CLASS 4 - STRAIN IN SOLIDS (CH 2)

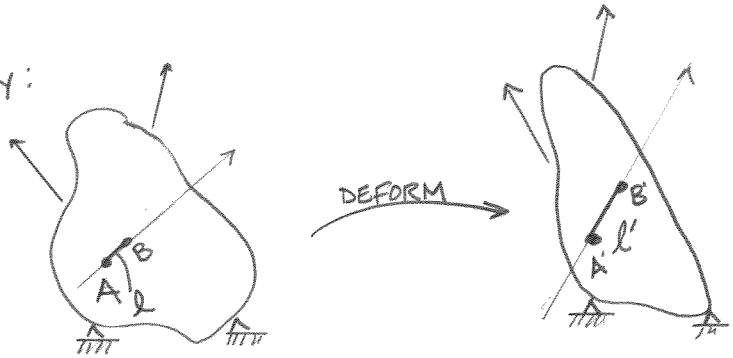
OBJECTIVES: ① DEFINE STRAIN

DEFORMATION: EXTERNALLY APPLIED LOADS RESULT IN DEFORMATION
- VISIBLE (e.g. BEAM)
- NOT VISIBLE TO NAKED EYE (e.g. COLUMN)

MOST CIVIL ENG. DEFORMATIONS ARE SMALL

NORMAL STRAIN: ELONGATION OR CONTRACTION of LINE SEGMENT AT A POINT PER UNIT LENGTH

CONSIDER BODY:



$\overline{AB}$ DISPLACED TO $\overline{A'B'}$

$$\epsilon_{AVG} = \frac{l' - l}{l} = \text{AVERAGE NORMAL STRAIN}$$

BUT STRAIN DEFINED AT A POINT, SAY A.
MAKE B APPROACH A:

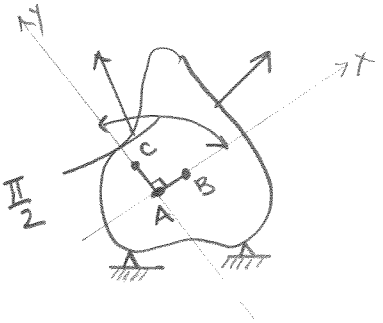
$$\lim_{l \to 0} \epsilon_{AVG} = \boxed{\lim_{l \to 0} \frac{l' - l}{l} = \epsilon} \rightarrow \boxed{\epsilon = \frac{\delta}{L}}$$

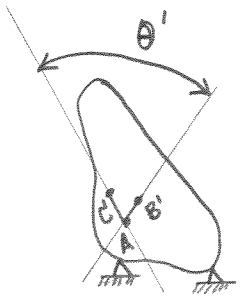
UNITS of STRAIN: DIMENSIONLESS

- BUT SOMETIMES GIVEN IN UNITS $^{m}/_{m}$, $^{in}/_{in}$, etc.
- SOMETIMES GIVEN IN %

$\epsilon = 0.01\ ^{in}/_{in} \longrightarrow \epsilon = 1\%$

SHEAR STRAIN: CHANGE IN ANGLE OF TWO ORTHOGONAL LINE SEGMENT AT A POINT.





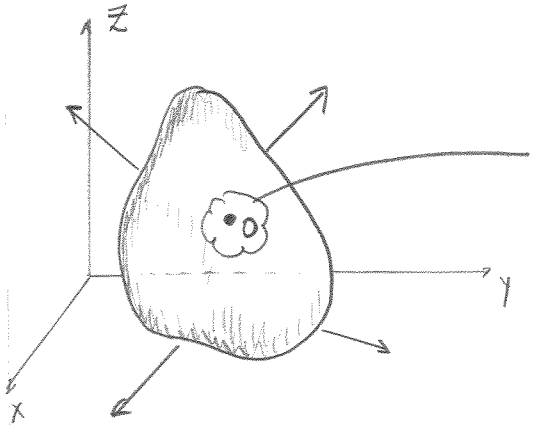
$$\gamma = \frac{\pi}{2} - \lim_{\substack{B \to A \\ C \to A}} \theta'$$

(NOTE: TO BE CONSISTENT WITH FIELD, ANGLES MUST BE IN RADIANS)

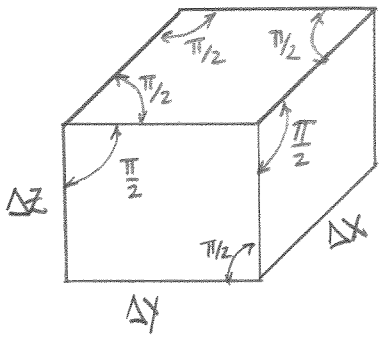
IF $\theta' < \pi/2$, $\gamma = +$

$\theta' > \pi/2$, $\gamma = -$

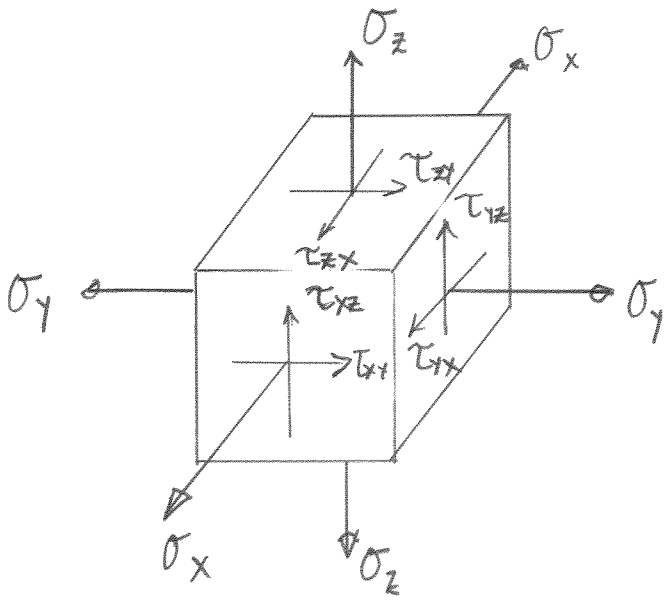
LET US GET MORE GENERAL



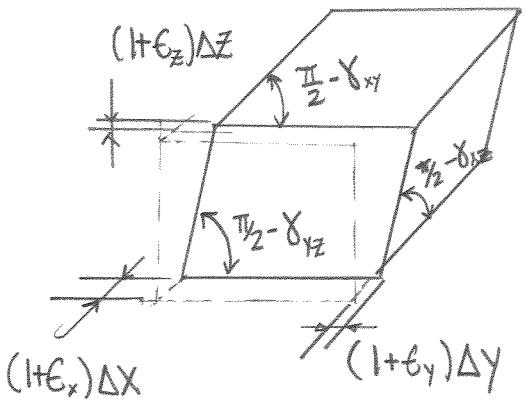
ISOLATE PT. O AS INFINTESTAMALLY SMALL CUBE VOLUME



UNDEFORMED ELEMENT



APPLIED STRESS



RESULTING DEFORMATION

- STRAIN DUE TO NORMAL & SHEAR STRESS

NORMAL STRAINS ⟶ CHANGE IN VOLUME

SHEAR STRAINS ⟶ CHANGE IN SHAPE

CIVIL ENGINEERING - MASSIVE STRUCTURES
- HUGE LOADS

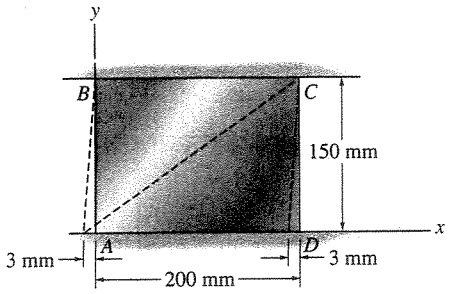
∴ SMALL DEFORMATIONS

$\epsilon << 1$

$\gamma << 1$

2-23. The rectangular plate is subjected to the deformation shown by the dashed lines. Determine the average shear strain γ_{xy} of the plate.

***2-24.** The rectangular plate is subjected to the deformation shown by the dashed lines. Determine the average normal strains along the diagonal AC and side AB.



Probs. 2–23/24

2.23) γ_{xy} ?

$$\gamma_{xy} = \frac{\pi}{2} - \theta' = \frac{\pi}{2} - \tan^{-1}\left(\frac{150\,mm}{3\,mm}\right)$$

$$= 0.02\ rad$$

2.24)

$$\Delta AC = AC' - AC$$

$$= \sqrt{150_{mm}^2 + 203_{mm}^2} - \sqrt{150_{mm}^2 + 200_{mm}^2}$$

$$= 252.41 - 250\,mm$$

$$= 2.41$$

$$\epsilon_{AC} = \frac{\delta_{AC}}{L_{AC}} = \frac{2.41\,mm}{250\,mm} = +0.00964\ \frac{mm}{mm}\ (\text{TENSION})$$

$$\epsilon_{AB} = 0.0002\ mm/mm\ (\text{TENSION})$$