ROSE-HULMAN Institute of Technology
Sophomore Engineering Curriculum

ES201 –Conservation & Accounting Principles | Winter 2014-2015

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

Name [1 pt] ____________________

CM [1 pt] ____________________

Exam 1

Dec 19, 2014

Problem 1	______/ 43
Problem 2	______/ 25
Problem 3	______/ 30
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.
- Problems involving conservation principles **must clearly identify the system in a separate drawing and show a clear, logical progression from the basic principle.**
- 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 (43 pts)

(a) [4 pts] When the Accounting Principle is applied **to a given system**, the generation term ($\dot{B}_{gen}$)

- o necessarily refers to a quantity at the system boundary
- o necessarily refers to a quantity within the system itself
- o Whether $\dot{B}_{gen}$ occurs within a system or at a system boundary depends on the system.

(b) [4 pts] When the Accounting Principle is applied **to a given system**, the "out" transport term ($\dot{B}_{out}$)

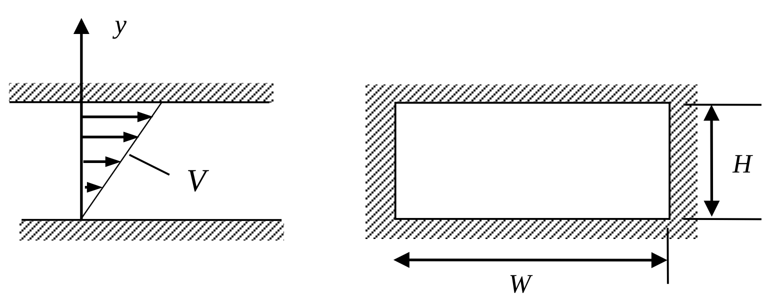
- o necessarily refers to a quantity at the system boundary
- o necessarily refers to a quantity within the system itself
- o Whether $\dot{B}_{out}$ occurs within a system or at a system boundary depends on the system.

(c) [18 pts, 3 pts each]

True	False	The Accounting Principle can be applied to the property *volume*.
True	False	The Accounting Principle can be applied to the property *temperature*.
True	False	If a system is at steady-state then dm_{sys}/dt must be equal to 0.
True	False	If $dm_{sys}/dt = 0$ for a system, then it must be at steady-state.
True	False	If a system is at steady-state then $\Sigma\dot{m}_{in} - \Sigma\dot{m}_{out}$ must be equal to 0.
True	False	If $\Sigma\dot{m}_{in} - \Sigma\dot{m}_{out} = 0$ for a system, then it must be at steady-state.

(d) [5 pts] The velocity flow of an incompressible fluid through a channel is given in the figure. The channel has a height H and width W.

$$V = V_0 \frac{y}{H}$$



What is the correct expression for the mass flow rate in the channel?

- o $\rho V_0 \frac{y}{H} HW$
- o $V_0 HW$
- o $\frac{V_0}{2} HW$
- o $\rho \frac{V_0}{2} HW$

(e) [4 pts] A coffee mug weighs 0.25 lbf on the surface of the earth. What is its mass in lbm on the international space station?

- o 0 lbm
- o 0.25 lbm
- o 2.45 lbm
- o 8.02 lbm

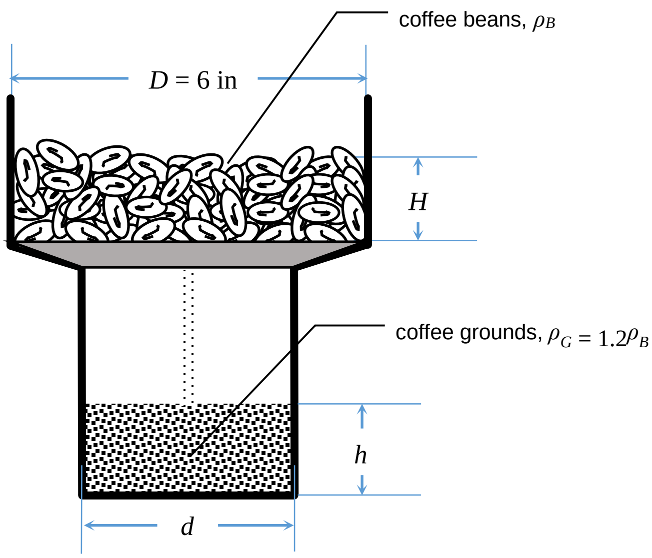
(f) [8 pts] Air exists at P = 200 kPa and 27°C. Find the density, ρ. (For air, R = 0.287 kJ/kg-K.)

Problem 2 (25 pts)

A coffee grinder grinds coffee beans contained in a hopper of diameter D. The ground beans subsequently fall as coffee grounds into a collection bin of diameter d. The coffee beans have a density of ρ_B whereas the grounds have a density of $\rho_G = 1.2\rho_B$.

(a) **Using a closed system consisting of only coffee beans/grounds**, find an expression for the time rate of change of the height of the grounds in the collection bin, dh/dt. **Use symbols only**. You may ignore the mass of the falling grounds as negligible.

(b) What diameter of collection bin, d, is necessary to make the rate of decrease in height of coffee beans in the hopper the same as the rate of increase in height of the grounds in the collection bin? (I.e., to make $-dH/dt = dh/dt$?)



Problem 33 (30 pts)

In a Chemex® coffee maker, coffee is brewed by pouring hot water over a cone-shaped filter partially filled with coffee grounds. For the Chemex® shown below, hot water filters through a height of coffee grounds, L, and drips into the carafe below as a circular stream of coffee at a velocity $V=C \cdot h^{1/2}$, where C is a constant. Other parameters are shown in the figure.

(a) Find the value of the volumetric flow rate of water, $\dot{\forall}_w$, needed to keep the height h constant. You can ignore the volume of water in the coffee grounds such that the volume of water in the cone section is given by $\forall = (h^3 - L^3)$ where L is constant. You may also assume that hot water and coffee have the same density, ρ.

(b) Find an equation that could be solved for the height h as a function of time after the flow of water in is stopped. You do not need to solve the equation.

(c) Assuming the height of water in the cone section is originally h=H, explain in words how you would solve the equation in part (b) to find the time it takes to the empty the cone section.