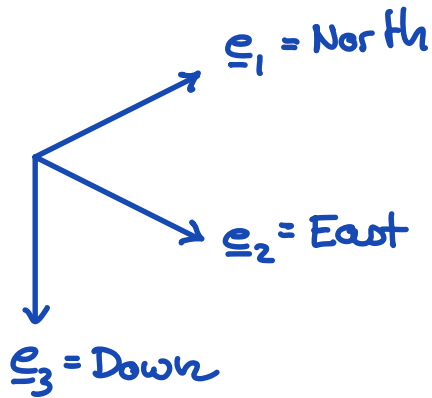


Fault normals from dip and strike

Geographic coordinate system (NED)



Geological description of a fault

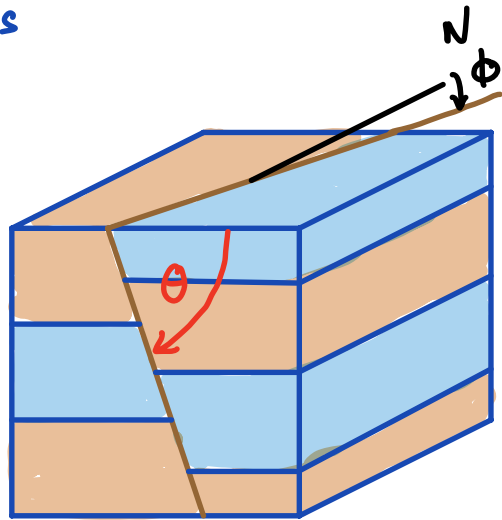
Fault is a discontinuity in the Earth across which rocks have been displaced. cross-section view

Faults are generated by earth quakes.

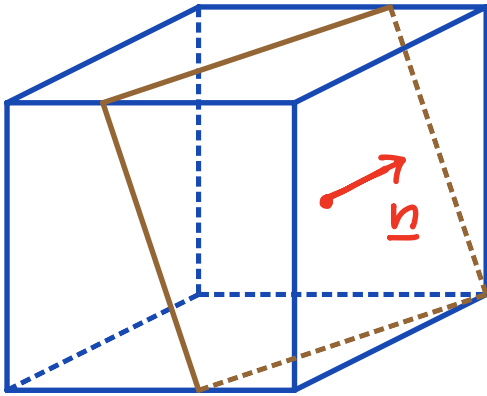
Orientation is given by dip and strike angles.

ϕ = strike = angle from north

θ = dip = angle from horizontal
(perpendicular from strike)



Q: Given ϕ & θ what is normal to fault plane?



Start with $-\underline{e}_3$

Two rotations:

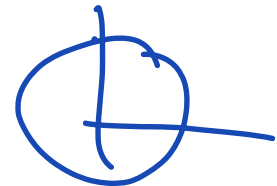
1) Rotation around \underline{e}_1

by dip: $\underline{Q}_D = \underline{Q}_1(\underline{e}_1, -\theta)$

2) Rotation around \underline{e}_3

by strike: $\underline{Q}_S = \underline{Q}(\underline{e}_3, \phi)$

$$\underline{n} = \underline{Q}_S \underline{Q}_D (-\underline{e}_3)$$



General rotation matrix

$$\underline{Q}(\underline{r}, \theta) = \underline{r} \otimes \underline{r} + \cos \theta (\underline{I} - \underline{r} \otimes \underline{r}) + \sin \theta \underline{R}$$

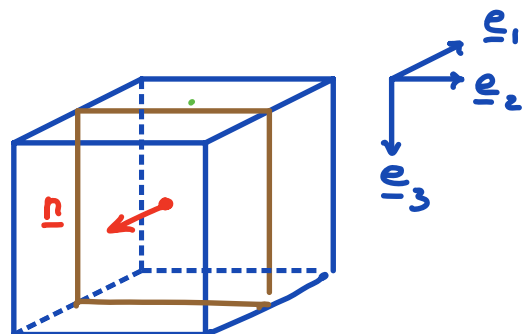
Simple example:

dip: $\theta = 90^\circ (\frac{\pi}{2})$

strike: $\phi = 90^\circ (\frac{\pi}{2})$

by inspection: $\underline{n} = -\underline{e}_1$

$$\sin(\frac{\pi}{2}) = 1 \quad \cos(\frac{\pi}{2}) = 0$$



$$\underline{R} = \begin{bmatrix} 0 & -r_2 & r_2 \\ r_3 & 0 & -r_1 \\ -r_2 & r_1 & 0 \end{bmatrix}$$

Dip rotation:

$$\underline{Q}_D = \underline{e}_1 \otimes \underline{e}_1 + \underline{R}_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}$$

$$\underline{Q}_D = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}$$

Strike rotation

$$\underline{Q}_S = \underline{e}_3 \otimes \underline{e}_3 + \underline{R}_3 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\underline{n} = \underline{Q}_S \underline{Q}_D (-\underline{e}_3)$$

$$= \underline{Q}_S \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix} = \underline{Q}_S \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

$$\underline{n} = \begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix} = -\underline{e}_1 \quad \checkmark$$