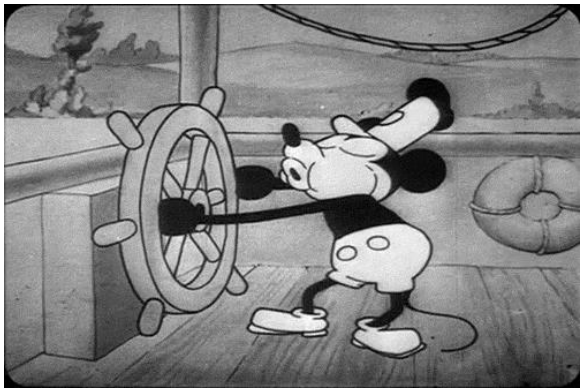
WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

STRESS ANALYSIS
ES-2502, D'2020

We will get started soon...



17 April 2020

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STRESS ANALYSIS
ES-2502, D'2020

We will get started soon...

Lecture 14:
Unit 6: tension/compression of slender longitudinal bars:
stress concentrations

17 April 2020

General information

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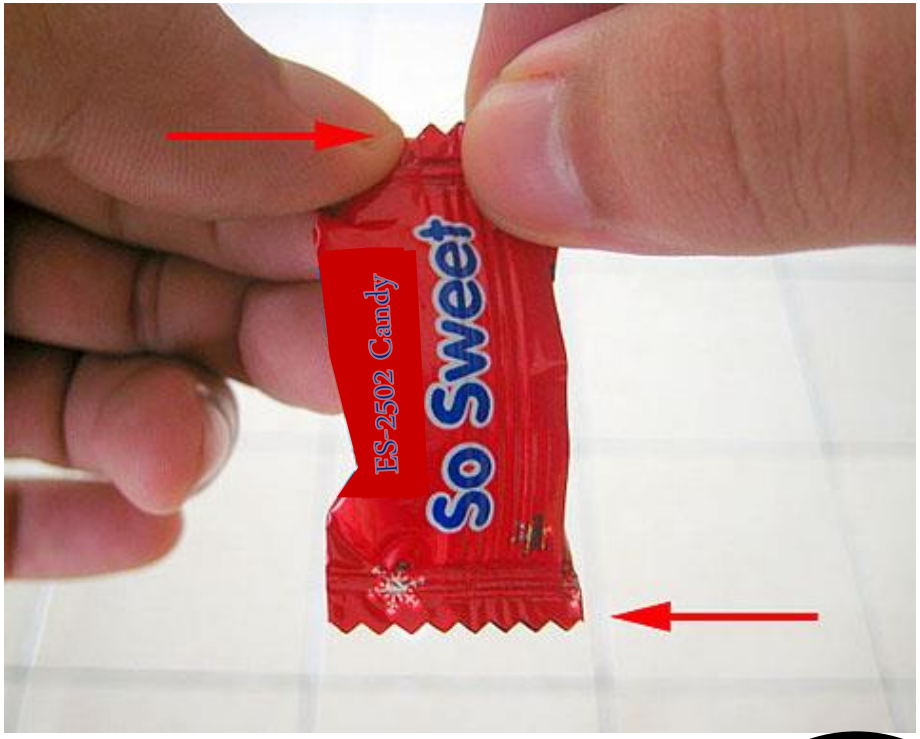
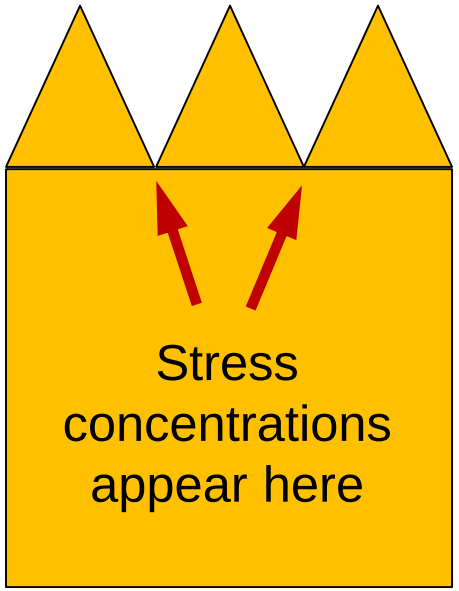
Email: zjzolotarevsky @ wpi.edu

Stress concentrations

Ripping open candy wrap with the help of stress concentration



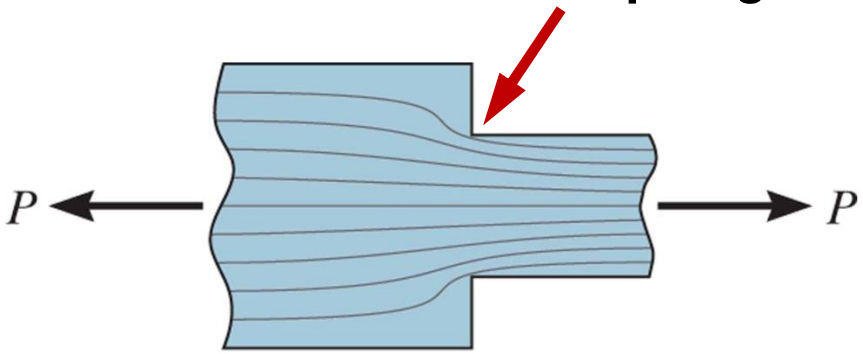
Zigzag edges added to **amplify** *applied* stresses



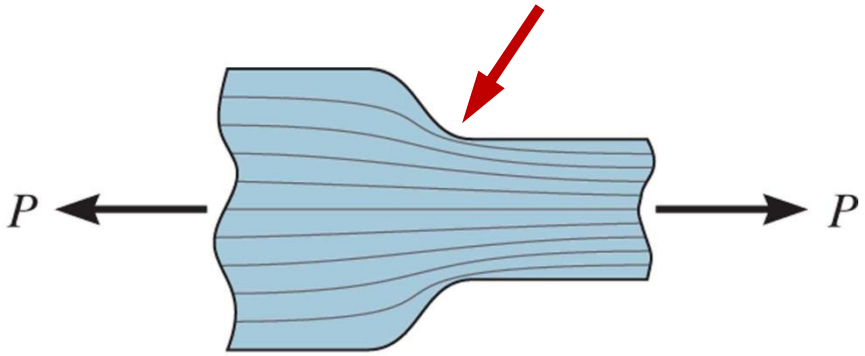
Stress concentrations: stress “flow”

Reducing stress concentrations

Stress concentration on:
sharp edges

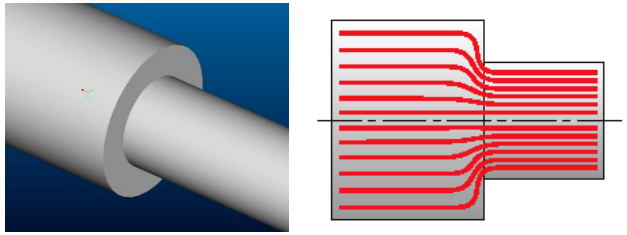


<u>Reducing</u> stress concentration:
rounding edges



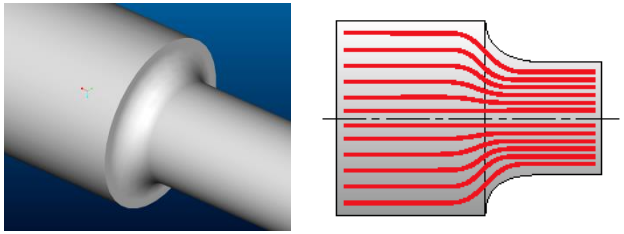
Designing to minimize stress concentrations

Initial design



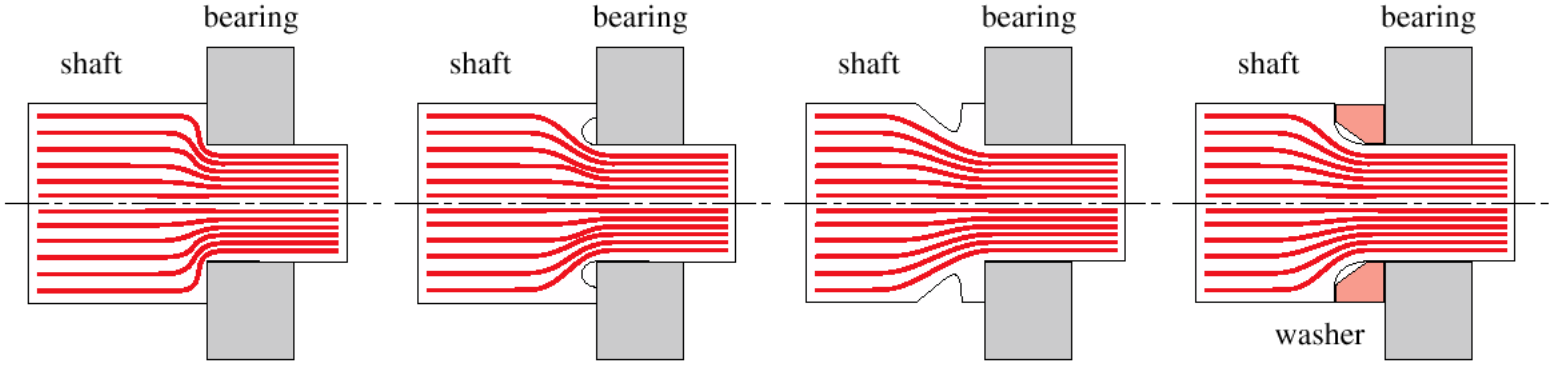
(*a*) Force flow around a sharp corner

Improved design



(*b*) Force flow around a radiused corner

Modifications to reduce stress concentrations at a sharp corner



(*a*) Stress concentration at a sharp corner

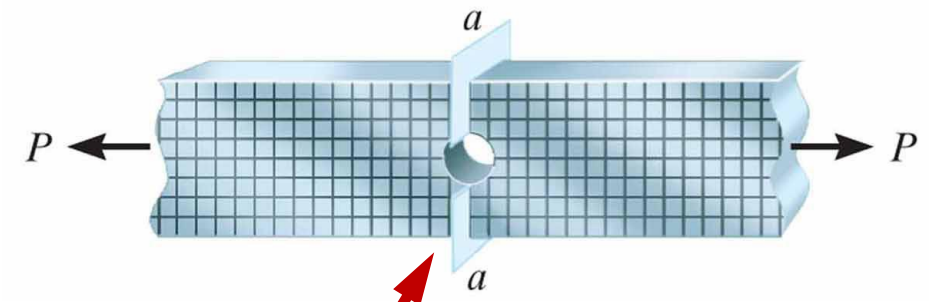
(*b*) Stress concentration reduced with radius

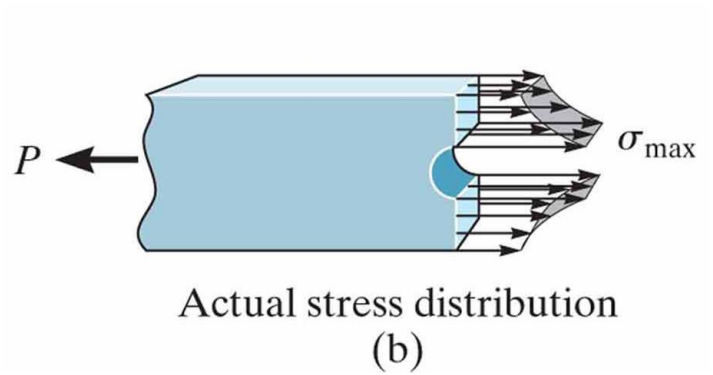
(*c*) Stress concentration reduced with groove

(*d*) Stress concentration reduced with washer

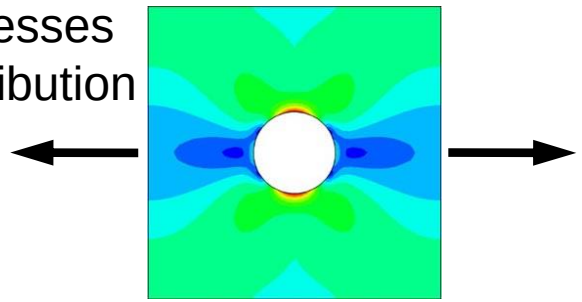
Stress concentrations

Axially loaded component with a hole: stress concentration factor

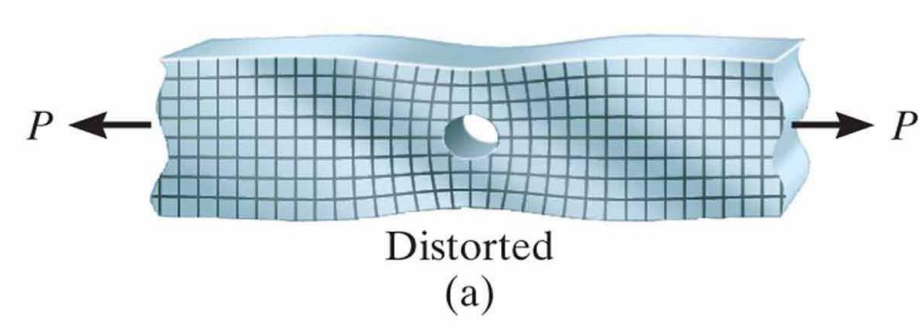


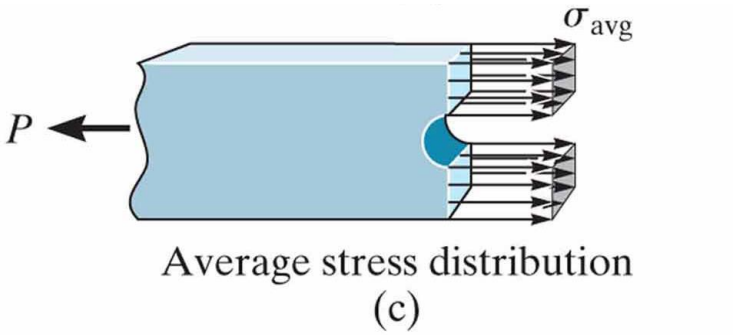


Stresses distribution



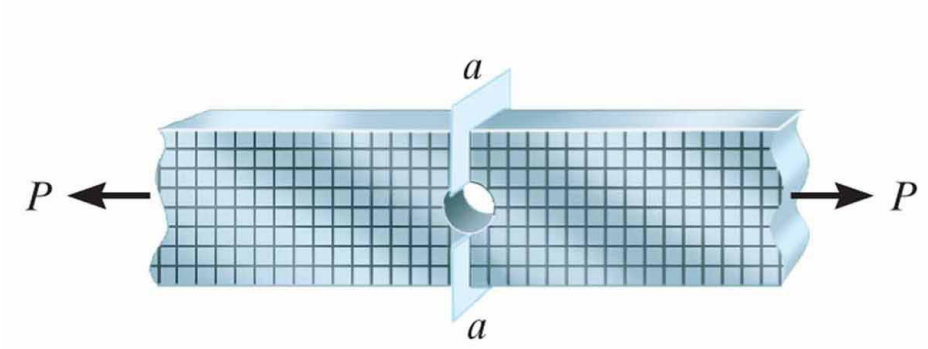
Stress concentration factor: $K = \dfrac{\sigma_{max}}{\sigma_{avg}}$

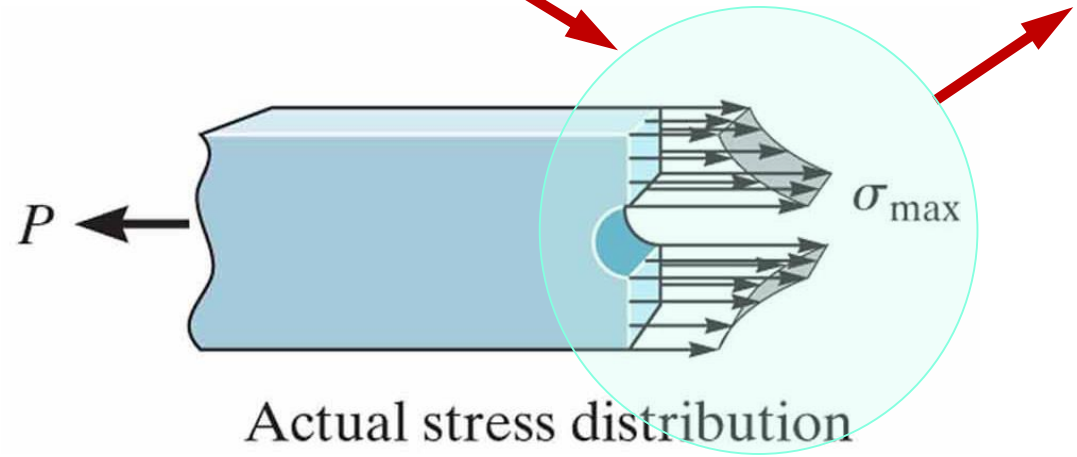




Stress concentrations

Axially loaded component with a hole: stress concentration factor



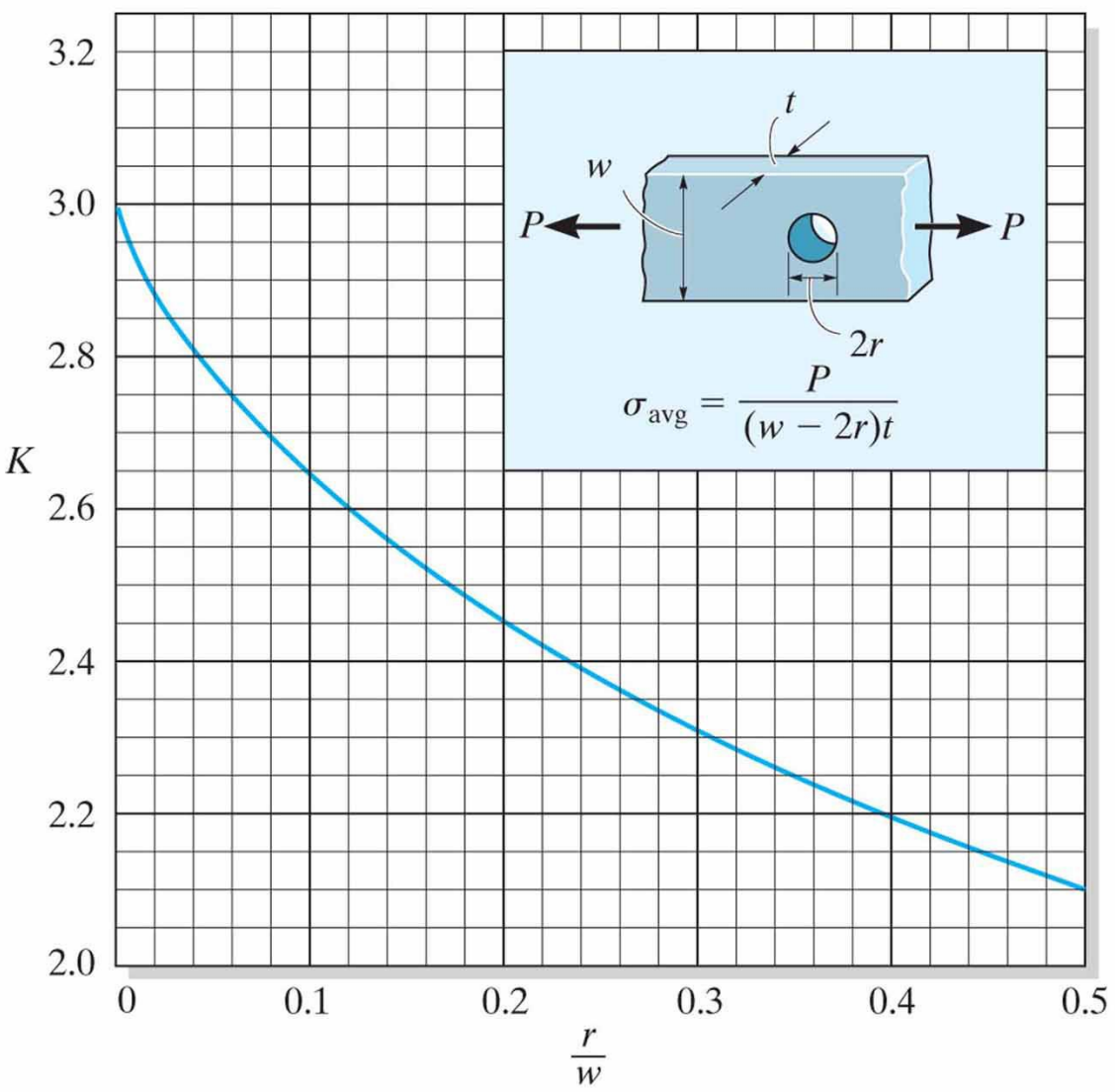


Internal balancing force at a-a

$$P = \int_{A\ @\ a\text{-}a} \sigma\, dA$$

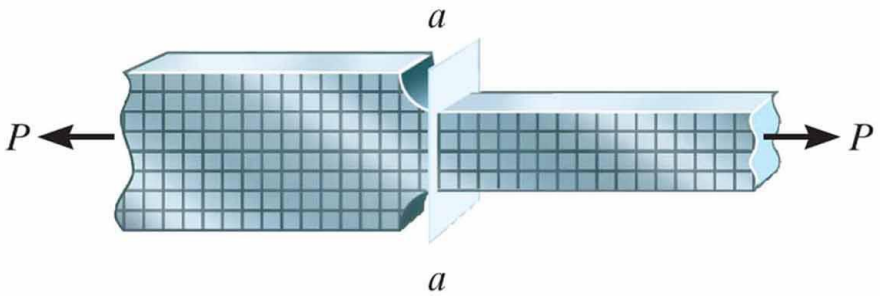
Stress concentration factor

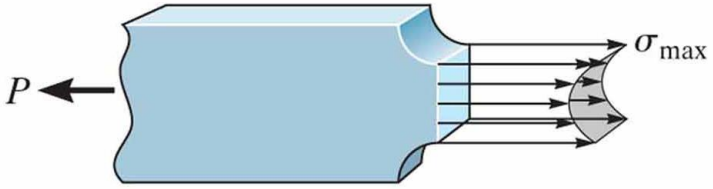
Axially loaded component with a hole



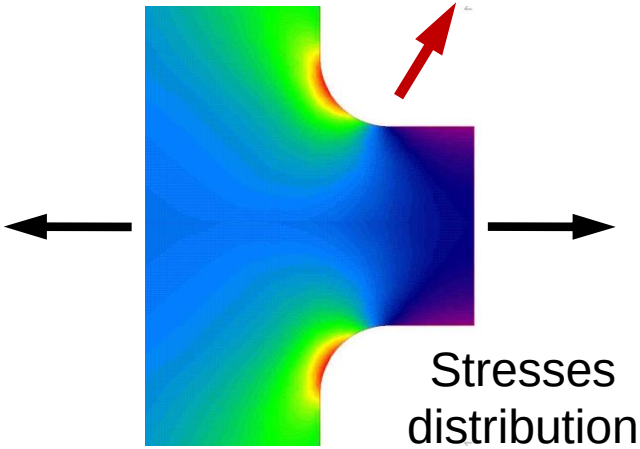
Stress concentrations

Axially loaded component with edges: stress concentration factor



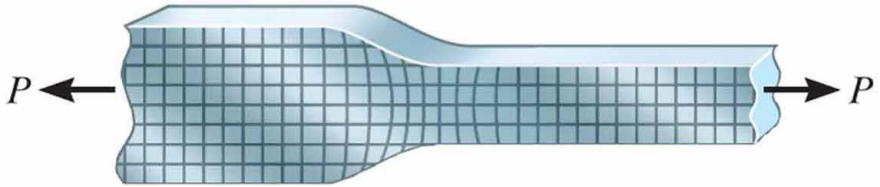


Actual stress distribution
(b)

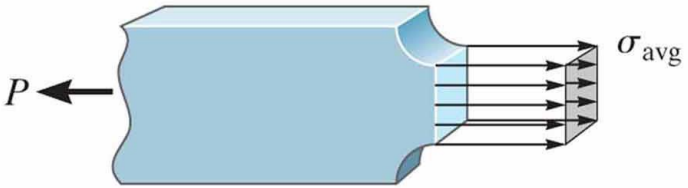


Stresses distribution

Stress concentration factor: $K = \dfrac{\sigma_{\max}}{\sigma_{\text{avg}}}$



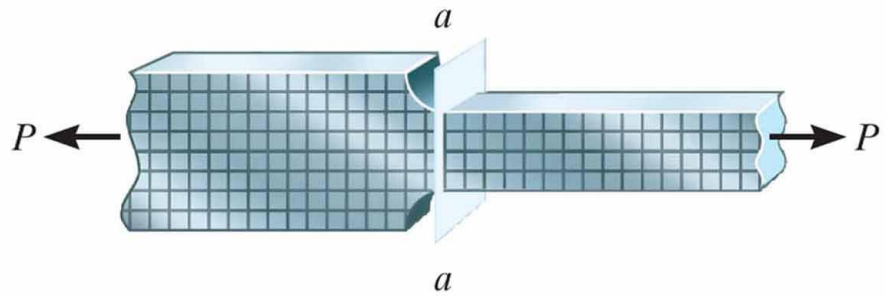
Distorted
(a)



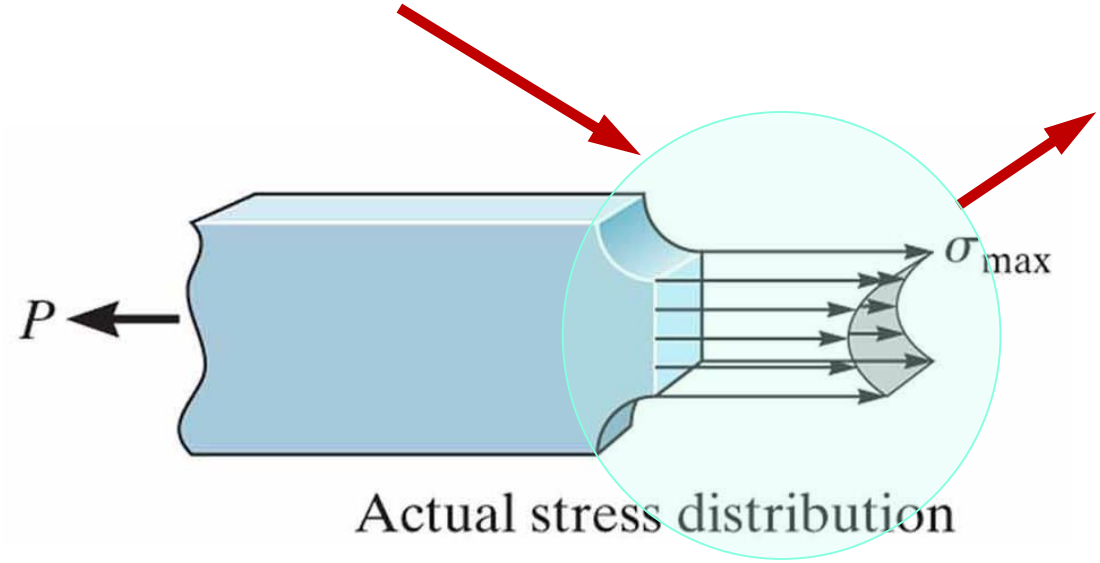
Average stress distribution
(c)

Stress concentrations

Axially loaded component with edges: stress concentration factor



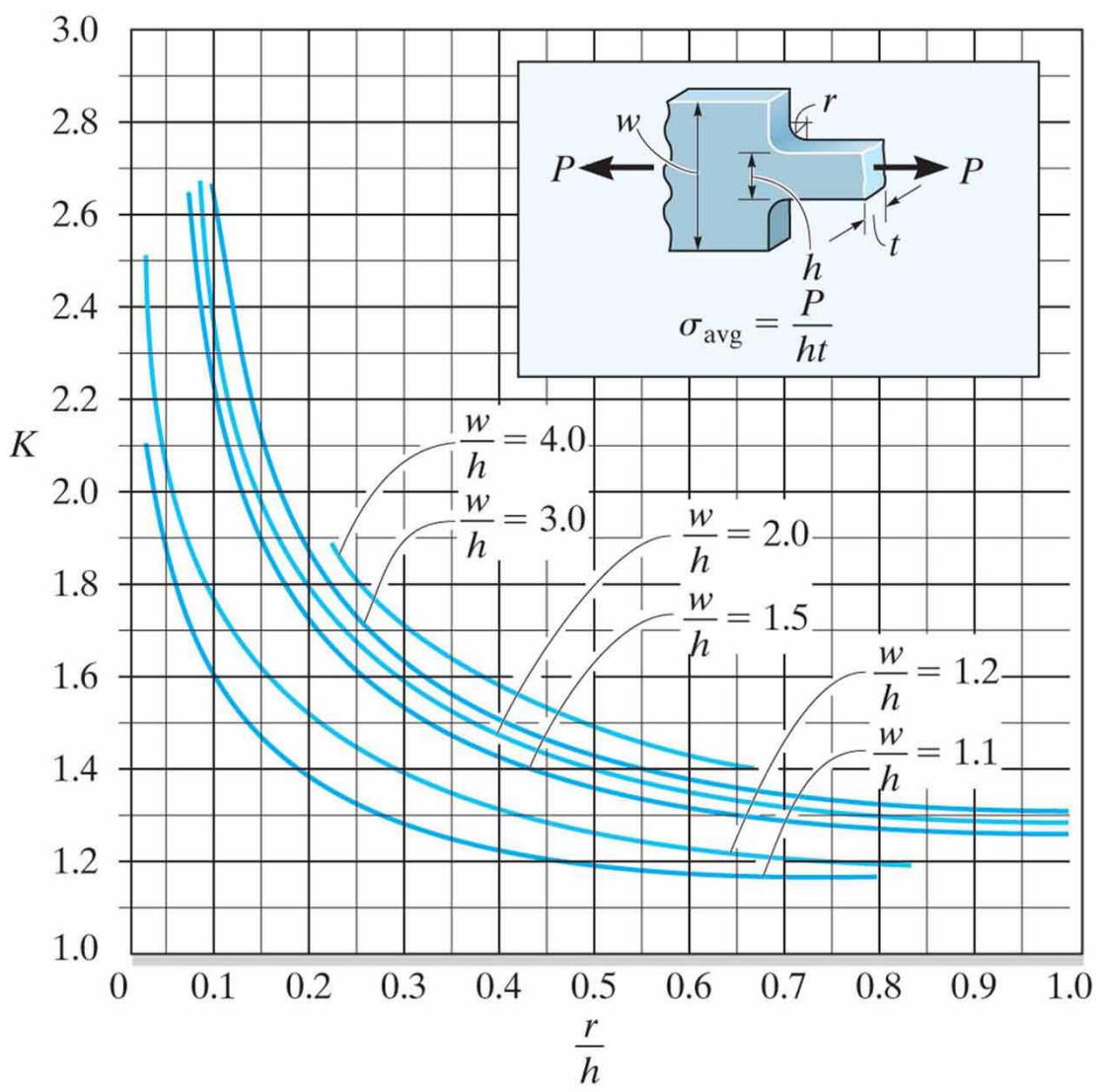
Internal balancing force at a-a



$$P = \int_{A\ @\ a\text{-}a} \sigma\, dA$$

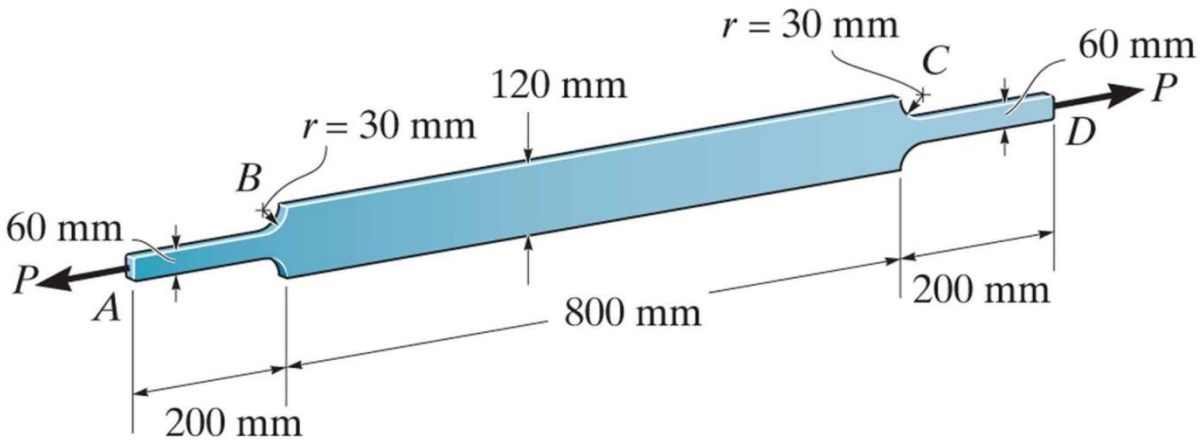
Stress concentration factor

Axially loaded component with edges



Axial load: example O

The A-36 steel plate has a thickness of $12\ \text{mm}$. If there are shoulder fillets at B and C, and $\sigma_{Allow} = 150\ \text{MPa}$, determine the maximum axial load P that it can support. Calculate its elongation, neglecting the effect of the fillets.

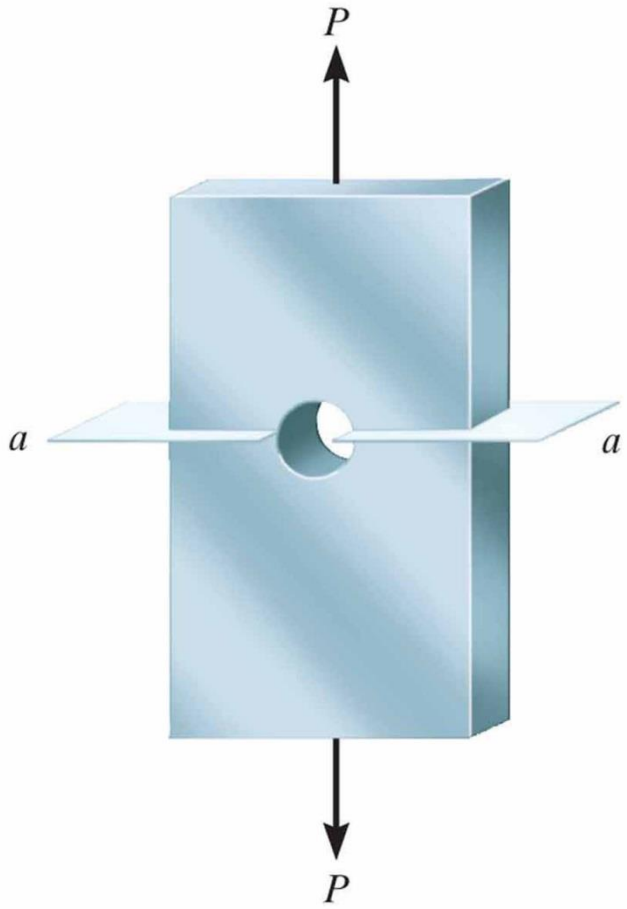


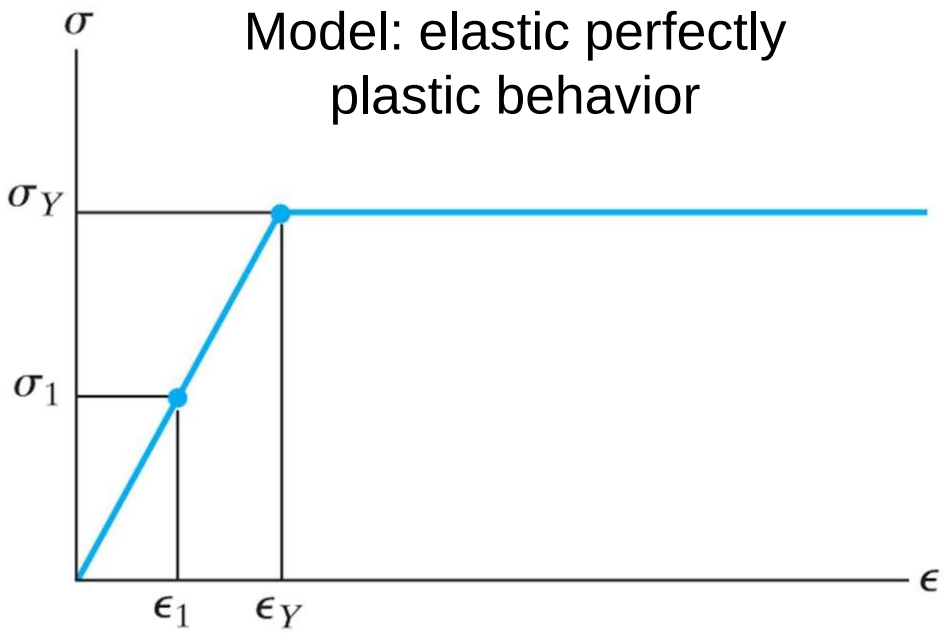
Approach:

1) Determine stress concentration factors
2) Compute maximum load
3) Compute elongation

Inelastic axial deformation

Plastic deformations



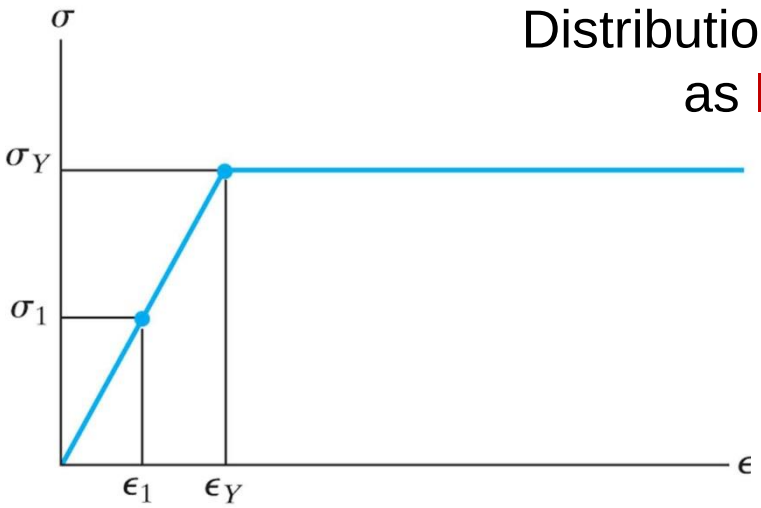


Model: elastic perfectly plastic behavior

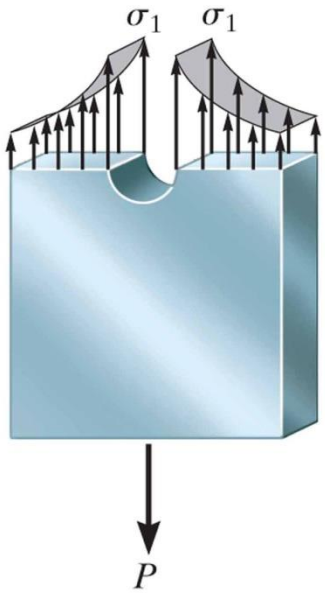
Inelastic axial deformation

Plastic deformations

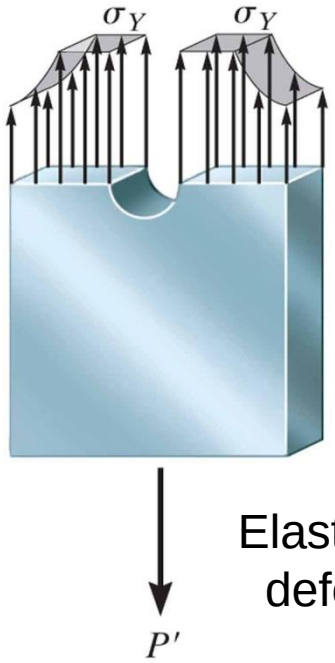
Distribution of **internal stresses** as **load increases**



Elastic deformations



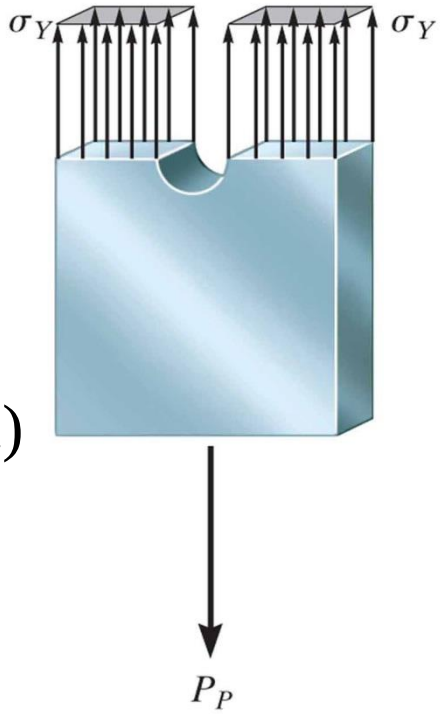
(a)



(b)

Elastic + plastic deformations

Plastic deformations



(c)

Reading assignment

- Chapters 3 and 4 of textbook
- Review notes and text: ES2001, ES2501

Homework assignment

- As indicated on webpage of our course