Expressions for mass flow rate

Remember

$$\frac{d}{dt}(m_{sys}) = \sum \dot{m}_{in} - \sum \dot{m}_{out}$$

System

dA

System
boundary
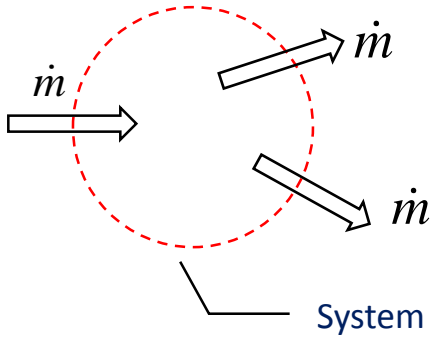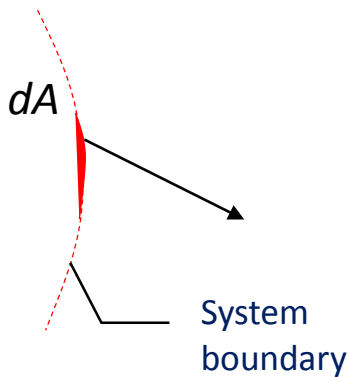
How far does a mass particle travel away from the boundary in time *dt*?

What volume has crossed the boundary?

What mass has crossed the boundary?

What is the mass flow rate across *dA*?

Total mass flow rate across all *A* is, then...

Note: V_n is _____ to the boundary!

Other expressions

If ρ = constant (**incompressible**)

_____ flow rate

What do you think $\int_A V_n dA$ is ?

If V_n is also constant and/or uniform:

and

If ρ = constant but V_n is *not* uniform

where

$$V_{n,avg} \equiv \frac{\int_A V_n dA}{A}$$