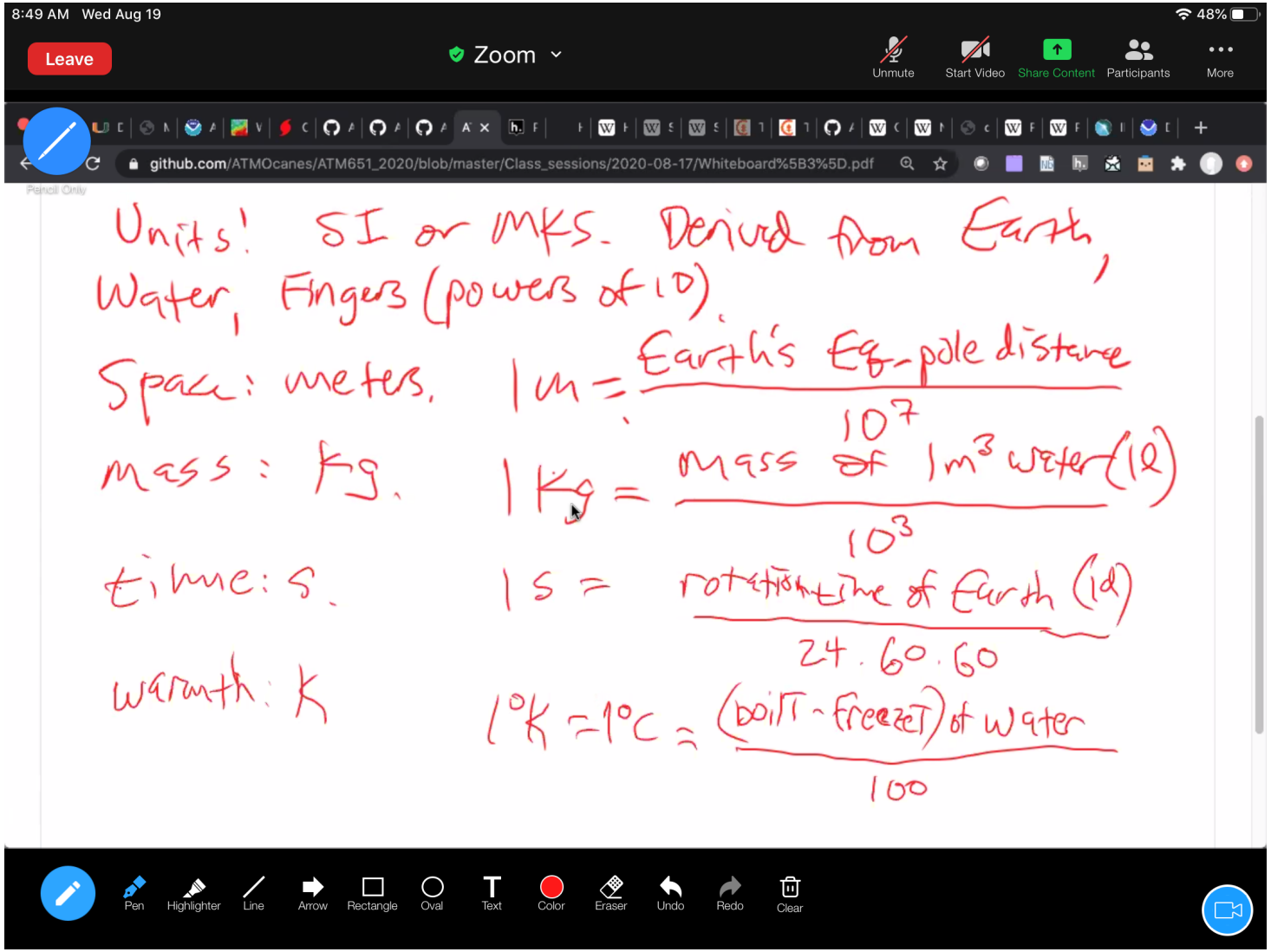
8:49 AM Wed Aug 19
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github.com/ATMOcanes/ATM651_2020/blob/master/Class_sessions/2020-08-17/Whiteboard%5B3%5D.pdf
Pencil Only
Units! SI or MKS. Derived from Earth, Water, Fingers (powers of 10).
Space: meters. 1 m = Earth's Eq-pole distance / 10^7
mass: Kg. 1 Kg = mass of $1 m^3$ water (1Q) / 10^3
time: s. 1 s = rotation time of Earth (1d) / 24 · 60 · 60
warmth: K $1°K = 1°C =$ (boil - freeze) of water / 100
Pen
Highlighter
Line
Arrow
Rectangle
Oval
Text
Color
Eraser
Undo
Redo
Clear

Compound units

velocity: m/s = momentum per unit mass

acceleration: m/s^2 = force per unit mass

force: $F = ma$! so units: $\frac{kg\,m}{s^2}$ = N ewtons.

pressure or stress: force per unit area $N/m^2 = \frac{kg}{s^2 m}$ = Pascal (Pa)

Energy:

1. Kinetic $\frac{1}{2}(mv^2)$ $kg\frac{m^2}{s^2}$ = J oule
2. work = $\int \vec{F} \cdot d\vec{x}$ $kg\frac{m^2}{s^2}$ = J

Power (rate of work) $\int \vec{F} \cdot \vec{v}$ $\left(kg\frac{m}{s^2}\right)\left(\frac{m}{s}\right) = \frac{J}{s}$ = Watt

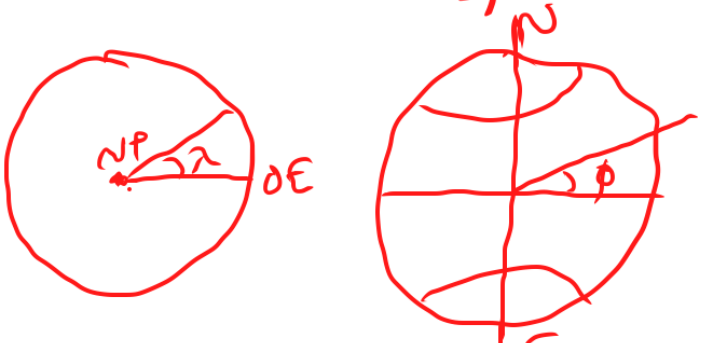
Math book-keeping tools.

Coordinates & functions $f(x)$

- domain or argument, range or value, mapping

x input, f output, $f(x)$

For meteorology, coordinates



ϕ = latitude (deg or radians)

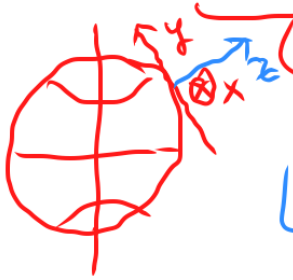
λ = longitude (" " ")

z = altitude (m) or height.

"above mean sea level"

For scales smaller than planetary, for convenience,

(weather up to continental scales)



use a tangent plane (cartesian domain

(x, y, z): derivatives (velocities): $\{u, v, w\} = \vec{V}_{3D}$

Use it! $T(x,y,z,t)$. Temperature everywhere, forever

~~Suppose~~ we have learned the 1st Law of Thermodynamics for a parcel of air (maybe 1kg) trapped in a piston.

How will we write that an equation for flowing air?

First law says: (rate of change of T with time) = (energy input).

Derivatives: what is $\dot{f}(t)$ or $f'(t)$ or $\frac{df}{dt}$, for $f(t)$

function of one variable only: $\frac{df}{dt} = \lim_{\Delta t \to 0}\left(\frac{f(t+\Delta t)-f(t)}{\Delta t}\right) = \lim_{\Delta t \to 0}\left(\frac{f(t)-f(t-\Delta t)}{\Delta t}\right)$

for T, $\left.\frac{\partial T}{\partial t}\right|_{x,y,z} = \lim_{\Delta t \to 0}\left(\frac{T(x,y,z,t+\Delta t)-T(x,y,z,t)}{\Delta t}\right) \equiv$ "$\partial_t T = \partial_t(T)$"

operator notation

To apply the First Law to free-range parcels of air, we need to define $\frac{dT}{dt}$ for moving parcels. **Chain Rule**

- Parcel position is a function of time

$\{x_p(t), y_p(t), z_p(t)\}$ have this set

$T(x_p, y_p, z_p, t)$ is available to us.

$$\frac{dT}{dt} = \frac{\partial T}{\partial t} + \frac{\partial T}{\partial x}\frac{dx_p}{dt} + \frac{\partial T}{\partial y}\frac{dy_p}{dt} + \frac{\partial T}{\partial z}\frac{dz_p}{dt} = \vec{\nabla} T \cdot \vec{v} + \frac{\partial T}{\partial t}$$

law of physics

thing we want

$\frac{dx_p}{dt} = u$

$\frac{dy_p}{dt} = v$

$\frac{dz_p}{dt} = w$