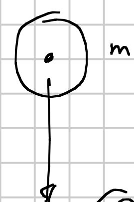
Free body diagram

$$F = G\frac{mM}{R^2} = \underbrace{\frac{GM}{R^2}}_{g}\, m$$

$$F = \underbrace{m\,g}_{kg\ \ \frac{m}{s^2}\ [9.81]} \qquad [N]$$

$$F = \frac{mg}{1000} \qquad [kN]$$

$$F = \underbrace{\frac{GM}{R^2}}_{g}\, m$$



$$F = \frac{GM}{R^2}\, m$$

$$F = m\,a$$

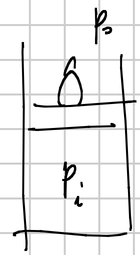
Therefore, $\frac{GM}{R^2}$ must be the accel of free fall.

$$g = \frac{GM}{R^2} = 9.81\ \frac{m}{s^2}$$

Benchmark for force: 1 kN is the weight of a 100 kg person on earth.

$$p_0 = 101\ kPa \approx 100\ kPa \quad \left[\frac{kN}{m^2}\right]$$

$$\underbrace{p_i A}_{kN.m^2 = kN} = \underbrace{p_0 A}_{kN} + \underbrace{\frac{mg}{1000}}_{kN}$$

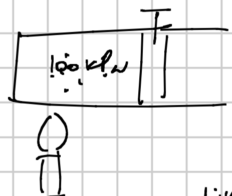


$$p_i = \underbrace{p_0}_{100\ kPa} + \frac{\underset{kg}{m}\ \underset{10\ m/s^2}{g}}{1000\ \underset{m^2}{A}}$$

//

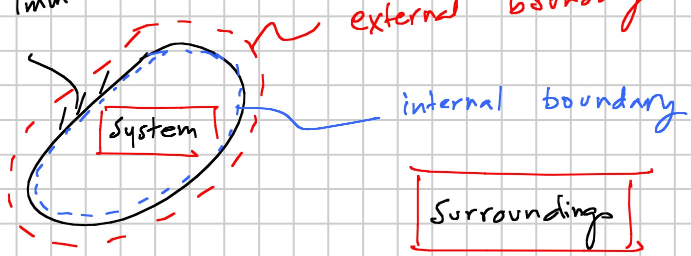
1·2

$\boxed{\text{subrata @ thermo. sdsu. edu}}$



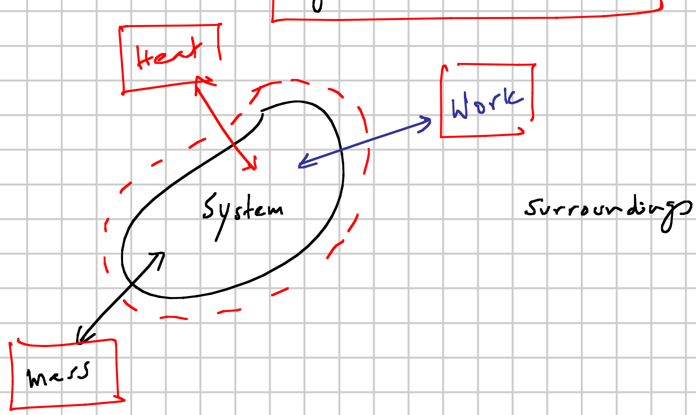
Immediate surroundings

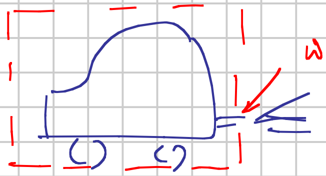
//



System + Immediate Surroundings

= $\boxed{\text{System's Universe.}}$

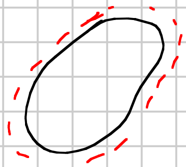


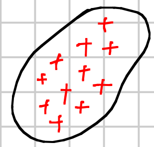


What interaction is this?

Obvious answer should be Mass

Mass Transfer:





Mass m [kg] Mole n [kmol]

A pure Substance means composition does not change from place to place.

$\frac{m}{n}\left[\frac{kg}{kmol}\right]$ must be a constant for a pure substance.

A simple system is made of a pure substance.

Molar mass is mass in kg per $\underbrace{\text{Dozen}}_{\text{aka kmol}}$ of a pure substance.

$$\bar{M} = \frac{m}{n} \left[\frac{kg}{kmol}\right]$$

$$\Rightarrow \quad n = \frac{m}{\bar{M}}$$

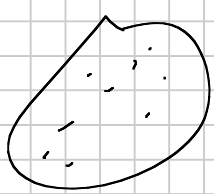
$\bar{M}_{H_2} = 2 \frac{kg}{kmol}$

$\bar{M}_{O_2} = 32 \frac{kg}{kmol}$

$\bar{M}_{N_2} = 28 \frac{kg}{kmol}$

$\bar{M}_{CO_2} = 44 \frac{kg}{kmol}$

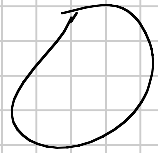
$\bar{M}_{Air} = 29 \frac{kg}{kmol}$



m kg, $\forall$ m^3 $\Big\}$ $\rho \equiv \frac{m}{\forall}\left[\frac{kg}{m^3}\right]$

$$\underbrace{v}_{\text{specific volume}} \equiv \frac{\forall}{m}\left[\frac{m^3}{kg}\right] = \frac{1}{\rho}$$

m, n, ρ, v, $\bar{M}$



Volume =	$\forall$	m^3	
mole	n	kmol	
mass	m	kg	

$\Rightarrow$

$v = \dfrac{\forall}{m} \quad \left[\dfrac{m^3}{kg}\right]$

$\bar{v} = \dfrac{\forall}{n} \quad \left[\dfrac{m^3}{kmol}\right]$

$$\bar{v} = \frac{\forall}{n} = \frac{\forall}{(m/\bar{M})}$$

$$= \frac{\forall \bar{M}}{m} = \bar{M} v$$

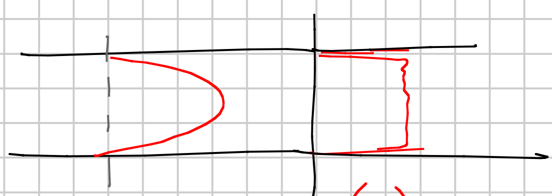
$$\therefore \boxed{\bar{v} = \bar{M} v}$$

[Advanced concept]

// Pipes & tubes & ducts carry mass

$$\dot{m} = \rho A V$$

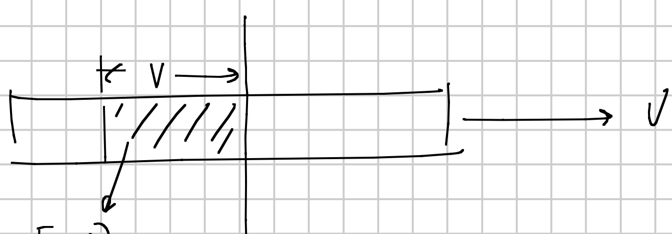
ρ: $\dfrac{kg}{m^3}$ $\quad$ A: m^2 $\quad$ V: $\dfrac{m}{s}$



(A) parabolic profile

(B) top-hat profile

// $\dot{m} = \rho A V$ [benchmark]



$$\dot{m} = \rho\,[A V]$$