

## Principal Stress & Maximal Shear Stress

### 2-Dimensional

$$\sigma_{x1} = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{x2} = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$\tau_{xy1} = \frac{\sigma_{xx} - \sigma_{yy}}{2} \sin 2\theta + \tau_{xy} \cos 2\theta$$

$$\tau_{xy2} = \frac{\sigma_{xx} - \sigma_{yy}}{2} \sin 2\theta - \tau_{xy} \cos 2\theta$$

$$\sigma_{x1} = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \tau_{xy1}$$

$$\sigma_{x2} = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \tau_{xy2}$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

### 3-Dimensional

Determinants Equations/Max. Tensionals

$$\sigma_{x1}^3 - I_1 \sigma_{x1}^2 + I_2 \sigma_{x1} - I_3 = 0 \Rightarrow \sigma_{x1}, \sigma_{x2}, \sigma_{x3}$$

$$I_1 = \sigma_{xx} + \sigma_{yy} + \sigma_{zz}$$

$$I_2 = \sigma_{xx}\sigma_{yy} + \sigma_{yy}\sigma_{zz} + \sigma_{zz}\sigma_{xx} - \tau_{xy}^2 - \tau_{yz}^2 - \tau_{zx}^2$$

$$I_3 = \sigma_{xx}\sigma_{yy}\sigma_{zz} + 2\tau_{xy}\tau_{yz}\tau_{zx} - \sigma_{xx}\tau_{yz}^2 - \sigma_{yy}\tau_{zx}^2 - \sigma_{zz}\tau_{xy}^2 - 3\tau_{xy}\tau_{yz}\tau_{zx}$$

$$\tau_{max} = \max \{ \tau_{xy}, \tau_{yz}, \tau_{zx} \}$$

$$\tau_{max, xy} = \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$\tau_{max, yz} = \sqrt{\left(\frac{\sigma_{yy} - \sigma_{zz}}{2}\right)^2 + \tau_{yz}^2}$$

$$\tau_{max, zx} = \sqrt{\left(\frac{\sigma_{zz} - \sigma_{xx}}{2}\right)^2 + \tau_{zx}^2}$$

See: ex. for principal direction

### Continual Bending

$$\sigma_{xx} = \sum \frac{M_y}{I_x} + \frac{F}{A}$$

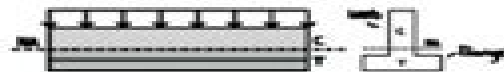
C is distance from NB to point of interest ; in radius for circular shaft

I & A will be MAXI near axis

bending stress will be MAXI (perpendicular axis)

M/A is axial (perpendicular) stress distribution

tensile bending → positive ; compression bending → negative

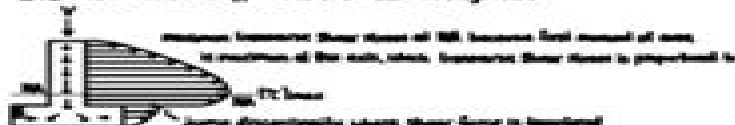


### Thermal Stress

$$\epsilon = \frac{\Delta L}{L}$$

Linear → Linear, for structures along axis but I & Q are with respect to

I & Q will be MAXI axis opposite to V (other axis (perpendicular))



beam will be change, twisting from a change in thickness which increases

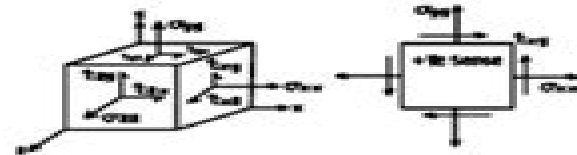
beam stress is directly proportional to

### Torsion

$$\tau = \frac{T \cdot r}{J}$$

$$\begin{bmatrix} \sigma_{xx} & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_{yy} & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_{zz} \end{bmatrix}$$

(3-Dimensional direction)



### Cross Sectional Properties

$$Centroid: \bar{y} = (\sum y_i A_i) / (\sum A_i)$$

Second Moment of Area

$$I = \sum I_{xx} + A_i \bar{y}_i^2 \text{ only use if when axis is not coincident}$$

$$I_y = \int y^2 dA$$

If  $I_{yy}$ , have  $\bar{y}$  in same perspective of  $y$ -axis

If  $I_{xx}$ , " "  $x$ -axis

Area Moment of Inertia

$$J = \int r^2 dA \text{ if bar is circular or shaft ; hollow use } \frac{\pi}{32} (D^4 - d^4)$$

$$I_x = \int x^2 dA \text{ if bar is round not a beam}$$

First Moment of Area

moment of area above or below point of interest

$$Q = A \bar{y}$$

where  $A$  is the remaining cross sectional area above or below that point

and  $\bar{y}$  is the distance between the centroid of that area to the centroid of the entire cross section

### 2-Dimensional Plane Stress & Strain

Stress

(1) — one dimension compared to other two dimension is very small

like a plate or a shell, stress with large constant

(2) — total has to be in the plane of the plate, etc., stress very 2, stress  $\sigma_{xx}$

Strain

(1) — one dimension compared to other two dimension is very large

(2) — symmetric loading condition

### Stress-Strain

A: point of interest

$$\begin{bmatrix} \sigma_{xx} & \sigma_{yy} & \sigma_{zz} \\ \sigma_{yx} & \sigma_{yy} & \sigma_{yz} \\ \sigma_{zx} & \sigma_{zy} & \sigma_{zz} \end{bmatrix} \rightarrow \begin{bmatrix} \epsilon_{xx} & \epsilon_{yy} & \epsilon_{zz} \\ \epsilon_{yx} & \epsilon_{yy} & \epsilon_{yz} \\ \epsilon_{zx} & \epsilon_{zy} & \epsilon_{zz} \end{bmatrix} \rightarrow \begin{bmatrix} \epsilon_{xx} & \epsilon_{yy} & \epsilon_{zz} \\ \epsilon_{yx} & \epsilon_{yy} & \epsilon_{yz} \\ \epsilon_{zx} & \epsilon_{zy} & \epsilon_{zz} \end{bmatrix}$$

### Stress-Strain Relationship

$$\epsilon_{xx} = \frac{1}{E} \left( \sigma_{xx} - \nu \frac{\sigma_{yy} + \sigma_{zz}}{2} \right)$$

$$\epsilon_{yy} = \frac{1}{E} \left( \sigma_{yy} - \nu \frac{\sigma_{xx} + \sigma_{zz}}{2} \right)$$

$$\epsilon_{zz} = \frac{1}{E} \left( \sigma_{zz} - \nu \frac{\sigma_{xx} + \sigma_{yy}}{2} \right)$$

$$\gamma_{xy} = \frac{1}{G} \tau_{xy} ; \gamma_{yz} = \frac{1}{G} \tau_{yz} ; \gamma_{zx} = \frac{1}{G} \tau_{zx}$$

$$G = \frac{E}{2(1+\nu)}$$

### Plane Stress Condition

$$\epsilon_{xx} = \frac{1}{E} \left( \sigma_{xx} - \nu \frac{\sigma_{yy}}{2} \right)$$

$$\epsilon_{yy} = \frac{1}{E} \left( \sigma_{yy} - \nu \frac{\sigma_{xx}}{2} \right)$$

$$\epsilon_{zz} = -\nu \frac{\sigma_{xx} + \sigma_{yy}}{2E}$$

$$\gamma_{xy} = \frac{1}{G} \tau_{xy}$$

# Course Notes Structural Mechanics Mechanical

**Joacim Rocklöv**



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**Lecture-notes on Chemistry for Dental Students** Henry Carlton Smith,1906 *Lecture-notes on the Theory of Electrical Measurements* William Arnold Anthony,1908 **The Multibody Systems Approach to Vehicle Dynamics** Michael Blundell,Damian Harty,2004-08-21 Multibody Systems Approach to Vehicle Dynamics aims to bridge a gap between the subject of classical vehicle dynamics and the general purpose computer based discipline known as multibody systems analysis MBS The book begins by describing the emergence of MBS and providing an overview of its role in vehicle design and development This is followed by separate chapters on the modeling analysis and post processing capabilities of a typical simulation software the modeling and analysis of the suspension system tire force and moment generating characteristics and subsequent modeling of these in an MBS simulation and the modeling and assembly of the rest of the vehicle including the anti roll bars and steering systems The final two chapters deal with the simulation output and interpretation of results and a review of the use of active systems to modify the dynamics in modern passenger cars This book intended for a wide audience including not only undergraduate postgraduate and research students working in this area but also practicing engineers in industry who require a reference text dealing with the major relevant areas within the discipline Full of practical examples and applications Uses industry standard ADAMS software based applications Guides readers from modelling suspension movement through to full vehicle models able to perform handling manoeuvres **Columbia University Bulletin** Columbia University,1916 **Announcement** Columbia University. Extension Teaching,1926 **Mathematical Methods in Interdisciplinary Sciences** Snehashish Chakraverty,2020-07-15 Brings mathematics to bear on your real world scientific problems Mathematical Methods in Interdisciplinary Sciences provides a practical and usable framework for bringing a mathematical approach to modelling real life scientific and technological problems The collection of chapters Dr Snehashish Chakraverty has provided describe in detail how to bring mathematics statistics and computational methods to the fore to solve even the most stubborn problems involving the intersection of multiple fields of study Graduate students postgraduate students researchers and professors will all benefit significantly from the author s clear approach to applied mathematics The book covers a wide range of interdisciplinary topics in which mathematics can be brought to bear on challenging problems requiring creative solutions Subjects include Structural static and vibration problems Heat conduction and diffusion problems Fluid dynamics problems The book also covers topics as diverse as soft computing and machine intelligence It concludes with examinations of various fields of application like infectious diseases autonomous car and monotone inclusion problems *Cumulated Index to the Books* ,1906 A world list of books in the English language *Handbook of Optomechanical Engineering* Anees Ahmad,2017-07-11 This comprehensive handbook covers all major aspects of optomechanical engineering from conceptual design to fabrication and integration of complex optical systems The practical information within is ideal for optical and optomechanical engineers and scientists involved in the design

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