ME323 LECTURE 35

Alex Chortos

PURDUE
UNIVERSITY

Combined Loading: Objectives

Ch 13: Mohr's Circles

- Given the loading conditions at a point, what are the stress states at different angles?
- At what angle does the max normal stress and max shear stress occur?

Ch 14: Combined Loading

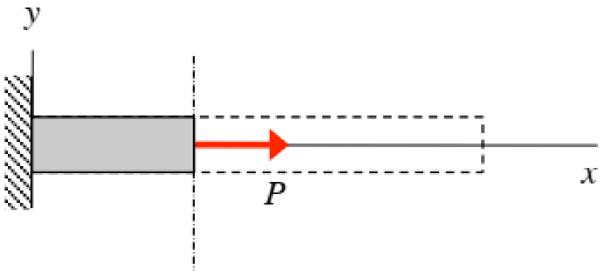
- What are the normal and shear stresses at points on a cross section due to combined axial, torsion, and bending loading?
- Determine the principal stresses and max shear stress at these points – use Mohr's circles.

Ch 15: Failure Analysis

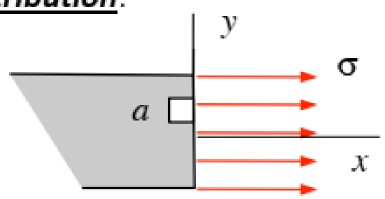
- Given the stress states at a point, under what condition will a 3D structure fail?

Review of Types of Loading

Internal loading:



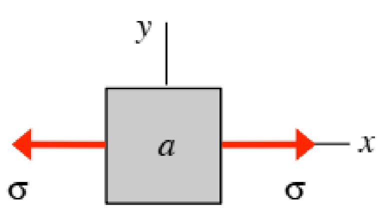
Stress distribution:



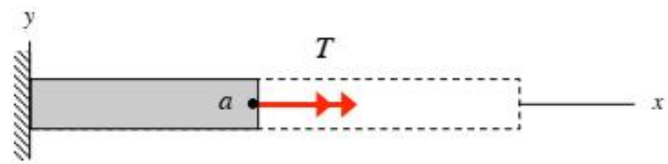
sign convention : σ *positive OUTWARD on face (tension)*

$$\sigma = \frac{P}{A} = \text{constant in } y \quad ; \quad A = \text{cross-sectional area}$$

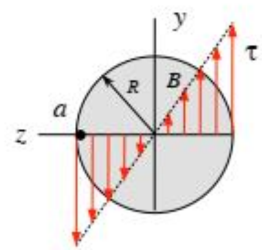
Stress element:



Internal loading:



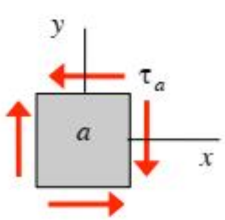
Stress distribution:



sign convention : T *positive OUTWARD on face (by right – hand rule)*

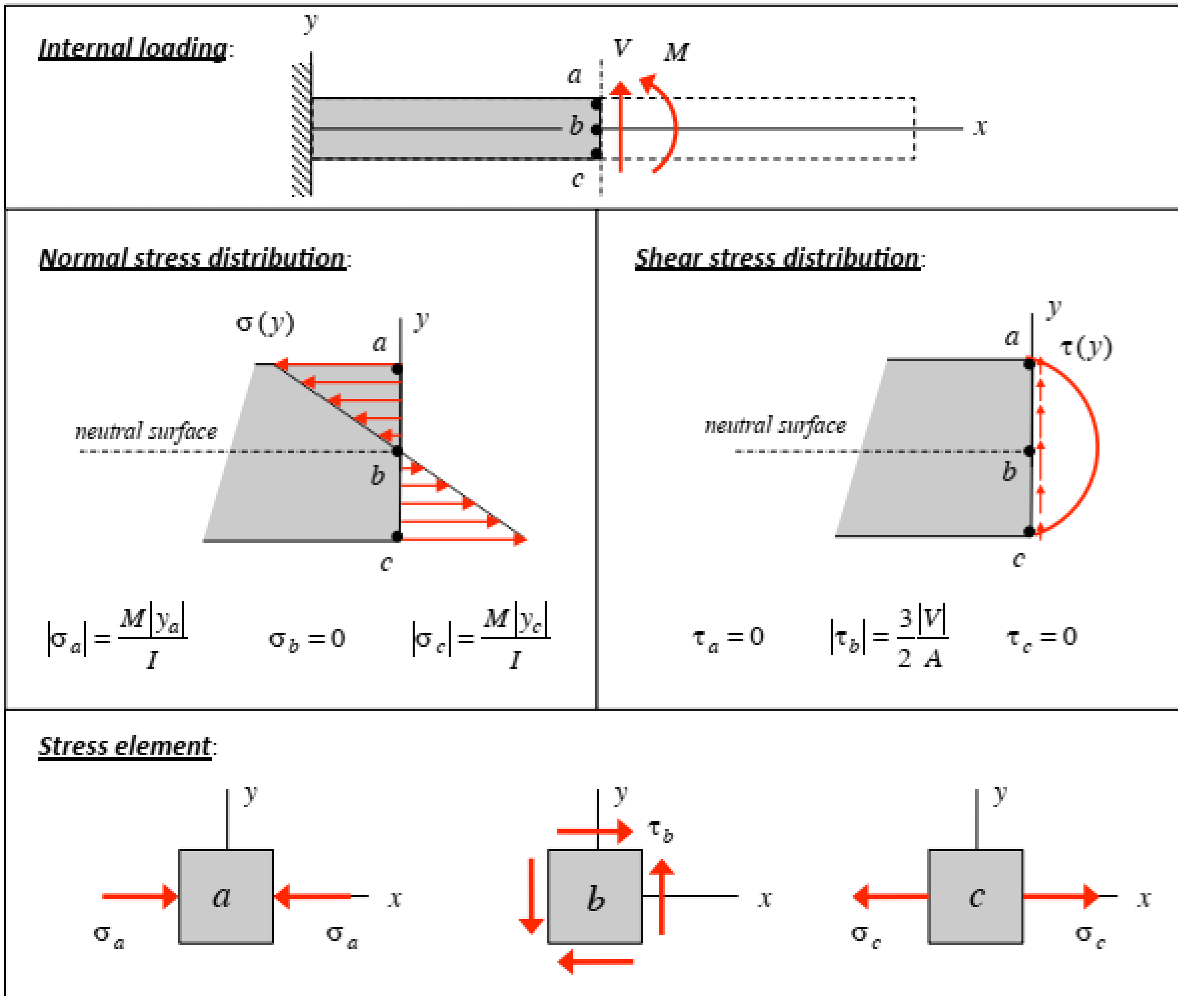
$$\tau_a = \frac{TR}{I_P} = \text{linear in radial position} \quad ; \quad I_P = \text{polar area moment}$$

Stress element:



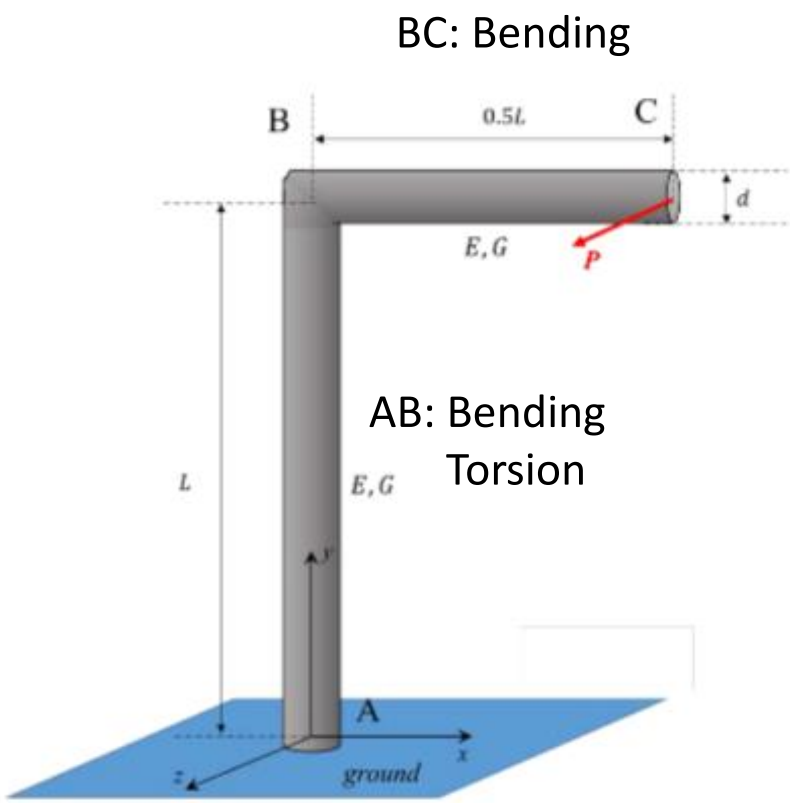
Review of Types of Loading

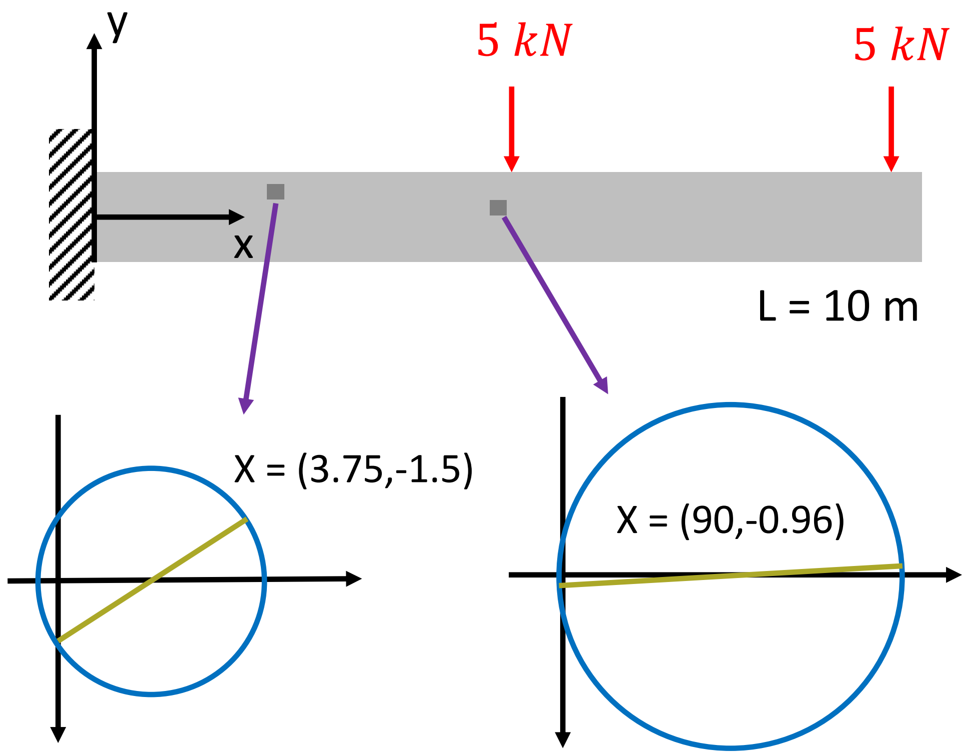
TRANSVERSE LOADING (e.g., rectangular cross section)



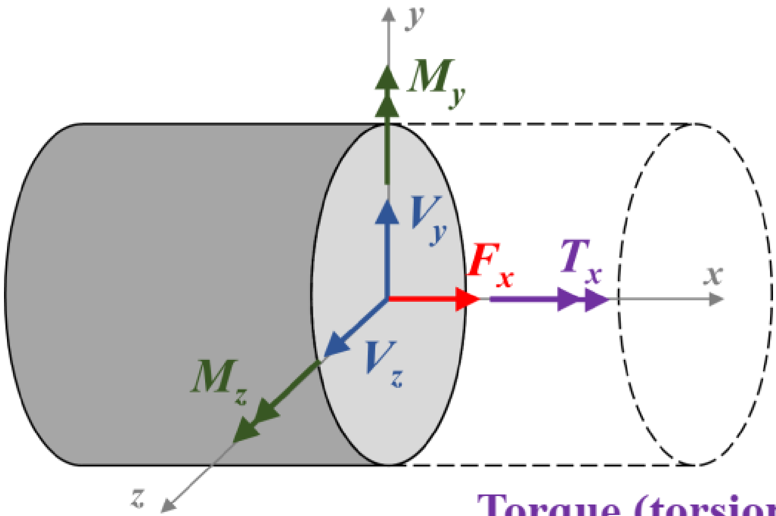
Complex Load States

HW 8





Summary of Loading Conditions

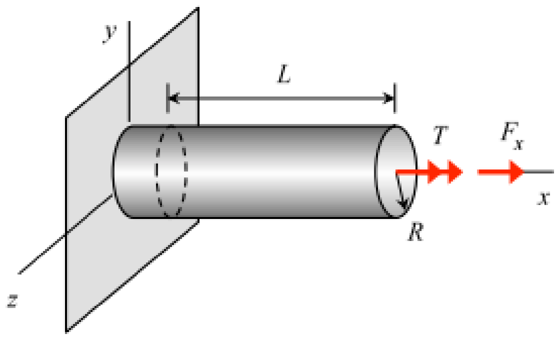


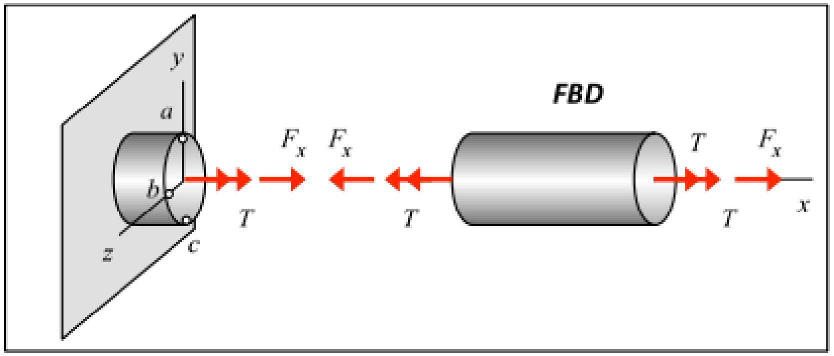
Load	Type of stress	Stress distribution	Lecture book ch.
Axial force F_x	Normal	$\sigma_x = F_x / A$	Ch. 6
Shear force V_y	Shear	$\tau_{xy} = \frac{V_y Q}{I_{zz} t}$	Ch. 10
Shear force V_z	Shear	$\tau_{xz} = \frac{V_z Q}{I_{yy} t}$	Ch. 10
Torque (torsional moment) T_x	Shear	$\tau = T\rho / I_p$	Ch. 8
Bending moment M_y	Normal	$\sigma_x = M_y z / I_{yy}$	Ch. 10
Bending moment M_z	Normal	$\sigma_x = -M_z y / I_{zz}$	Ch. 10

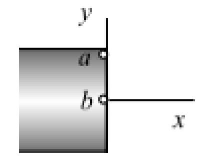
For combined loads, use superposition (possible because of the assumption of linearity).

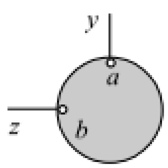
Axial + Torsion

Example I



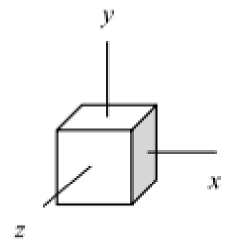




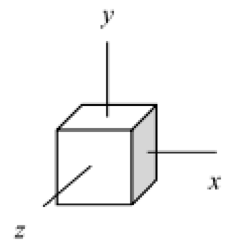


loading	*stress comp. @ "a"*	*stress comp. @ "b"*

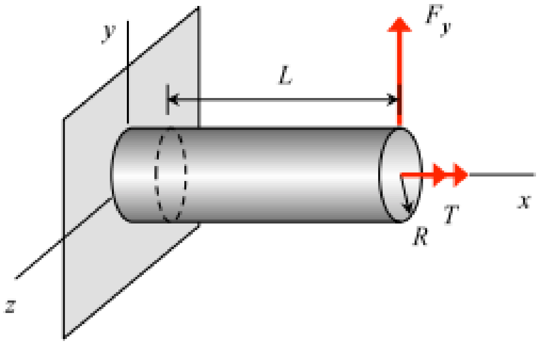
point "a"

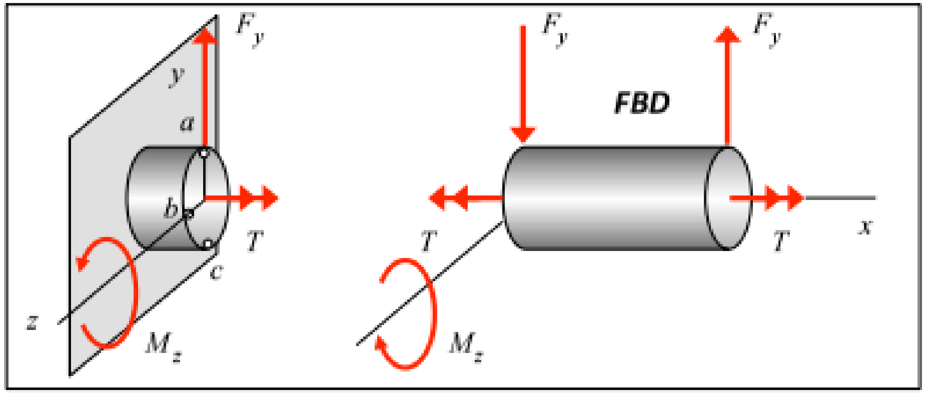


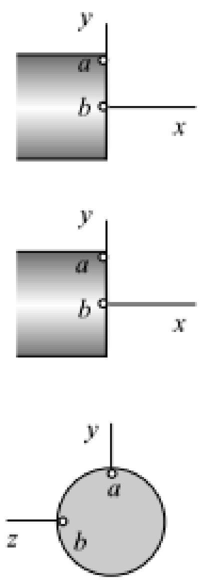
point "b"



Torsion + Bending



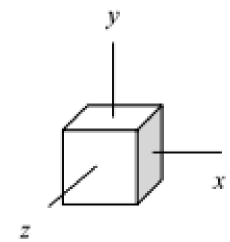




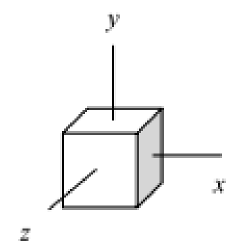
loading

loading	stress comp. @ "a"	stress comp. @ "b"

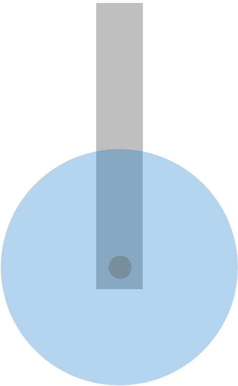
point "a"

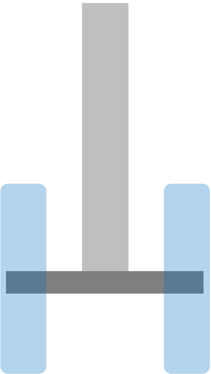


point "b"



Group Activity (not graded)





What are the loading conditions on each component of the landing gear? What information would you need to determine the stresses?

Example 14.2

A crane is made up of a vertical column AB with a boom pinned to the column at B. The columnn has a tubular cross section of thickness t, as shown below. The boom supports a block with a weight of W. Determine the maximum tensile stress and maximum compressive stress near the base cross section at A when the boom is in the position shown.