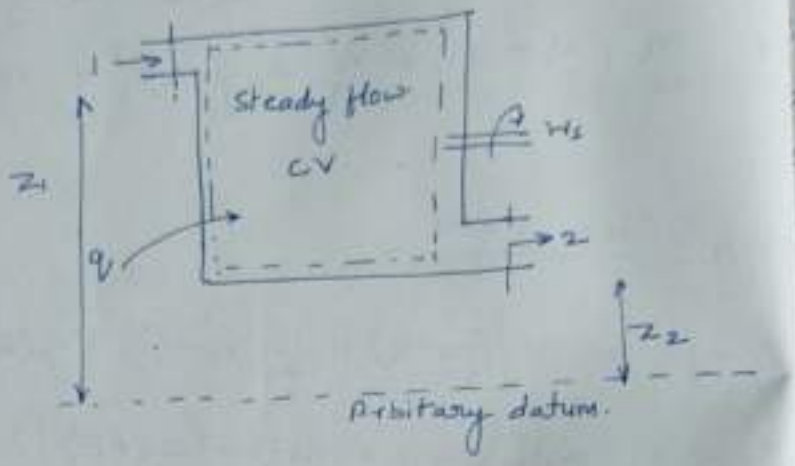
Steady flow Energy Equation-



Note ⇒ Unlike closed system, control volumes involve flow across their boundaries, and some work is required to push the mass into or out of the control volum This work is known as flow work or flow energy.

$$W_{flow} = P \cdot V$$

Total energy of non flowing fluid

$$E = U + K.E + P.E$$

Total energy of a flowing fluid

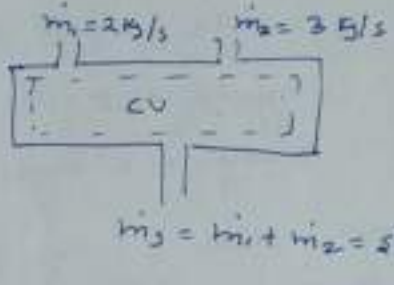
$$E = P \cdot V + U + K.E + P.E$$

The fluid enters the control volume at section 1 with avg velocity V_1, pressure P_1, specific volume v_1, and intern energy U_1. The corresponding values at the exit Sectio 2 are V_2, P_2, v_2 and U_2.

→ Further during the fluid flow, heat q and work W_s

⇒ During a steady flow process, the total amount of mass contained within a control volume does not change with time. Then the conservation of mass principle requires that the total amount of mass entering a control volume equal the total amount of mass leaving it.

$$\sum_{in} \dot{m} = \sum_{out} \dot{m}$$



⇒ Many engineering devices such as nozzles, diffusers, turbine, involve a single stream (only one inlet and one outlet)

$$\dot{m}_1 = \dot{m}_2$$

$$= \rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

Steady and Unsteady flow process-

A flow process is said to be steady when the fluid parameter at any point of the control volume remain constant w.r.t time

for steady flow $\frac{dP}{dt} = 0$ P = flow parameter.

Flow process is unsteady when the conditions vary w.r.t time

$$\boxed{\frac{dP}{dt} \neq 0}$$

Mass and Energy Analysis of Control Volumes:-

Conservation of mass → Mass, like energy, is a conserved property and it cannot be created or destroyed during a process. However, mass m and energy E can be converted to each other according to Albert Einstein's eqⁿ.

$$E = mc^2$$

where c is the speed of light in a vacuum ($c = 2.997 \times 10^8$ m/s). This eqⁿ suggests that the mass of a system changes when its energy changes.

For example when 1 kg of water is formed from oxygen and hydrogen, the amount of energy released is 15.879 kJ, which corresponds to a mass of 1.76×10^{-10} kg. A mass of this magnitude is beyond the accuracy required by practically all engineering calculations and thus can be disregarded.

Mass flow rate → The amount of mass flowing through a cross-section per unit time is called the mass flow rate.

$$\dot{m} = \rho A \cdot V_{avg}$$

Conservation of mass principle –

The principle of mass conservation for a control volume can be expressed as: The net mass transfer to or from a control volume during a time interval Δt is equal to the net change in the total mass within the control volume during Δt.