UNIT STUDY AID & PARAMETRIC THOUGHT

Understanding units and unit conversion is the first primary skill for parametric engineering modeling!!!

- ✓ Be able to determine correct dimensional units for constants within SI and BKS measurement systems if given any arbitrary function.
- ✓ Considering the velocity stream of $\vec{V}(x,y)[\frac{m}{s}] = \left\{10.2[\,]x^{\frac{1}{3}} - 20.4[\,]e^{-\frac{y[m]}{3[\,]}}\right\}[\frac{m}{s}]$, the chemical molar dispersion [moles/sec] is measured as:

$$\psi(t,x,y)\left[\frac{moles}{s}\right] = 3.5[\,]e^{-5[\,]t[s]} + 20.2[\,]x^2[m^2] - 0.3[\,]y^3[m^3],\ \text{where x and y are in meters.}$$

What are the units [] in brackets for both

$$\vec{V}\left[\frac{m}{s}\right],\ \psi\left[\frac{moles}{s}\right],\ \frac{\partial\psi}{dt}\left[\frac{\frac{moles}{s}}{s} = \frac{moles}{s^2}\right],\ \text{and,}\ \frac{\partial\psi}{dx}\left[\frac{\frac{moles}{s}}{m} = \frac{moles}{s-m}\right]\ ?$$

SHOW THAT UNITS ARE CORRECT FOR EACH TERM

$$\vec{V}(x,y)[\frac{m}{s}] = \left\{10.2[]x^{\frac{1}{3}} - 20.4[]e^{-\frac{y[m]}{3[]}}\right\}[\frac{m}{s}]$$

"10.2"

$$[\frac{m}{s}] = []m^{\frac{1}{3}} \rightarrow [] = \frac{[\frac{m}{s}]}{m^{\frac{1}{3}}} = \frac{m^{\frac{2}{3}}}{s}$$

"20.4"

$$[\frac{m}{s}] = [][\text{unitless}] \rightarrow [] = \frac{m}{s}$$

"3"

$$\frac{y[m]}{3[]} = [\text{unitless}] \rightarrow [] = m$$

$$\psi(t,x,y)\left[\frac{moles}{s}\right] = 3.5[]e^{-5[]t[s]} + 20.2[]x^2[m^2] - 0.3[]y^3[m^3]$$

"3.5"

$$\frac{moles}{s} = [][unitless] \rightarrow [] = \frac{moles}{s}$$

"5"

$$[unitless] = []s \rightarrow [] = \frac{1}{s}$$

"20.2"

$$\frac{moles}{s} = []m^2 \rightarrow [] = \frac{\frac{moles}{s}}{m^2} = \frac{moles}{s-m^2}$$

"0.3"

$$\frac{moles}{s} = []m^3 \rightarrow [] = \frac{\frac{moles}{s}}{m^3} = \frac{moles}{s-m^3}$$

$$\psi(t,x,y)\left[\frac{moles}{s}\right] = 3.5[\,]e^{-5[\,]t[s]} + 20.2[\,]x^2[m^2] - 0.3[\,]y^3[m^3]$$

$$\frac{\partial \psi(t,x,y)}{\partial t}\left[\frac{\frac{moles}{s}}{s} = \frac{moles}{s^2}\right] = \overbrace{\underbrace{-3.5[\frac{moles}{s}]\bullet 5\left[\frac{1}{s}\right]}_{\text{NEVER WRITE ANY NUMBER WITHOUT PROPER UNITS}}}^{\text{IT IS IMPORTANT TO CARRY UNITS WITH THESE NUMBERS}} \quad e^{-5[1/s]t[s]}$$

$$= -(3.5 \bullet 5)\left[\frac{moles}{s^2}\right]e^{-5[1/s]t[s]}$$

$$\frac{\partial \psi(t,x,y)}{\partial x}\left[\frac{\frac{moles}{s}}{m} = \frac{moles}{s-m}\right] = 2 \bullet 20.2[\frac{moles}{s-m^2}]x[m]$$

$$= \left\{2 \bullet 20.2[\frac{moles}{s-m^{\cancel{2}}}]x[\cancel{m}]\right\}\left[\frac{moles}{s-m}\right]$$

As staff scientist for Cosmic Physics Inc. on the deep space research vessel **PROTIUS ONE**, your team after months of analysis has measured data and have determined the following equation for the Neutron Power Flux (Ψ) emitted within a Black Hole where "c" is the speed of light (m/s), "t" is time, and "J" is Joules:

$$\Psi(t)\left[\frac{J}{s}\right] = A[]^{3/2}t^{1/2} + B[]^{-1/3}t^{3} + C[]^{-2/3}t^{5/6} + D[]c[m/s]^{2}t^{-12}$$

a. Determine the units of time varying constants A[], B[], C[], and D[].

b. The time rate of change of the neutron power flux $(\frac{d\Psi}{dt})$ provides the power absorption rate of radiant energy. Determine $(\frac{d\Psi}{dt}\left[\frac{J/s}{s}\right])$ and show that units are **<u>CORRECT</u>**.

$$\left[\frac{J}{s}\right] = A[]^{3/2}[s]^{1/2}$$

$$A[]^{3/2} = \frac{\frac{J}{s}}{s^{1/2}} = \frac{J}{s^{3/2}}$$

$$A[] = \left[\frac{J}{s^{3/2}}\right]^{2/3} = \frac{J^{2/3}}{s}$$

$$\left[\frac{J}{s}\right] = B[]^{-1/3}[s]^{3}$$

$$B[]^{-1/3} = \frac{\frac{J}{s}}{s^{3}} = \frac{J}{s^{4}}$$

$$\frac{J}{s} = C[]^{-2/3}[s]^{5/6}$$

$$C[]^{-2/3} = \frac{\frac{J}{s}}{s^{5/6}} = \frac{J}{s^{11/6}}$$

$$C[] = \left[\frac{J}{s^{11/6}}\right]^{-3/2} = J^{-3/2}s^{\frac{33}{12}}$$

$$\left[\frac{J}{s}\right] = D[]\left[m/s\right]^{2}[s]^{-12}$$

$$D[] = \frac{\frac{J}{s}}{\left[m/s\right]^{2}s^{-12}} = \frac{J/m^{2}}{s^{-13}}$$

Gradient

$$\frac{d\Psi}{dt}\left[\frac{J/s}{s}\right]=1/2A^{3/2}t^{-1/2}-3B^{-1/3}t^{2}+5/6C^{-2/3}t^{-1/6}-12Dc[m/s]^{2}t^{-13}$$

UNITS

$$\left[\frac{J/s}{s}\right]=A^{3/2}[s]^{-1/2}=\left[\frac{J^{2/3}}{s}\right]^{3/2}s^{-1/2}=\left[\frac{J/s}{s}\right]$$

$$A[]=\frac{J^{2/3}}{s}$$

$$\left[\frac{J/s}{s}\right]=B^{-1/3}t^{2}=\left[\frac{J^{-3}}{s^{12}}\right]^{-1/3}s^{2}=\left[\frac{J}{s^{4}}\right]s^{2}=\left[\frac{J/s}{s}\right]$$

$$B[]=\frac{J^{-3}}{s^{12}}$$

$$\frac{J/s}{s}=C^{-2/3}t^{-1/6}=\left[J^{-3/2}s^{\frac{33}{12}}\right]^{-2/3}s^{-1/6}=Js^{-72/36}=\left[\frac{J/s}{s}\right]$$

$$C[]=J^{-3/2}s^{\frac{33}{12}}$$

$$\left[\frac{J/s}{s}\right]=Dc[m/s]^{2}t^{-13}=\left[\frac{J/m^{2}}{s^{-13}}\right][m/s]^{2}s^{-13}=\frac{J}{s^{-13}s^{13}s^{2}}=\left[\frac{J/s}{s}\right]$$

$$D[]=\frac{J/m^{2}}{s^{-9}}$$