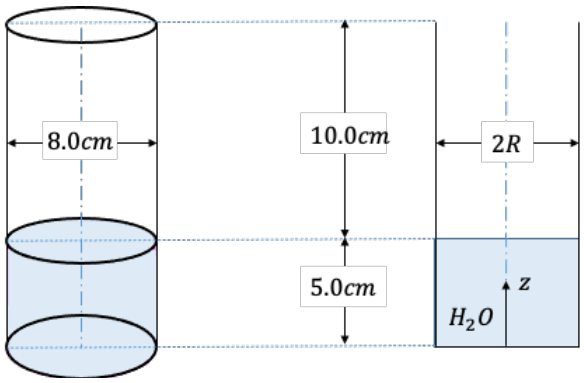
Signature _____

Date _____

Exam Instructions:

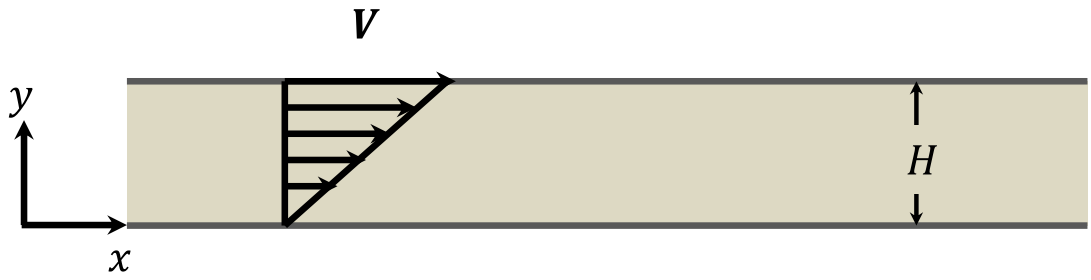
i. You may work on the exam for up to two hours (120 minutes).
ii. Please be neat. Only neat answers will be granted partial credit. Please use a dark pencil or pen so that your work is readable once scanned.
iii. Significant figures always count.
iv. Please box your final answers.
v. Submit your work 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)
vi. 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 gauge pressure at the bottom of the vessel shown below? The fluid is room temperature water and the container is open to air.



2. (20 points) What are the problem-solving steps you would follow to calculate the velocity field for flow of a Newtonian incompressible fluid in a chosen flow scenario? (Hint: step one is to sketch the problem)

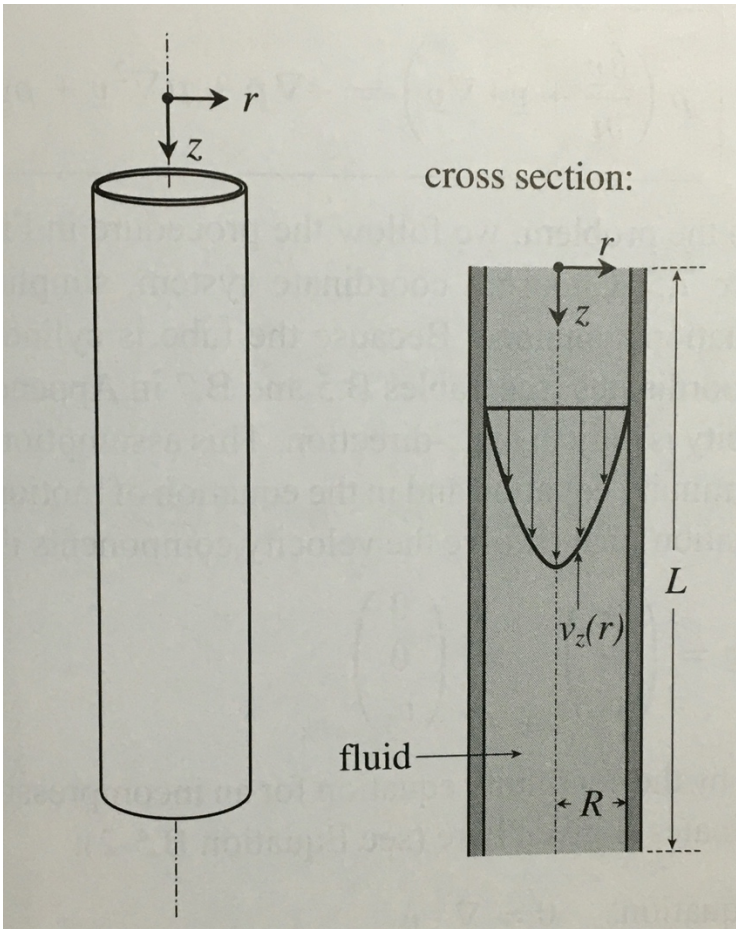
3. (20 points)
   a. In your own words, what is the definition of viscosity?
   b. Consider two fluids with the following properties:
      Fluid 1: density $= 1.23\ g/cm^3$; viscosity$= 0.923\ centipoise$
      Fluid 2: density $= 13.6\ g/cm^3$; viscosity$= 0.923\ centipoise$
      Which of these two fluids generates more shear stress in drag flow (Newton's experiment, shown here)? Justify your answer with calculations or a sentence.



4. (20 points) An incompressible, Newtonian fluid (viscosity μ) flows downward in a long circular tube of length L and radius R as shown schematically in the figure below. The flow is steady. If we neglect the effect of gravity, we can show that the velocity profile is given by

$$v_z(r) = \frac{(p_0 - p_L)R^2}{4\mu L}\left[1 - \frac{r^2}{R^2}\right]$$

   a. What is the flow rate Q through the tube? Show how you arrive at your answer beginning with the velocity profile above.
   b. What is the average velocity through the tube $\langle v_z \rangle$?



5. (20 points) Calculate the velocity profile for the flow shown below. The flow is steady flow of an incompressible, Newtonian fluid between two long, wide plates. The flow is partially driven forward by the motion of the top plate (the top plate moves in the x-direction at speed V), and the flow is also assisted by a driving pressure, which is slightly higher at the entrance (left side), P_0, than at the exit, P_L (right side). The entrance and exit are separated by a distance L. You may neglect the effect of gravity. Show your work and indicate your assumptions. Use the coordinate system given in the sketch.