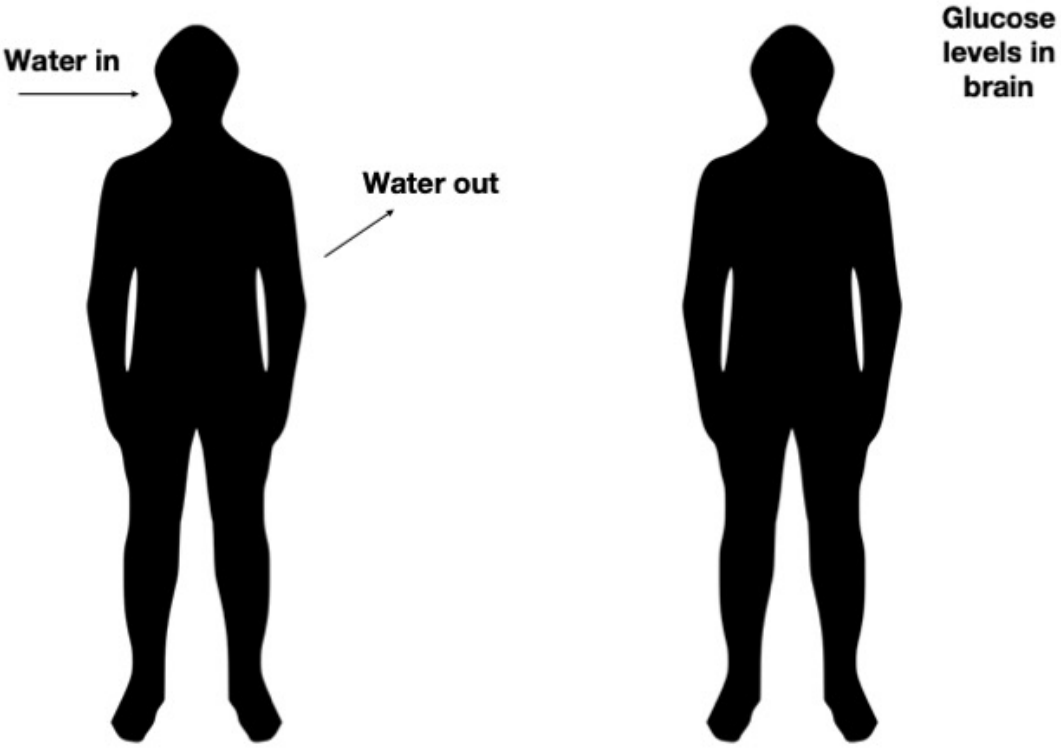
BME 200
Mass Balance 1
Sep 1, 2020

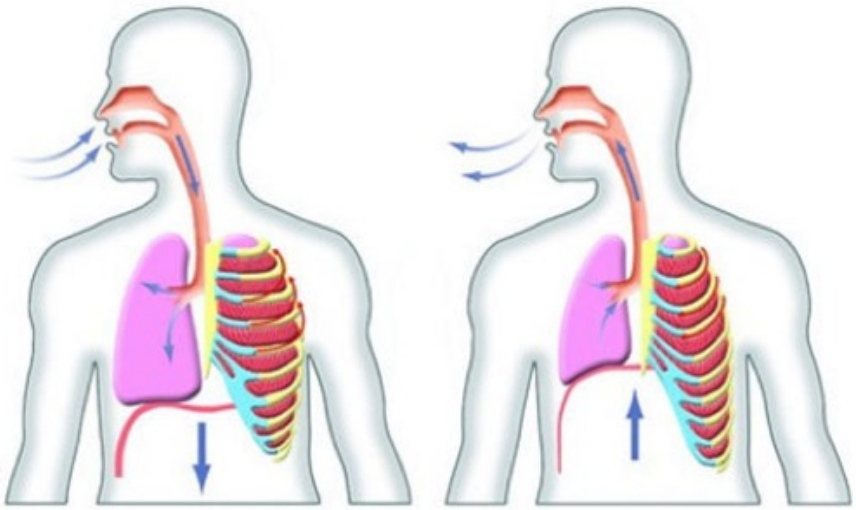
By the end of the class and after reading the assignment students should be able to:
- Define an engineering system, system boundaries, open systems, closed systems, steady state
- Determine appropriate system boundaries for a system
- Identify closed and open systems
- Use conservation of mass to solve problems

I. Control Volumes
   A. A control volume defines the system you want to analyze
      1. Do this by drawing a dashed box around the system of interest
   B. The control volume is a boundary that delineates your system from the rest of the universe
   C. Example(s) -

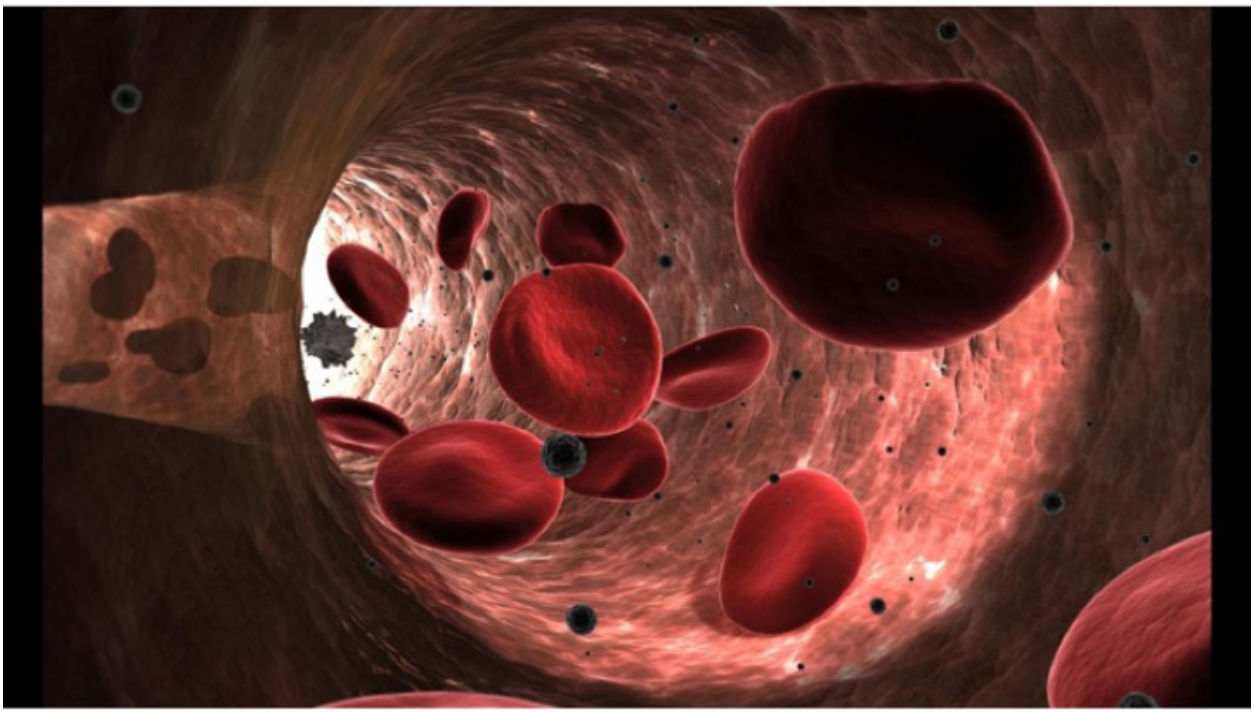


Heat going into and out of control volume

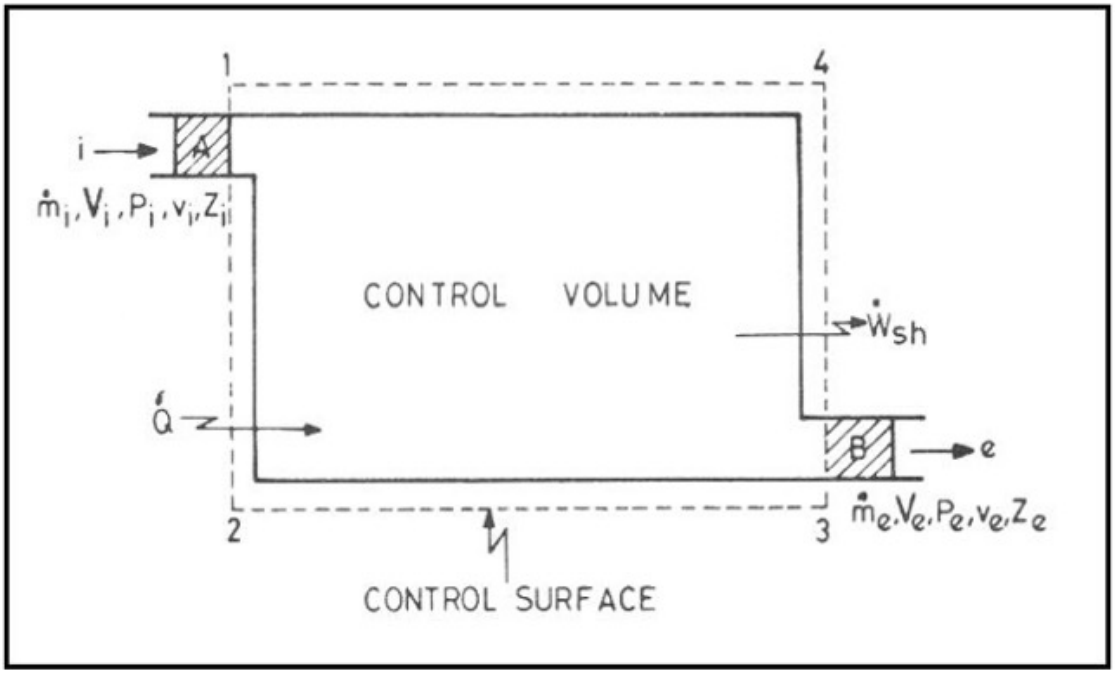
D. A control volume can move over time and it can change shape and size



Control volumes can change size



Control volumes can move



Classical engineering control volume

Student Exercise 1 Imagine pouring coffee into a cup that is already half-full (or half-empty, depending on your world view). Sketch the control volume if

1. The CV is the coffee in the cup
2. The CV is a rectangle that encompasses the whole cup

II. Mass Balance
   A. Systems often interact with the world around them
   B. For example, if your system is a baked potato and you put it in a 350 degree oven, heat will flow across the boundary of the system and raise the temp of your potato
   C. So we need two more definitions:
      1. Open system - allows mass and/or energy to cross the boundary
      2. Closed system - no mass and/or energy can cross the boundary
   D. Once we have the control volume we can start to analyze stuff entering and leaving the system
      1. For now we're going to focus only on **mass** crossing boundaries
      2. This is known as a **mass balance** and is used in many branches of engineering
   E. Simple idea: the change in mass of a system is equal to in minus out
      1. **Very important:** if your system has more than one type of mass (we call this a species) then you have to deal with each type of mass separately
      2. Write the equation like this:

3. If the mass per unit volume is constant (i.e., constant density) then you can write a volume balance:

Student Exercise 2

You start pouring coffee into the cup. Write the mass balance for coffee in (a) and (b) of Student Exercise 1.

Student Exercise 3

How many different species (substances) can you write a mass balance for in (a) and (b) in Student Exercise 1? Remember, you need to consider all of the masses that could enter or leave your CV.

4. Here is the procedure:
    a) Draw control volume
    b) Write mass balance for the species you are interested in
    c) Solve MB

F. Example - Two arteries coming together into a third one

Student Exercise 4

You are filling an empty intravenous (IV) bag that can hold a total of 500 mL of saline. You begin filling the bag at a rate of 50 mL/min. After two minutes of filling, the bag springs a leak and saline starts flowing out of the bag at 13 mL/min while you are still filling it. What is the total time that it will end up taking you to fill the bag?