ROSE-HULMAN Institute of Technology
Sophomore Engineering Curriculum

ES201 –Conservation & Accounting Principles | Winter 2015-2016

Section: □ 01 (1st period)
□ 02 (2nd period)

Name ____________________

CM ____________________

Exam 1

Dec 18, 2015

Problem 1	______/ 30
Problem 2	______/ 35
Problem 3	______/ 35
Total	______/ 100

Rules:

- Closed book/notes exam. (Unit conversion page provided)
- Help sheet allowed. (8-1/2 x 11" sheet of paper, one side, handwritten)
- Laptops may be used for computational purposes only; no pre-prepared worksheets or files may be used.

Instructions:

- Show all work for complete credit.
- Start all problems at the **analysis** stage, but clearly label any information you use for your solution.

Fail bomb!

Problems involving conservation principles **must clearly identify the system in a separate drawing and show a clear, logical progression from the basic principle; otherwise no credit will be given.**

- Don't expect us to read your mind as to how or why you did something in the solution. Clearly indicate how you arrived at your answer.
- **Always crunch numbers last on an exam**. The final numerical answer is worth the least amount of points. (Especially if all I would have to do is plug in the numbers into a well-documented solution.)

Problem 1 [30 pts]

(a) [4 pts] Which of the following equations are correct? (Circle all that apply.)

- o $P = \frac{1}{\rho} RT$
- o $P = \rho RT$
- o $P\forall = NR_u T$
- o $P\forall = mR_u T$

(b) [15 pts, 3 pts each]

True False The definition of a steady-state system is one for which $dm_{sys}/dt = 0$.

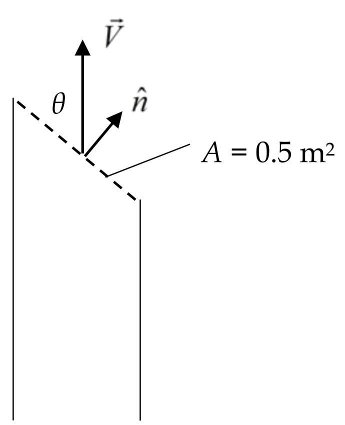
True False If a system is at steady-state then $dm_{sys}/dt = 0$.

True False In a closed system, $dm_{sys}/dt = 0$.

True False A **conserved property**, B, is one for which, $dB_{sys}/dt = 0$.

True False The **accounting principle** can be applied to extensive properties only.

(c) [6 pts] Calculate the volume flow rate exiting from the area marked A in the accompanying figure. The magnitude of $\vec{V}$ is 5 m/s and the area is $A = 0.5$ m². The value of the angle is $\theta = 60°$.

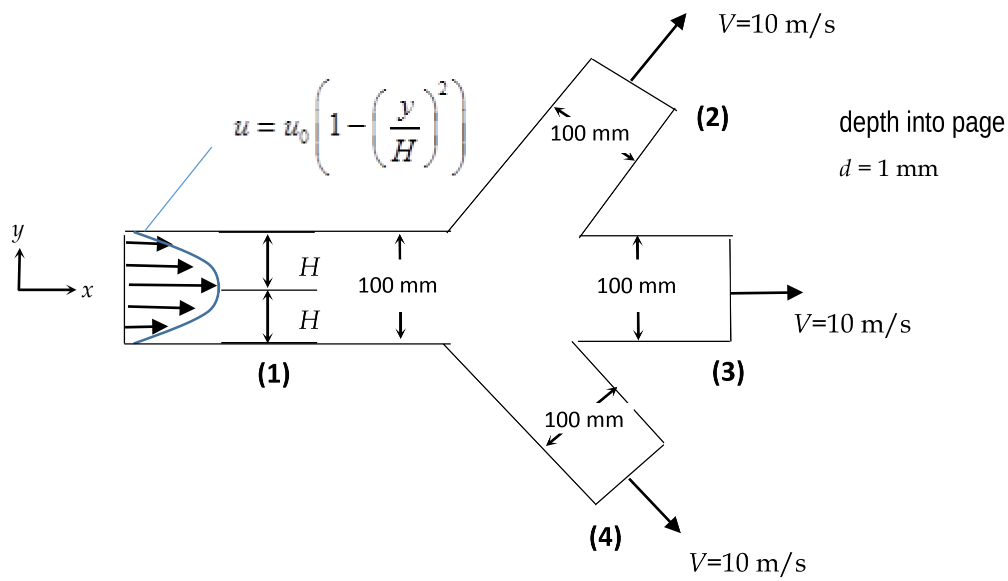


(d) [5 pts] A piston-cylinder arrangement contains air at P = 101 kPa, $\forall$ = 0.2 m^3, and T_1 = 300 K. Calculate the mass of the gas. You may assume air to be an ideal gas with R = 0.287 kJ/[kg·K].

Problem 2 [35 pts]

Consider steady flow of water (density 1000 kg/m³) through a channel of double wye construction as shown in the figure below. The velocity profile at section 1 (inlet) is shown below, where y is measured from the central plane. The depth into the plane of the paper is d = 1 mm. The height of the channel, $2H$, is 100 mm for all sections. The velocity profiles at (2), (3) and (4) are each uniform at a value of V = 10 m/s.

(a) Find the mass flow rate at the inlet, $\dot{m}_1$, in kg/s.
(b) Find the value of u_0, in m/s.



Problem 33 [35 pts]

A Rose student is using a hair dryer to inflate an air mattress. The dryer supplies a constant volumetric flowrate of $\dot{\forall}_1 = 0.040$ m³/s to the mattress. Because of the high temperature, the density of the air entering is lower than normal with a value $\rho_1 = 1.078$ kg/m³. Unbeknownst the student, a leak has developed and air leaves the mattress at point (2) with a density of $\rho_2 = 1.168$ kg/m³. Other parameters, including the volume of the mattress, are shown in the figure.

(a) Find the value of the <u>volumetric flow rate</u> of the air leaving at (2), $\dot{\forall}_2$, that would be required to keep the mattress at <u>steady-state</u>.

(b) As it turns out the mattress is not a steady-state and the actual volumetric flowrate leaving the mattress is $\dot{\forall}_2 = 0.015$ m³/s. Assuming that the volume of the mattress remains constant, find the <u>time rate of change of the density of the air inside the mattress</u>, $d\rho_{air,mat}/dt$.