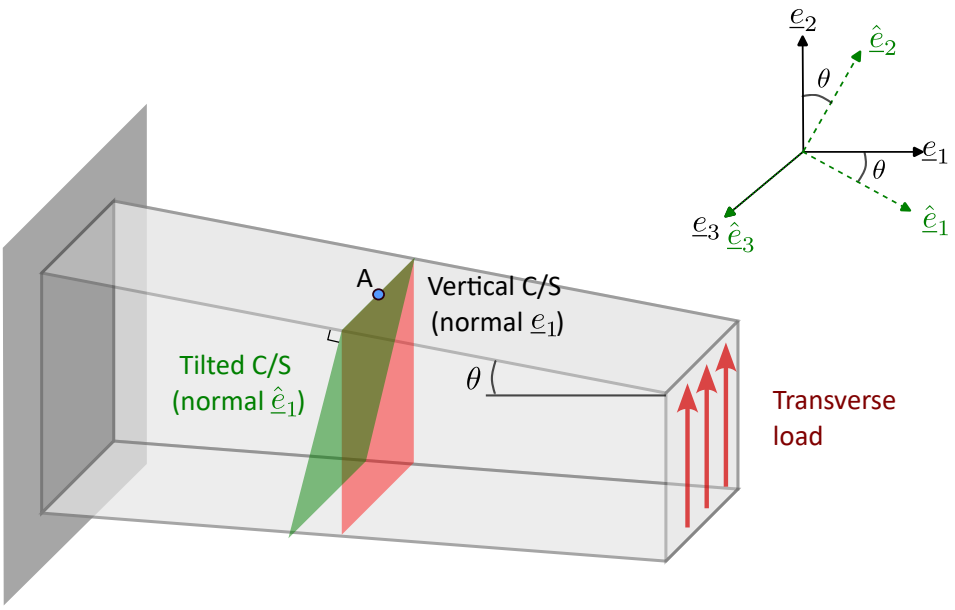
Tutorial 3: Stress tensor and its transformation

APL 104 - 2022 (Solid Mechanics)

Q1. A tapered beam is clamped at one end and subjected to transverse load (along $\underline{e}_2$) at the other end. Think of a point A on the top slanted surface of the beam. What can you say about the state of stress at point A? Suppose we know $\hat{\sigma}_{11}$ at point A. Can we find the components $\tau_{21}, \sigma_{11}, \hat{\tau}_{21}$ at point A? Assume that traction has no component along $\underline{e}_3$ at any point in the body.



Q2. The state of stress at a point is given by $\left[\underline{\underline{\sigma}}\right] = \begin{bmatrix} \sigma_{11} & 2 & 1 \\ 2 & 0 & 2 \\ 1 & 2 & 0 \end{bmatrix}$.
What should be σ_{11} such that there is at least one plane at that point on which the traction vanishes? Also, find the corresponding plane normal.

Q3. Suppose the stress matrix at a point equals $\left[\underline{\underline{\sigma}}\right] = \begin{bmatrix} a & 0 & d \\ 0 & b & e \\ d & e & c \end{bmatrix}$.
Determine the plane having its normal perpendicular to z-axis such that the traction on that plane is tangential to the plane.

Q4. Consider a sphere of radius R subjected to diametrical compression as shown in the figure. Let σ_{rr}, $\sigma_{\theta\theta}$, and $\sigma_{\phi\phi}$ be the normal stresses and $\tau_{r\theta}$, $\tau_{\theta\phi}$ and $\tau_{\phi r}$ the shear stresses at any point in the sphere. At point $P(x, y, z)$ on the sphere's surface and lying in the $y - z$ plane, determine the rectangular normal stress components σ_{xx}, σ_{yy} and σ_{zz} in terms of the spherical stress components.