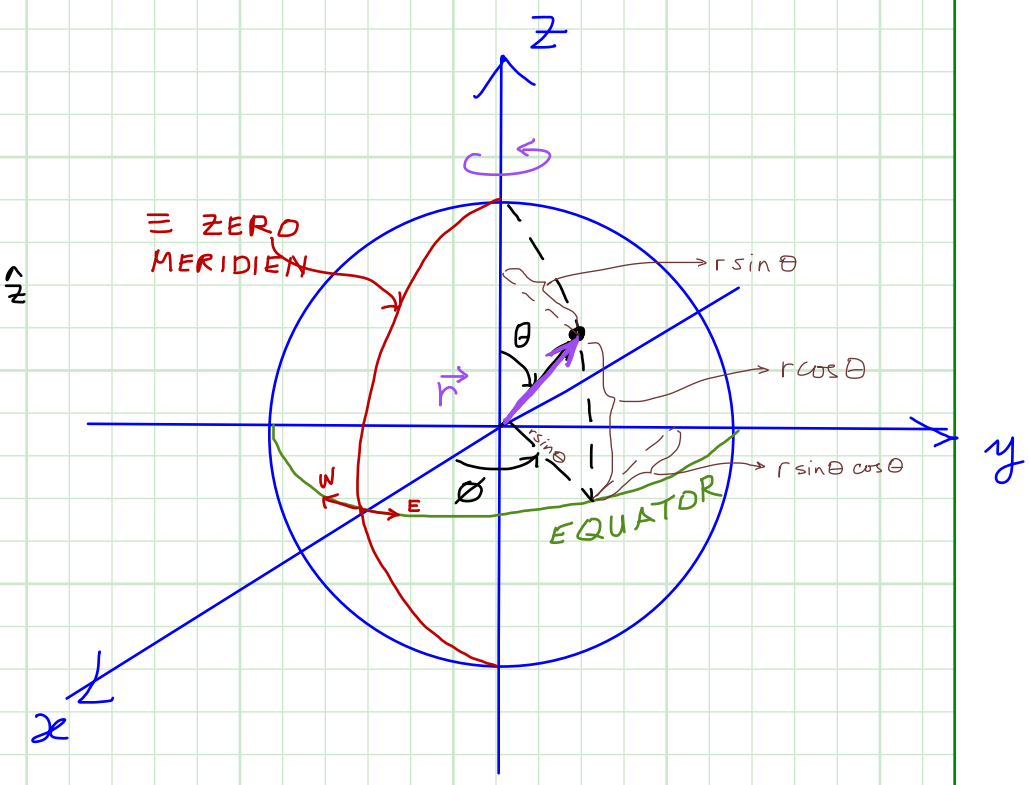
• A note about coordinate systems:

a) Global cartesian coordinates:

Position vector $\vec{r} = r_x \hat{x} + r_y \hat{y} + r_z \hat{z}$

For a point on Earth's surface,

$|\vec{r}| = R_E$, radius of the Earth



b) Spherical polar coordinates:

(r, θ, ϕ), again for points on the surface, $r = R_E$

Conversion to Cartesian:

$r_x = r \sin\theta \cos\phi$

$r_y = r \sin\theta \sin\phi$

$r_z = r \cos\theta$

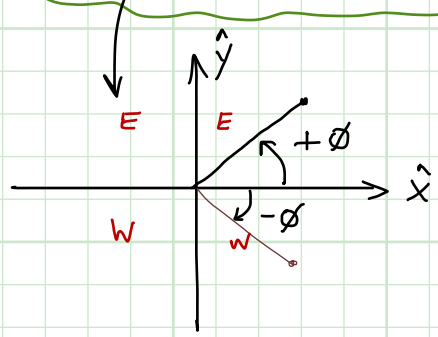
c) Global geographic coordinates:

latitude, $\lambda \equiv 90° - \theta$ (+ for N hem.; − for S hem.)

Sometimes, the polar angle θ is given the name "co-latitude"

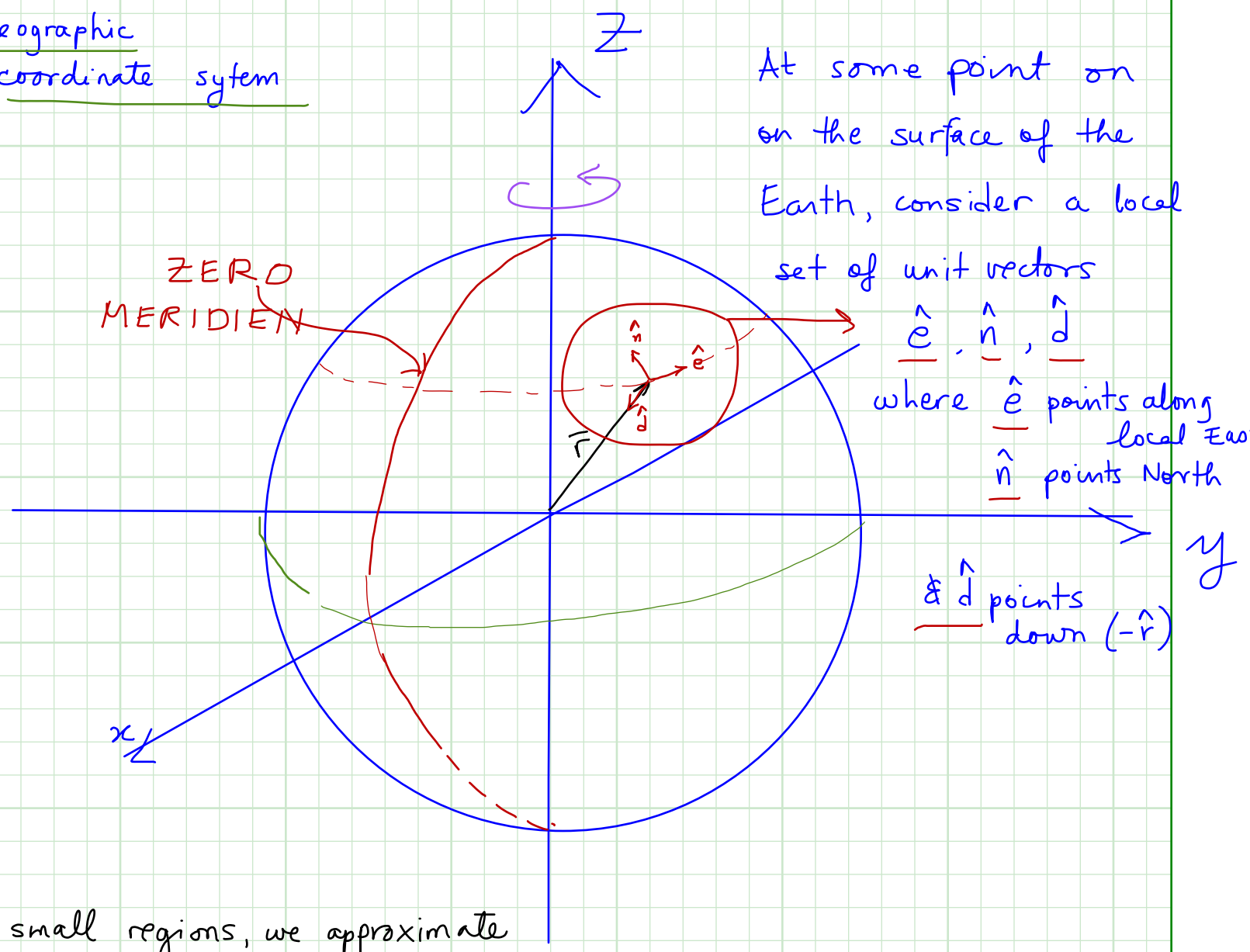
longitude, ϕ, which may be reported in the interval $[0°, 360°]$ → counter-clockwise from $\hat{x} \equiv$ zero meridien (by convention)

alternatively, may be reported as $[0°, +180°]$ → counter clockwise; $[0°, -180°]$ → clockwise



• Sometimes, longitude is also reported as 100° E or 90° W using the E(+) & W(−) hemispheres shown

d) Local geographic coordinate sytem



At some point on on the surface of the Earth, consider a local set of unit vectors $\hat{e}$, $\hat{n}$, $\hat{d}$

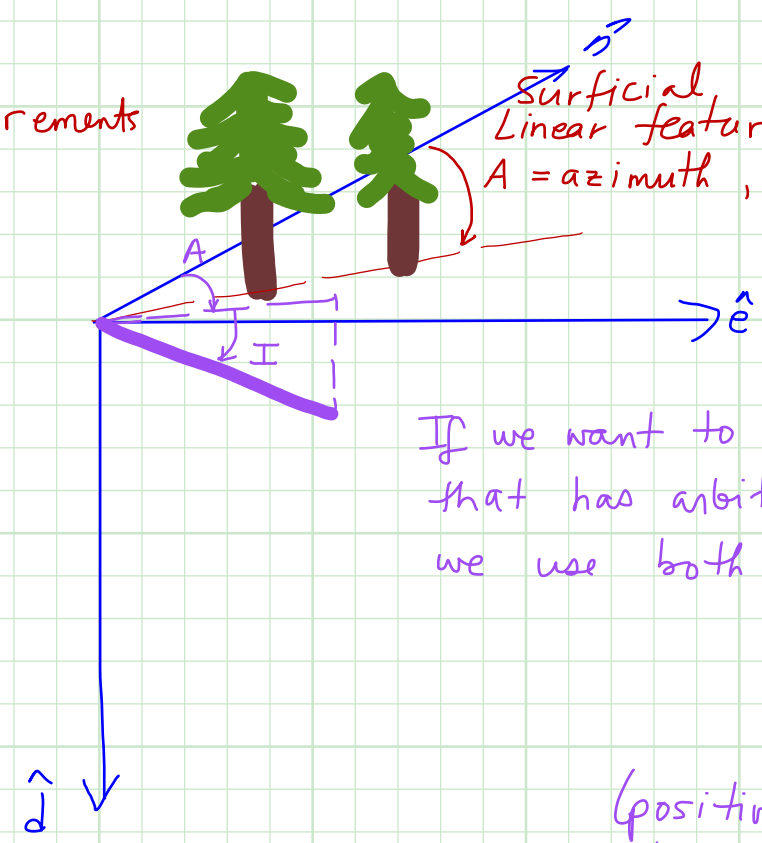
where $\hat{e}$ points along local East

$\hat{n}$ points North

& $\hat{d}$ points down $(-\hat{r})$

Looking at small regions, we approximate a LOCAL (cartesian) system here:

This is very useful for doing fieldwork/measurements

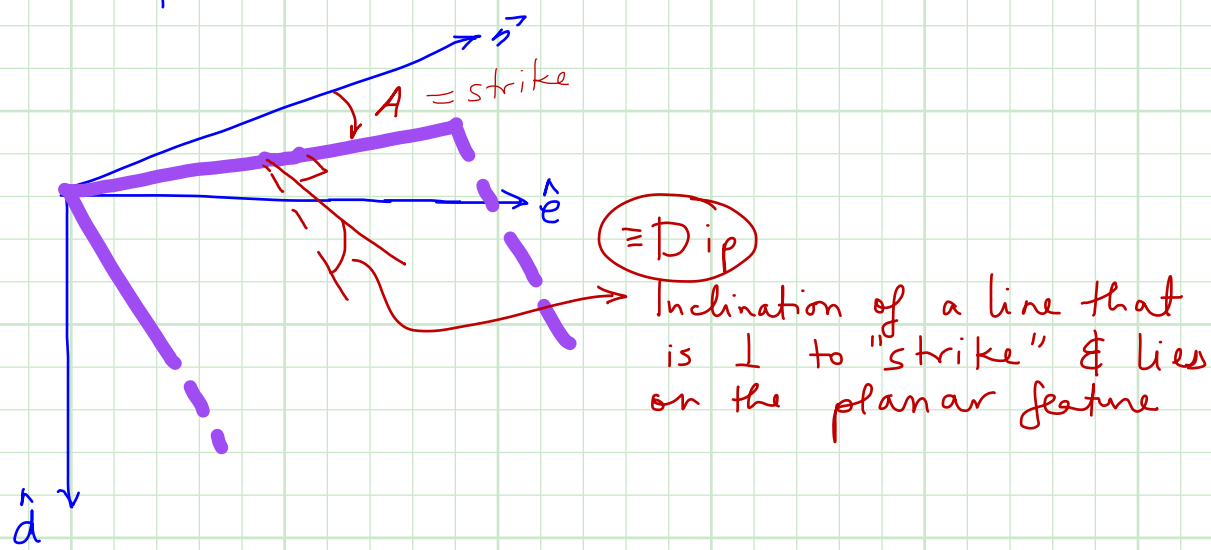


Surficial Linear features are given by the azimuth A = azimuth, measured from North (local)

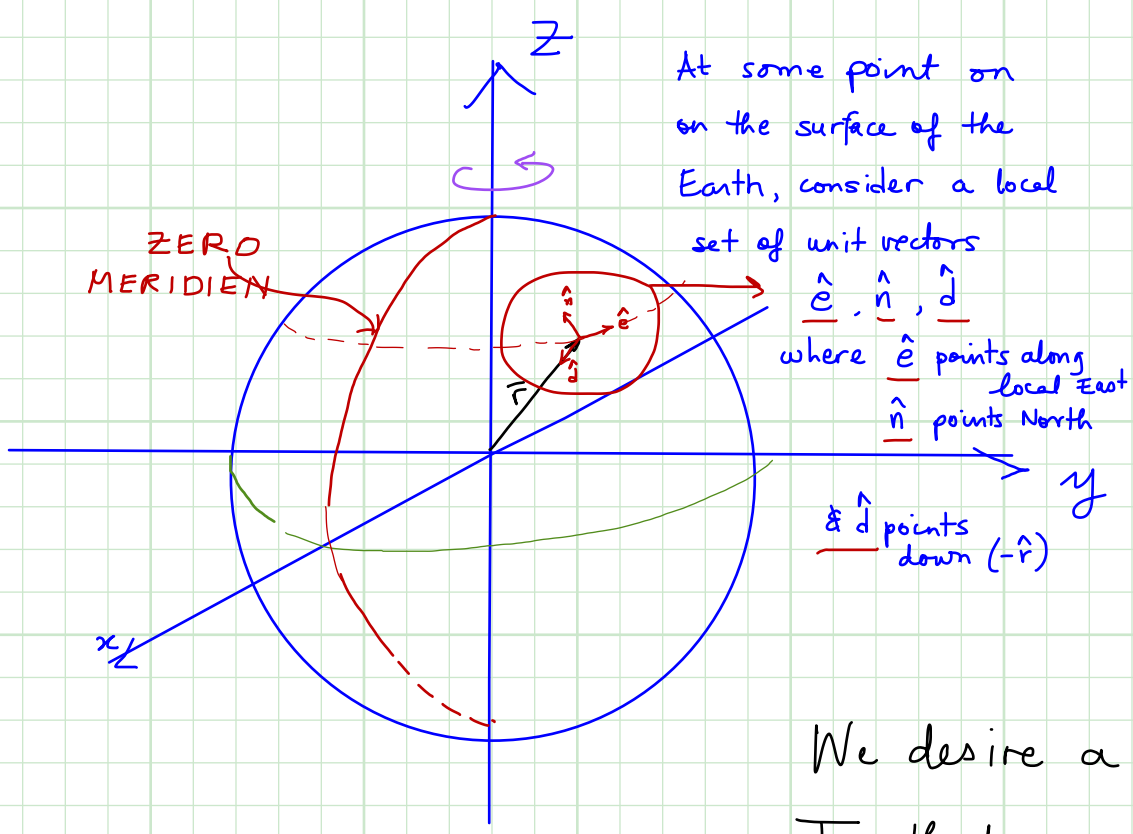
If we want to describe a line that has arbitrary orientation, we use both $\begin{cases} A \text{ (azimuth from North)} \\ I \equiv \text{inclination beneath the local surface} \end{cases}$

(positive inclination measured beneath surface, by convention)

More generally to planar surfaces, we use:



e). Transforming a vector, such as linear plate velocity, $\bar{v}$, from global geocentric coordinates (Cartesian) to <u>local</u> Cartesian coordinates:



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We desire a transformation matrix, T, that converts a vector given in terms of $(\hat{x}, \hat{y}, \hat{z})$ components into one given in $(\hat{e}, \hat{n}, \hat{d})$ coords.

$$T = \begin{pmatrix} T_{nx} & T_{ny} & T_{nz} \\ T_{ex} & T_{ey} & T_{ez} \\ T_{dx} & T_{dy} & T_{dz} \end{pmatrix} = \begin{pmatrix} -\sin\lambda\cos\phi & -\sin\lambda\sin\phi & \cos\lambda \\ -\sin\phi & \cos\phi & 0 \\ -\cos\lambda\cos\phi & -\cos\lambda\sin\phi & -\sin\lambda \end{pmatrix}$$

$\hookrightarrow T_{nx} = \hat{n}\cdot\hat{x}$, etc.

$\hookrightarrow \lambda, \phi$ = lat, lon at point of interest.