1

I-01-50

Check which equations for volume v and area A are dimensionally consistent

a) $V = \pi r^2 h, \quad [V] = L^2 \cdot L = L^3$, OK

b) $A = 2\pi r^2 + 2\pi r h, \quad [A] = L^2 + L \cdot L = L^2$, OK

c) $V = 0{,}5\, bh$, if $[b] = L \rightarrow [V] = L \cdot L = L^2$, not OK

d) $V = \pi d^2, \quad [V] = L^2$, not OK

e) $V = \pi d^3/6, \quad [V] = L^3$, OK

1-01-53

$[s] = L, \quad [t] = T, \quad v = \frac{ds}{dt}, \quad a = \frac{dv}{dt}$

$\rightarrow$

a) $[v] = \frac{L}{T}$

b) $[a] = \frac{L}{T} \cdot \frac{1}{T} = \frac{L}{T^2}$

2

c) $\left[\int v\, dt\right] = \frac{L}{T} T = L$

d) $\left[\int a\, dt\right] = \frac{L}{T^2} \cdot T = \frac{L}{T}$

e) $\left[\frac{da}{dt}\right] = \frac{L}{T^2} \cdot \frac{1}{T} = \frac{L}{T^3}$

f) $E_{kin} = \frac{1}{2} m \left(\frac{dv}{dt}\right)^2 \rightarrow [E_{kin}] = M \frac{L^2}{T^2}$

g) $E_{pot} = \frac{1}{2} m (\omega x)^2 \rightarrow [E_{pot}] = M \frac{1}{T^2} L^2$, as $[\omega] = \frac{1}{T}$

so the different forms of energy we will see later all have the same dimension

3

1-01-64

Estimate the mass of a virus. Lets take C-19, it has close to spherical shape

In https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7224694/ we see that the diameter of the C-19 virus is approximately 100 nm, $d = 100\ nm = 100 \cdot 10^{-9}\ m = 10^{-7} m$

$V = \frac{4\pi}{3} r^3 = \frac{4\pi}{3}\left(\frac{d}{2}\right)^3 = \frac{4\pi}{3 \cdot 8} d^3 \approx 0.52 \cdot 10^{-21}\ m^3$

$\approx 0.5 \cdot 10^6\ nm^3$

we estimate the virus to have density close to water

$\rho_{H_2O} = 1000\ kg/m^3 \qquad m = \rho V \simeq 1000 \frac{kg}{m^3} \cdot 0{,}5 \cdot 10^{-21}\ m^3$

$\approx 0{,}5 \cdot 10^{-18}\ kg = 0{,}5\ fg$

So, we estimate the mass of a C-19 to be 0.5 fg half a femtogram.
C, N, O, all have similar mass, and H is in water and in the virus.
For fun there is a publication estimating the total mass of all C-19 viruses during the pandemic
https://www.pnas.org/doi/10.1073/pnas.2024815118

4

1-02-70

a) If $\bar{A} \times \bar{F} = \bar{B} \times \bar{F}$ is then $\bar{A} = \bar{B}$?

Remember that for two vectors $\bar{G}$ and $\bar{H}$ parallel or antiparallel means that $\bar{G} \times \bar{H} = 0, \quad \bar{H} \times \bar{G} = 0$

So, we select $\bar{D}$ parallel to $\bar{F}$ then

$(\bar{A} + \bar{D}) \times \bar{F} = \bar{A} \times \bar{F}$, but $\bar{A} + \bar{D} \neq \bar{A}$ generally

b) what about $\bar{A} \cdot \bar{F} = \bar{B} \cdot \bar{F}$ is then $\bar{A} = \bar{B}$?

Now we select $\bar{D}$ that is perpendicular to $\bar{F} \rightarrow \bar{D} \cdot \bar{F} = 0$

$(\bar{A} + \bar{D}) \cdot \bar{F} = \bar{A} \cdot \bar{F}$, but $\bar{A} + \bar{D} \neq \bar{A}$ generally

c) If $F \bar{A} = \bar{B} F$ is then $\bar{A} = \bar{B}$

F is a scalar $\rightarrow \bar{B} F = F \bar{B}$

$F(\bar{A} - \bar{B}) = 0$, if $F \neq 0$ then $\bar{A} = \bar{B}$