Fundamental Concepts: Mass Balance

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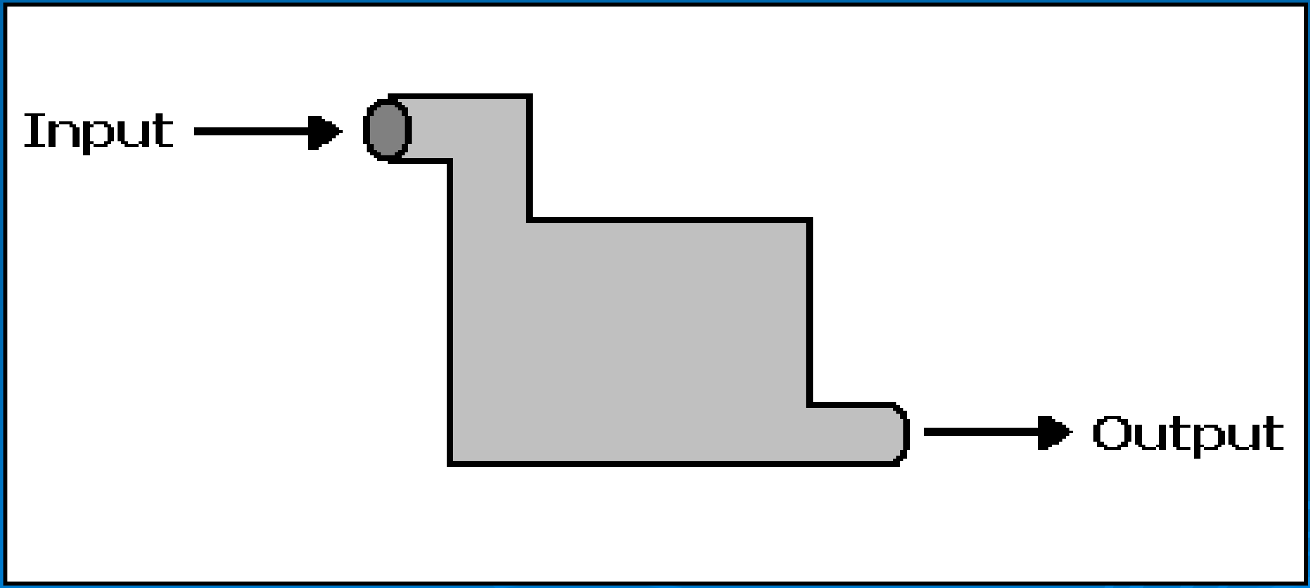
Conservation of Mass

Mass is neither created nor destroyed

Therefore, mass that enters a system will either collect in the system or leave the system

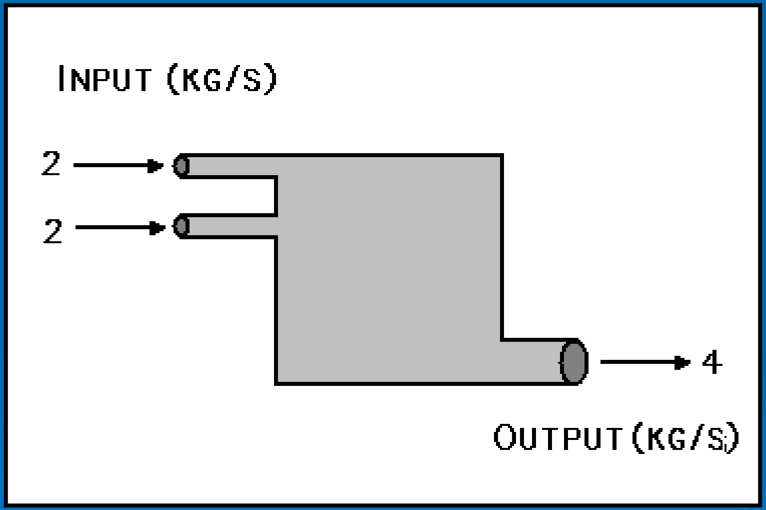
Conservation of Mass

Input = Output + Accumulation

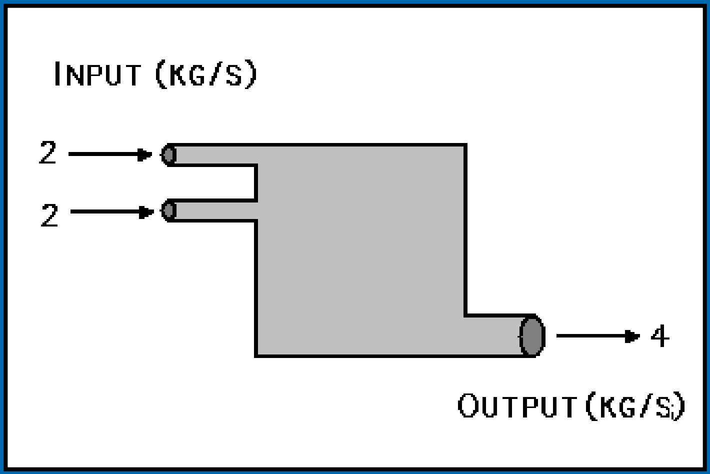


Conservation of Mass

- Often there will be multiple inputs and outputs
- We still assume that everything that goes in must be equal to the amount that leaves or accumulates inside the system

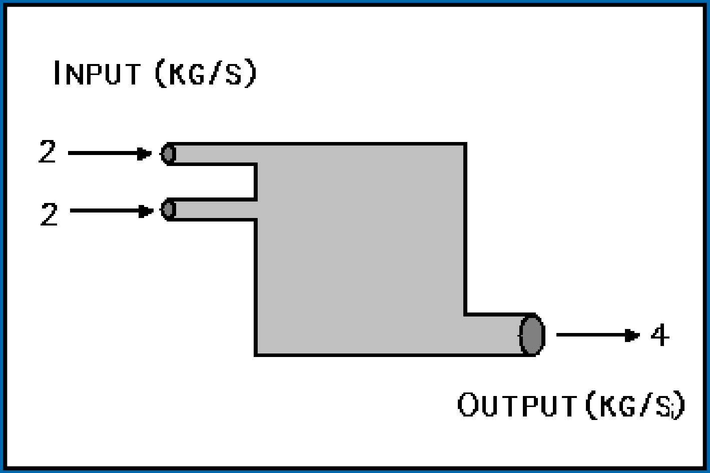


Conservation of Mass



What is the rate of accumulation of this system?

Conservation of Mass



Rate of Accumulation = Input - Output

Input = 2 kg/s + 2 kg/s = 4 kg/s

Output = 4 kg/s

Rate of Accumulation = 4 kg/s – 4 kg/s = 0 kg/s

Conservation of Mass

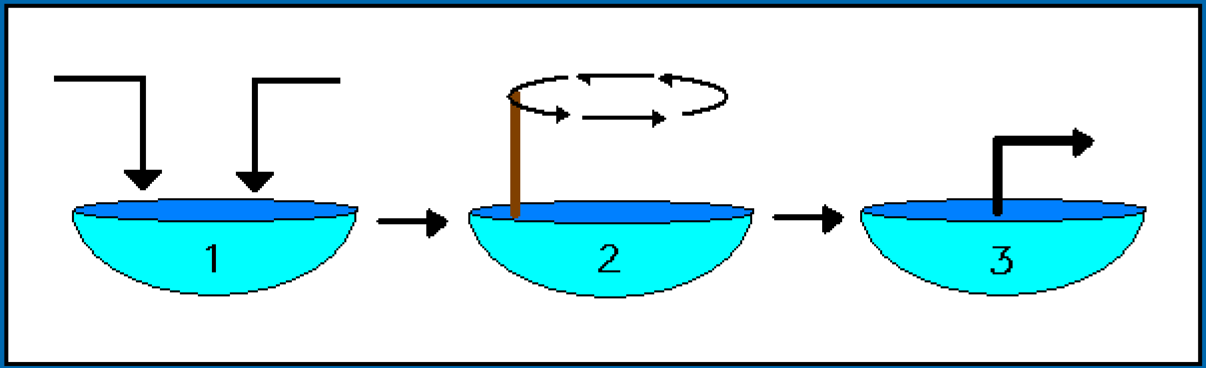
Conservation principals are still used when input materials are mixed

1/2 cup of milk is poured into a bowl, along with 2 cups of flour, and one egg. The material is thoroughly mixed. All of the material is poured out. How much milk was poured out of the bowl?

Types of Processes

- **Batch Process**
- **Continuous Process**

Batch Process



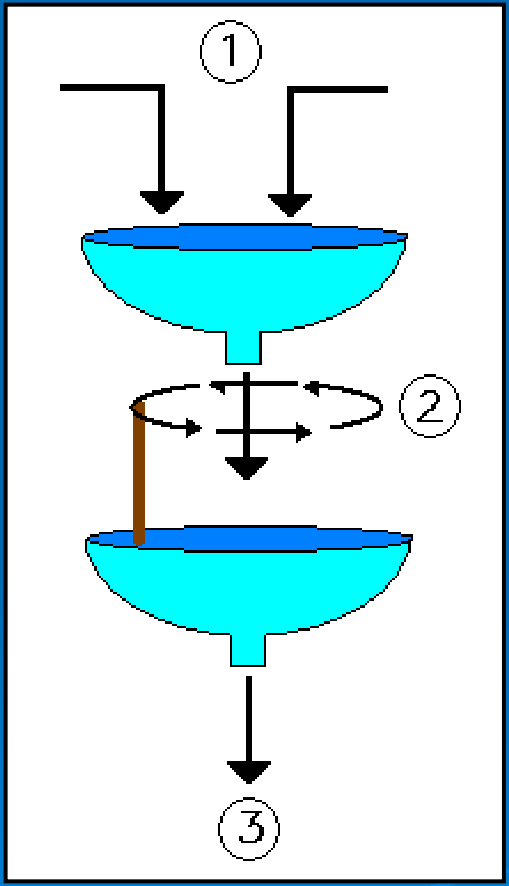
- All input materials added into system
- Input materials processed
- All material released from system

Batch Process

The follow equation can be applied:

Accumulation = Input - Output

Continuous Process



- Inputs are continuously added
- Material continuously processed
- Output material released continuously

Continuous Process

The following equation may be applied:

Rate of Accumulation =

Rate of Input – Rate of Output

Concentration

- We will often need to know the amount of matter that passes through a system

- For example, we might want to know how much particulate matter is going through a system

Concentration

We must know the following:

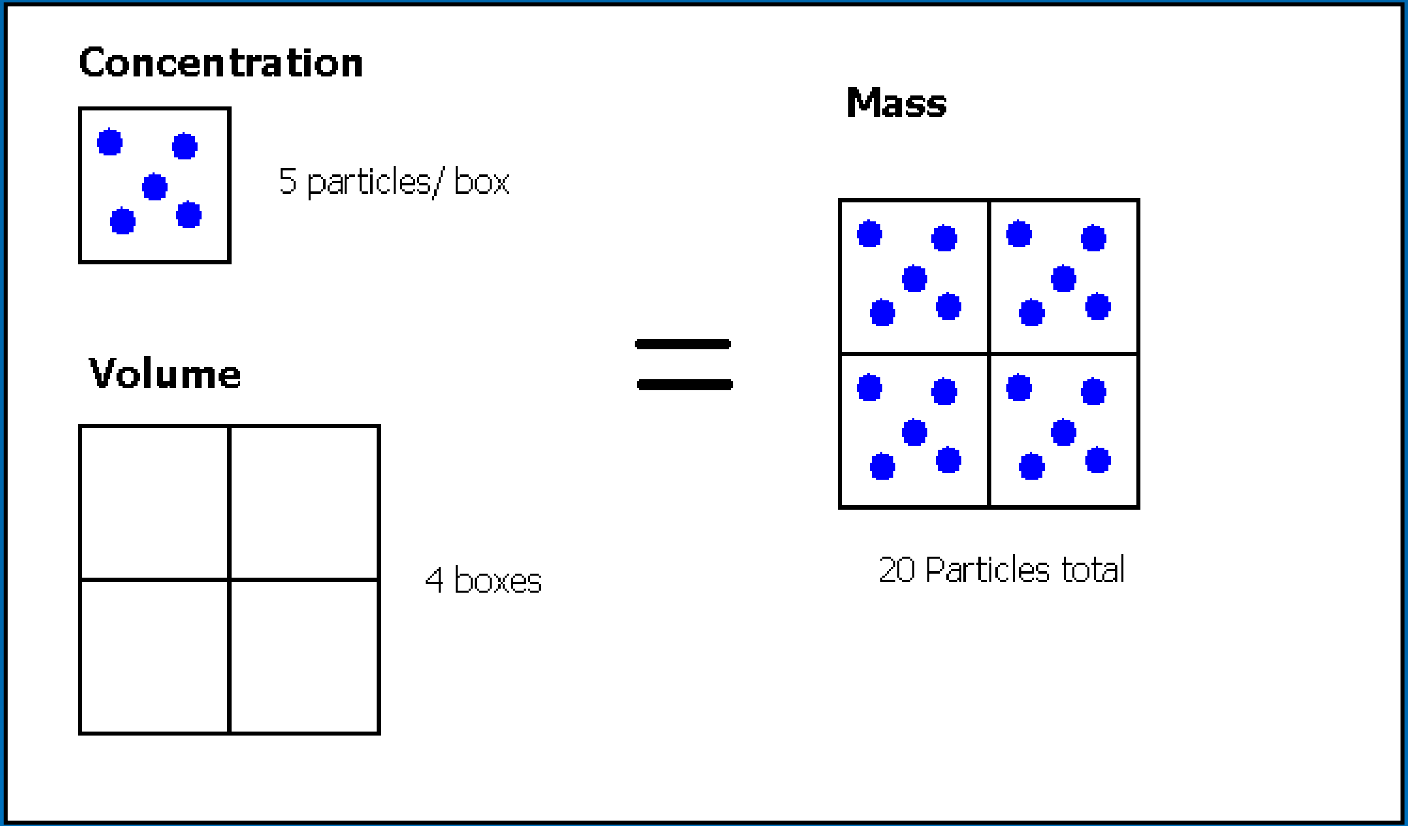
- How much material is in every unit volume
- What volume of material is passing through the system

Mass flow rate = Conc. * Vol. flow rate

Or

Mass = Concentration * Flow Volume

Concentration



Mass = Concentration * Volume

Mass = 5 particles/ box * 4 boxes = 20 particles

Percent Composition

- Materials may have a percent composition by mass
- A slurry might have 30% solids. This means that for every 100kg of slurry there are 30kg of solids

Percent Composition

Constituent Mass =

Total Mass * Fraction Composition

Percent Composition

The mass of water present can be found by subtracting the mass of the solid material from the total mass.

Water mass =

Total mass – Constituent mass

Cookbook Procedure

- Identify the system and define the system boundaries—you choose based on your needs
- Determine whether the process is batch or continuous. Determine whether the materials involved change form or composition
- Identify all inputs and outputs—diagram as needed
- Identify known quantities of mass or flow rates
- Identify unknown quantities and assign a variable to each
- Use mass balance equations to determine unknowns and solve