力学与航空航天工程系
DEPARTMENT OF MECHANICS AND AEROSPACE ENGINEERING

MECHANICS OF MATERIALS

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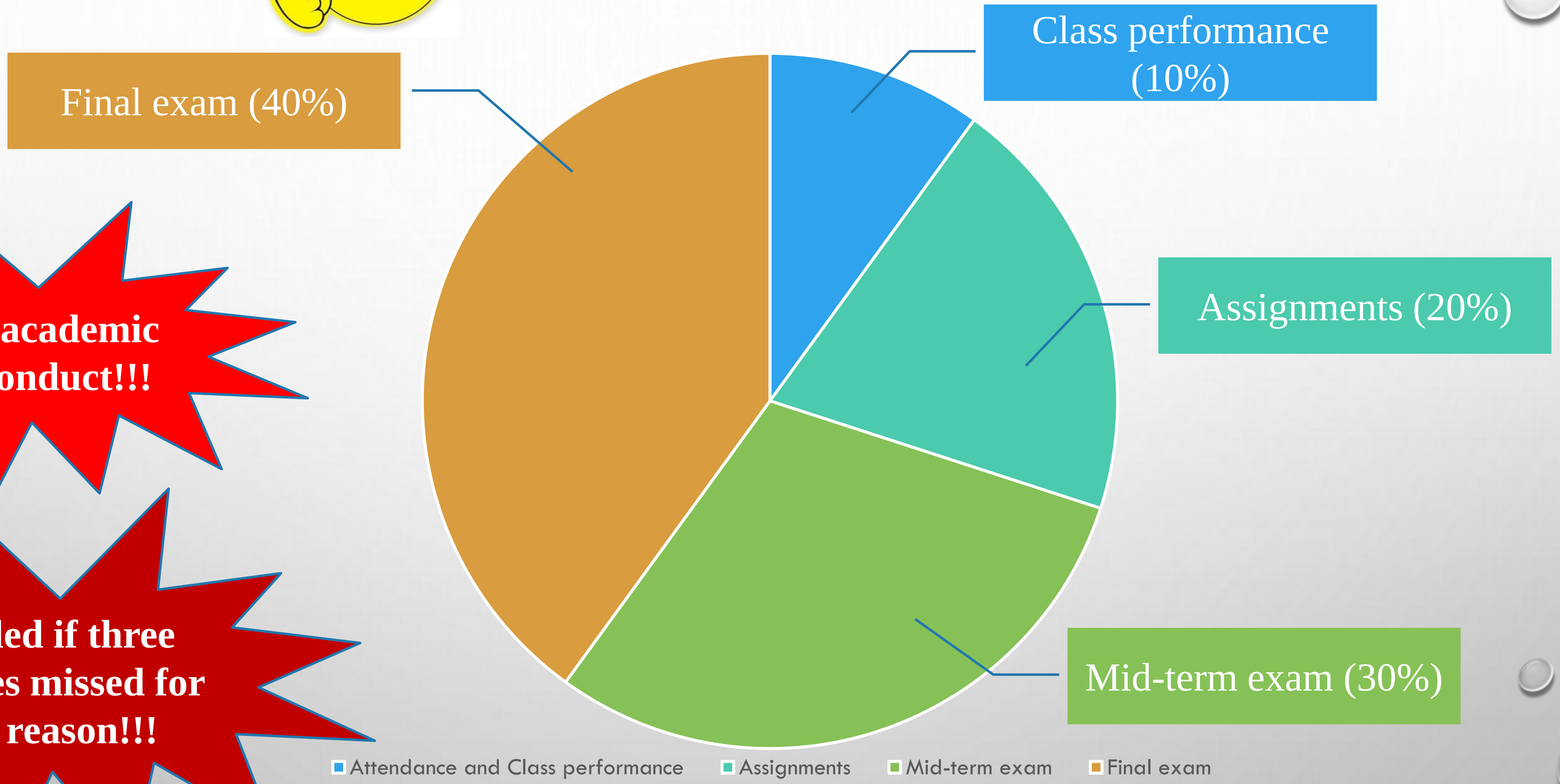
MAE202 SPRING 2022

Letter grades

Final Score	Letter Grade
97-100	A+
93-97	A
90-93	A-
87-90	B+
83-87	B
80-83	B-
77-80	C+
73-77	C
70-73	C-
67-70	D+
63-67	D
60-63	D-
0-60	F

Assessment



0 for academic misconduct!!!

Failed if three classes missed for no reason!!!

Mechanics of Materials-2022S

该二维码7天内(2月18日前)有效，重新进入将更新

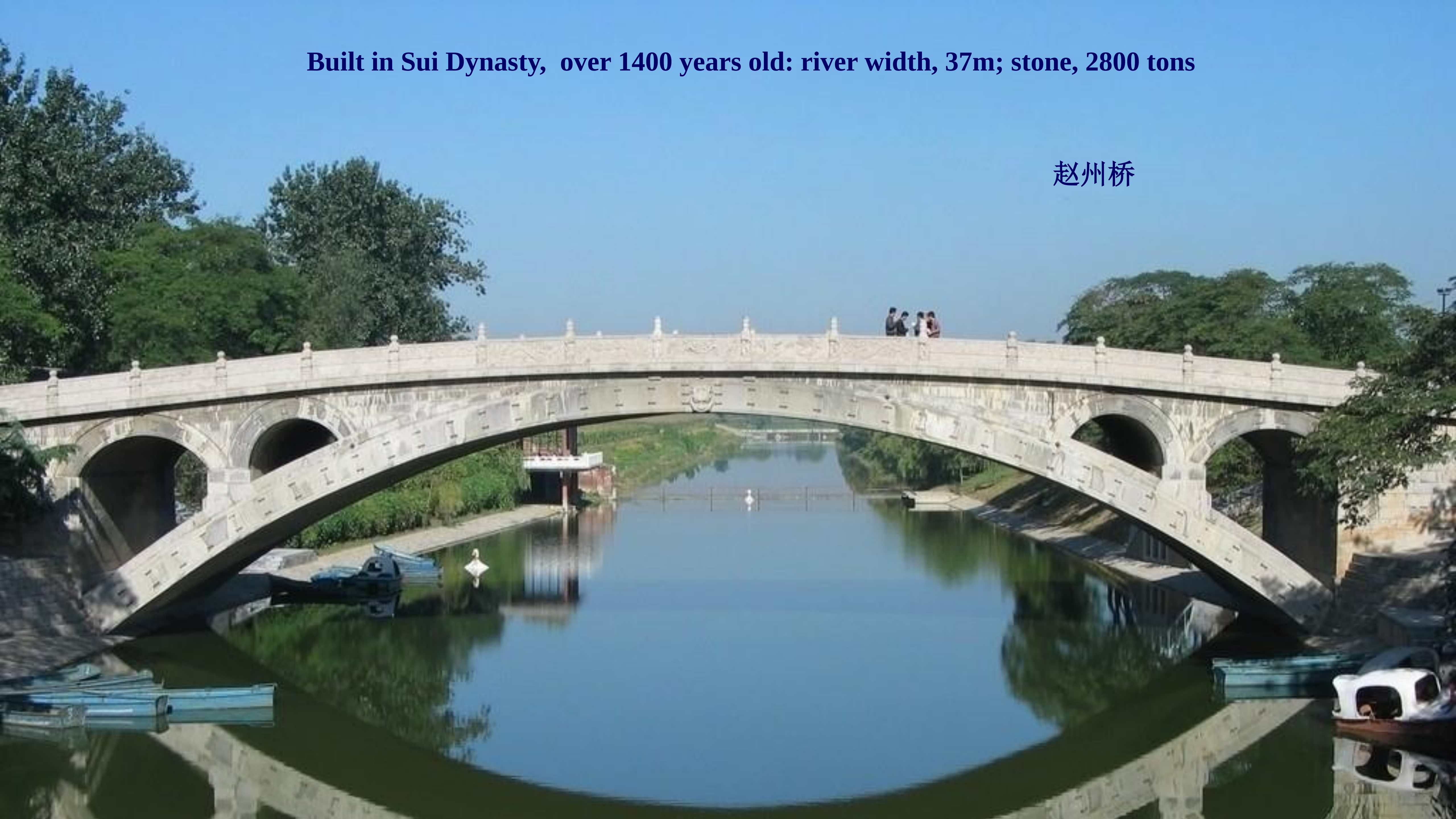
Textbooks

- Ferdinand P. Beer, E. Russell Johnston, Jr. John T. DeWolf, David F. Mazurek, Mechanics of Materials, 6th edition.
- R. C. Hibbeler, Mechanics of Materials, 8th edition, Pearson (Reprints available in Mainland China)
- 孙训方，方孝淑， 关来泰编， 《材料力学》第六版，高等教育出版社，2020
- 殷有泉，励争，邓成光编， 《材料力学》第二版，北京大学出版社，2006

Lesson 1： Introduction

- Basic tasks and main objects of Mechanics of Materials,
- Deformable bodies and basic assumptions,
- Internal forces, stress, strain
- Basic deformation of rod members.

Built in Sui Dynasty, over 1400 years old: river width, 37m; stone, 2800 tons



山西应县佛宫寺释迦塔

Over 950 years old

Height, 67m, 7200 tons of wood

The highest wood tower

都江堰安澜竹索桥，**built at ~250 B. C.**


Mavic Pro


说到跨海大桥

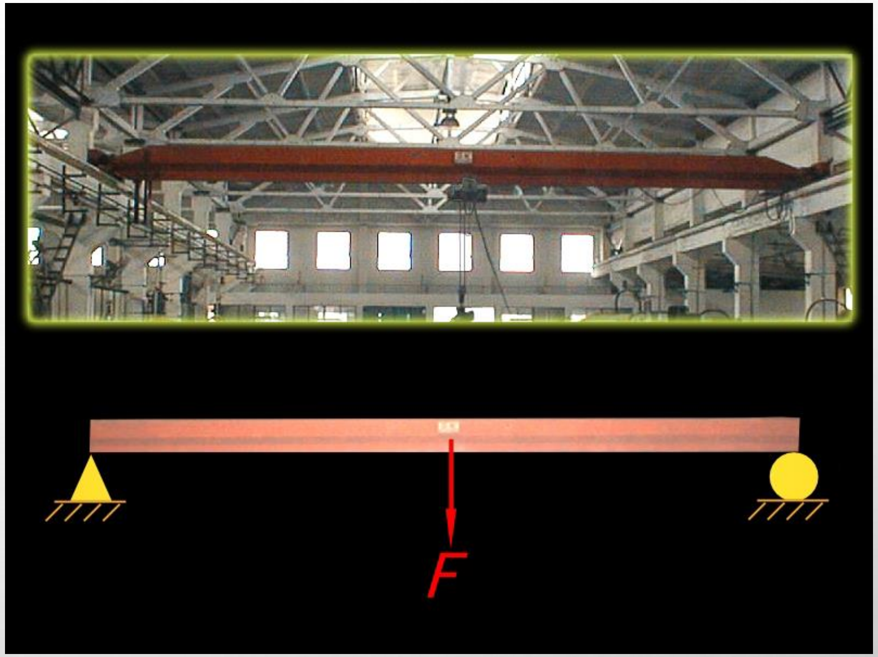

BRITISH
PATHÉ
TACOMA BRIDGE
COLLAPSE
PATHE GAZETTE

§ 1.1 Main objective of this course

The main objective of the study of the mechanics of materials is to provide the future engineers with the means of analyzing and designing various machines and load bearing structures.

strength	stiffness	stability
damage	deformation	equilibrium

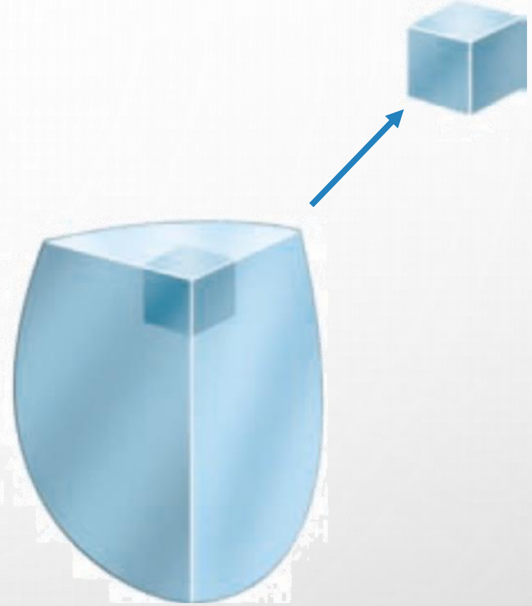
§ 1.2 Deformable solid bodies

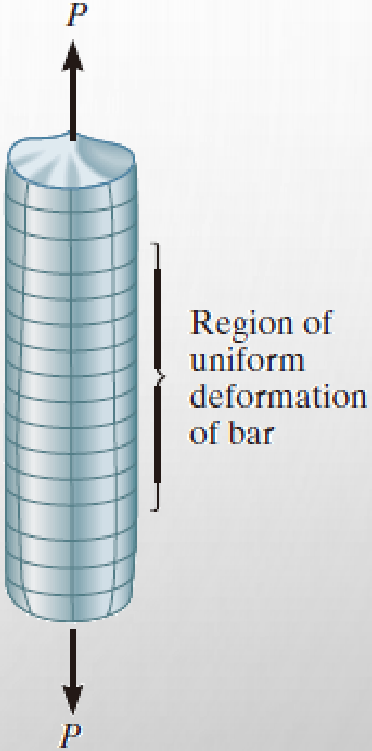


A solid body is deformable in the sense that its shape and/or size is changed under loads.

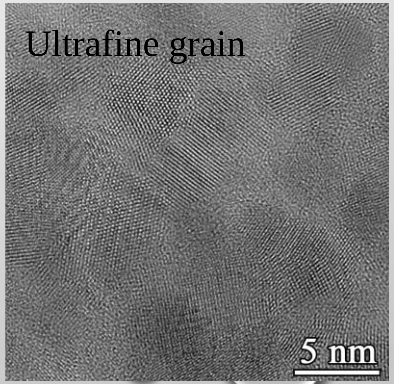
§ 1.3 Basic assumptions

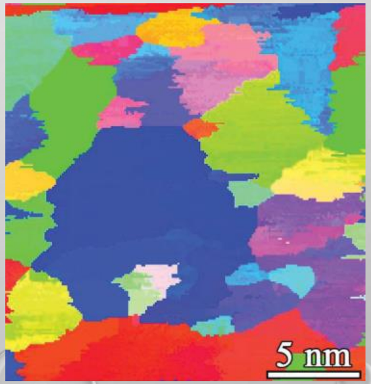
- **Continuous**: it consists of a continuum or uniform distribution of matter having no voids.
- **Homogeneous**: it has the same physical and mechanical properties throughout its volume
- **Isotropic**: it has the same properties in all directions





Magnesium alloy



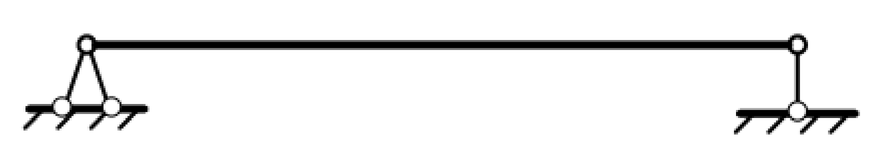


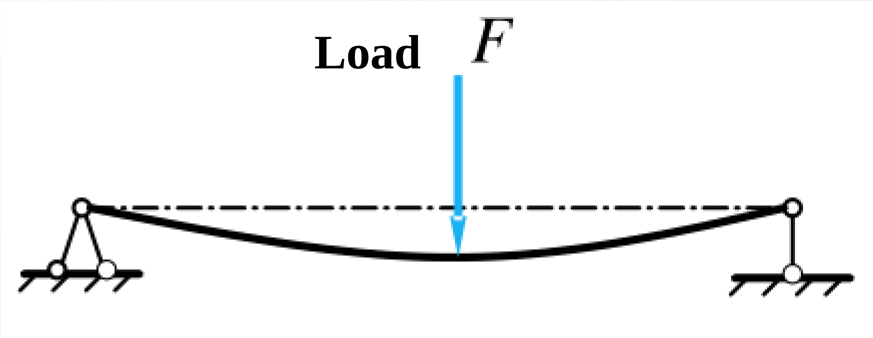
§ 1.4 Deformation

- **Elastic deformation**: reversible, Hooke’s law
- **Plastic deformation**: irreversible

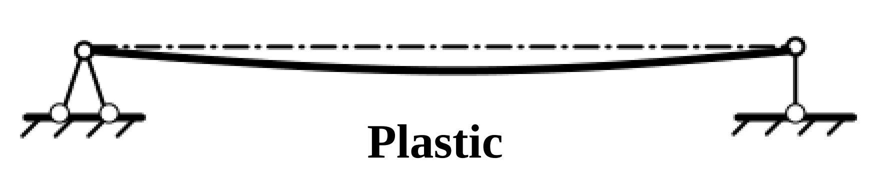
Small or elastic deformation assumption

Initial



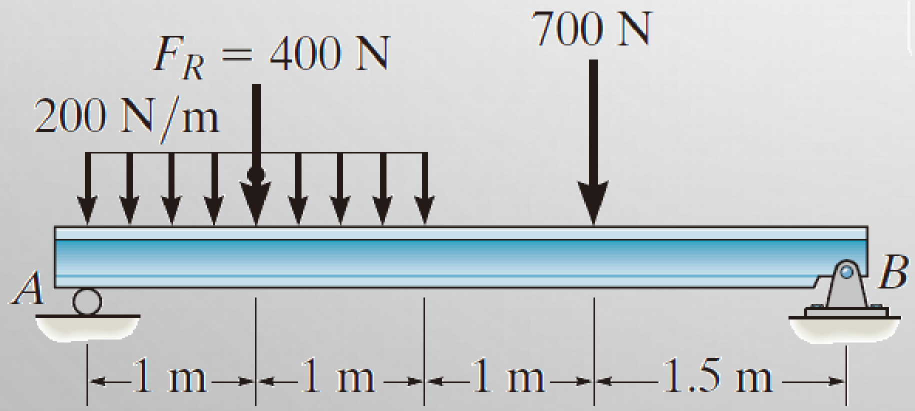


Unload



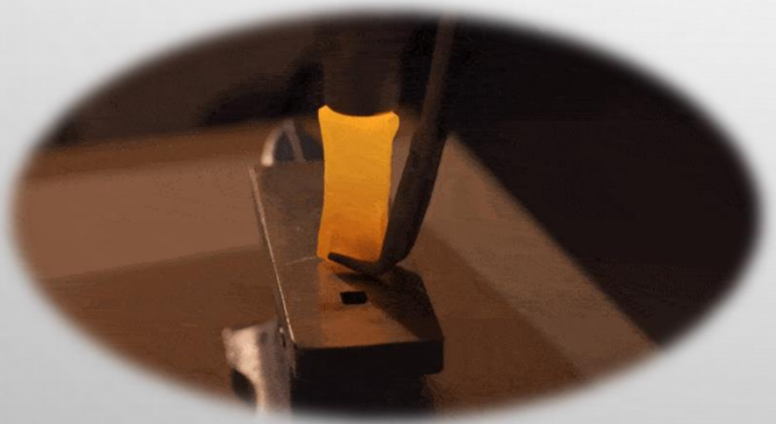
§ 1.5 External loads

- **Body loads**: due to gravitation, inertia or magnetic field
- **Surface loads**: distributed forces and concentrated forces

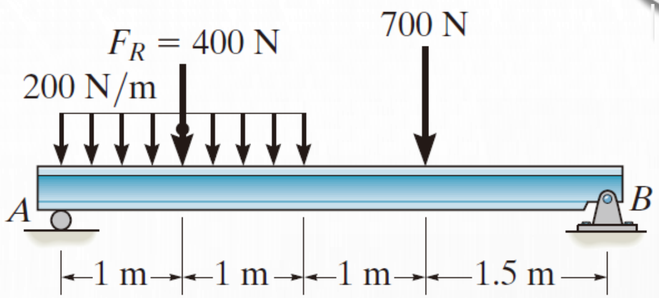


§ 1.5 External loads – time dependence

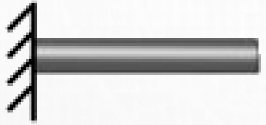
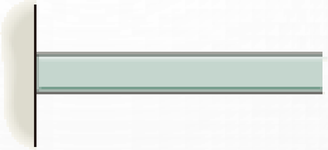
- **Static loads:** keep constant after being loaded
- **Dynamic loads**: impact, periodic, random



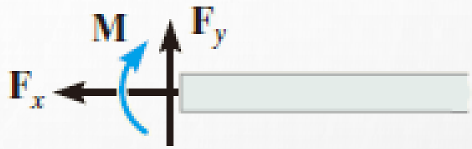
§ 1.6 Support reactions



- **Fixed support:**

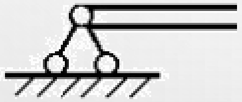
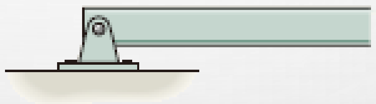



Fixed support

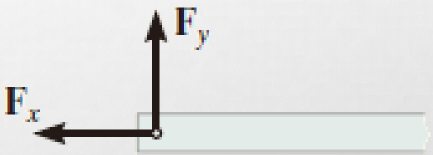


Three unknowns: F_x, F_y, M

- **External pin**:

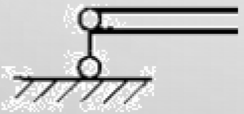



External pin

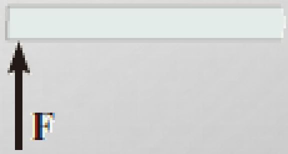


Two unknowns: F_x, F_y

- **Roller**:



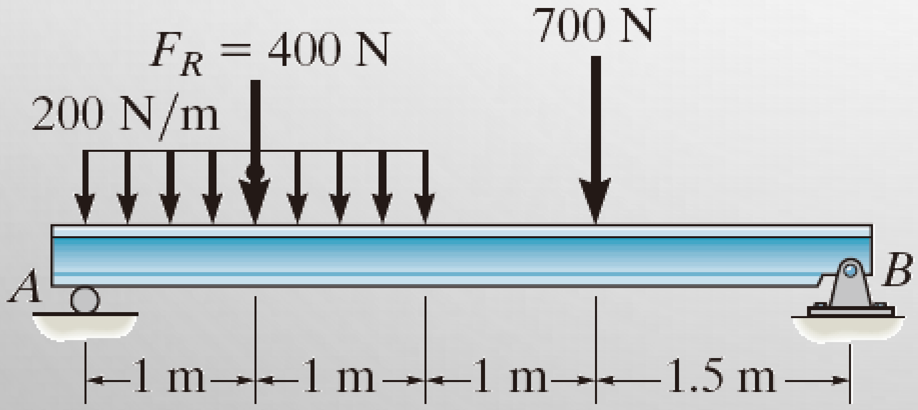

Roller

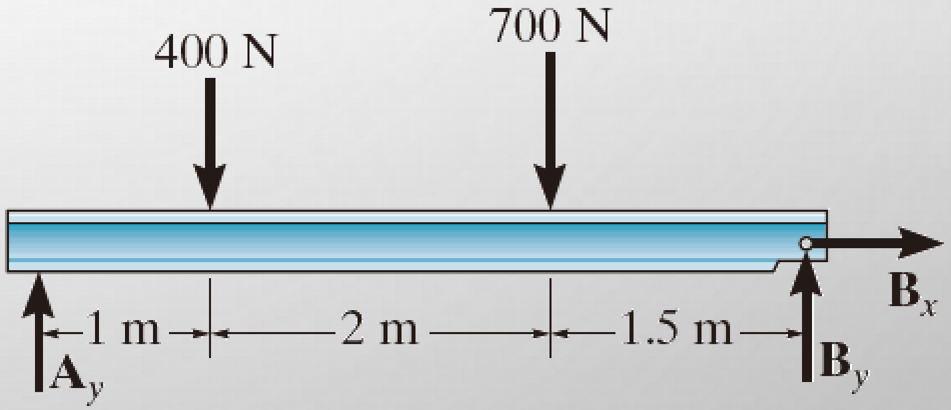


One unknown: F

§ 1.7 Equilibrium of a deformable body

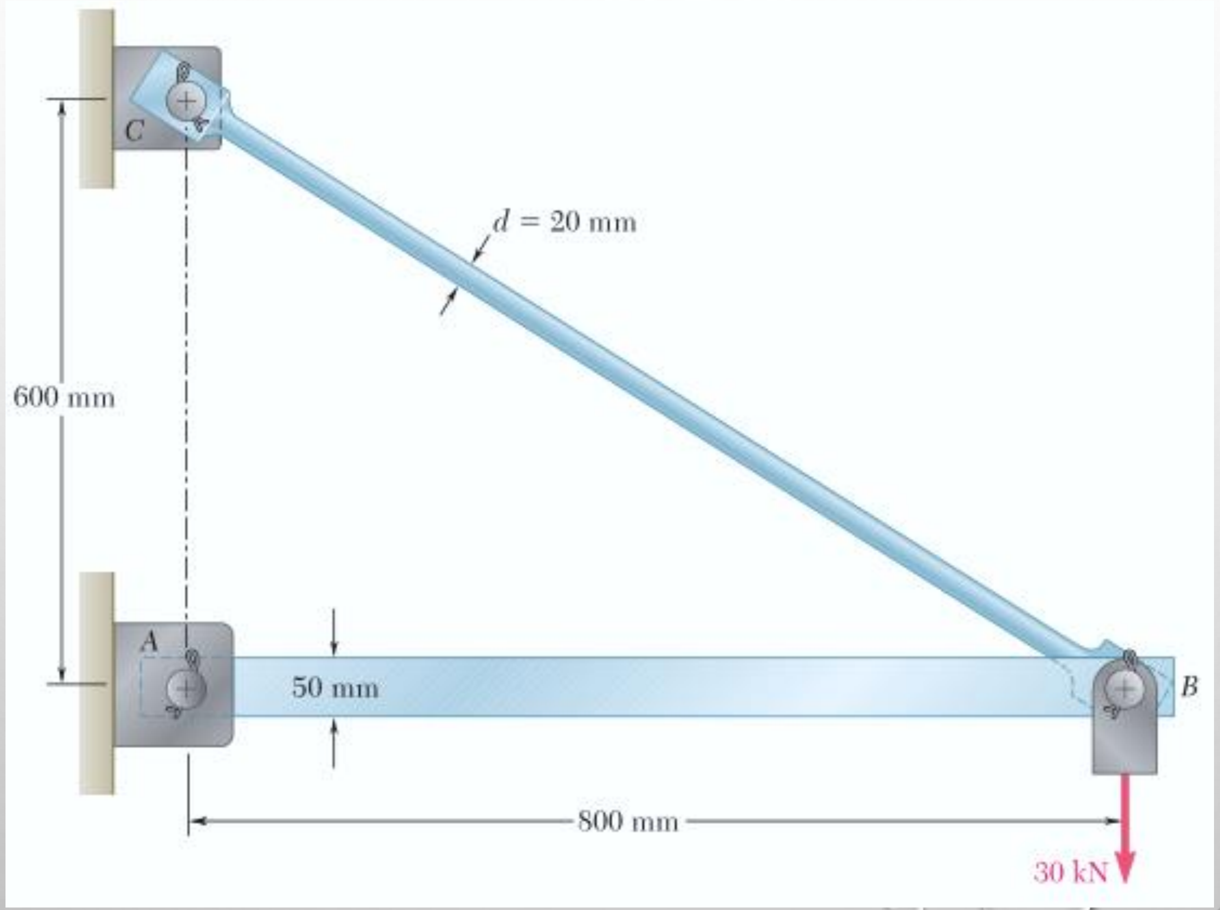
- **Balance of forces** $\Sigma \mathbf{F} = 0$ $\Sigma F_x = 0$ $\Sigma F_y = 0$ $\Sigma F_z = 0$
- **Balance of moments** $\Sigma \mathbf{M}_O = 0$ $\Sigma M_x = 0$ $\Sigma M_y = 0$ $\Sigma M_z = 0$



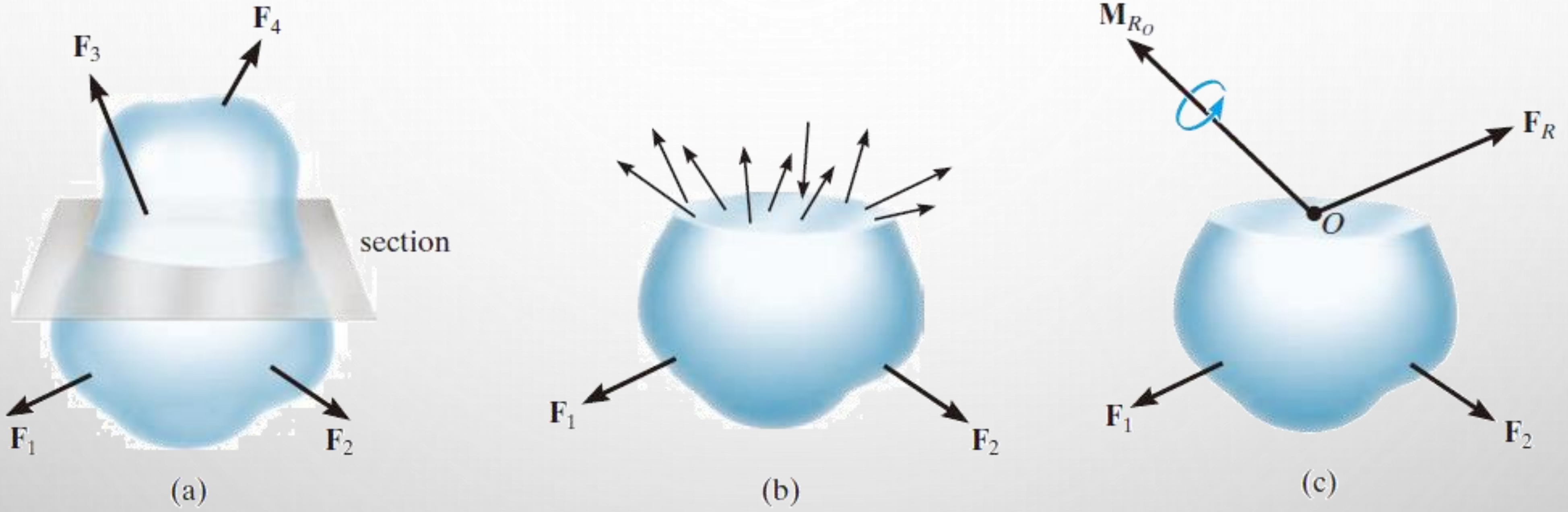


Example 1.1

Determine the support reactions under a 30 kN load.

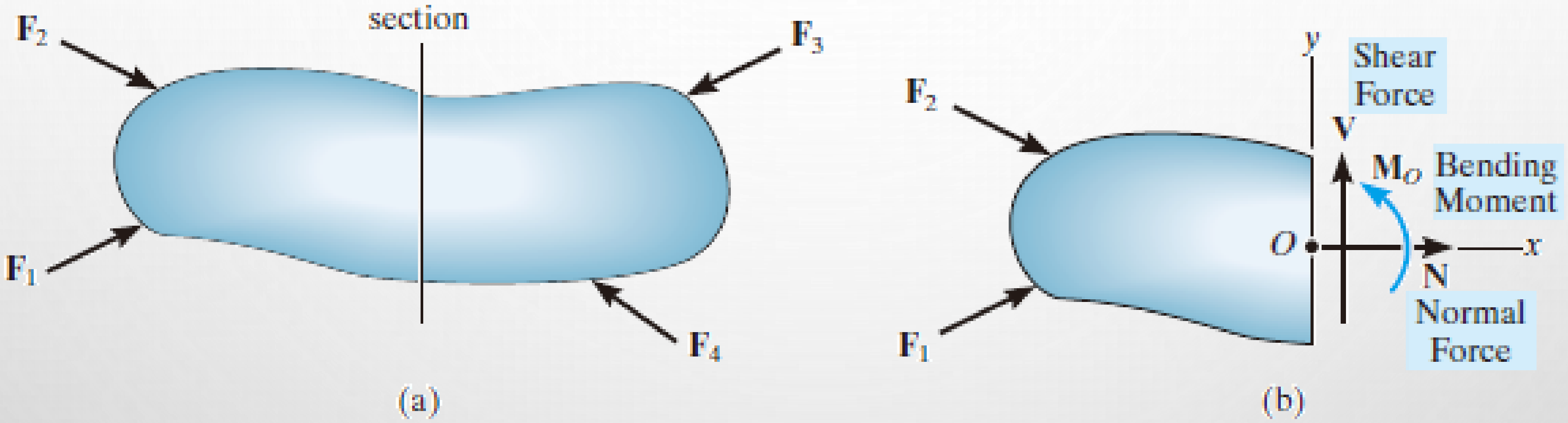


§ 1.8 Internal resultant loadings and method of section



In order to obtain the internal loadings acting on a specific region within the body, it is necessary to pass an imaginary section or “cut” through the region where the internal loadings are to be determined.

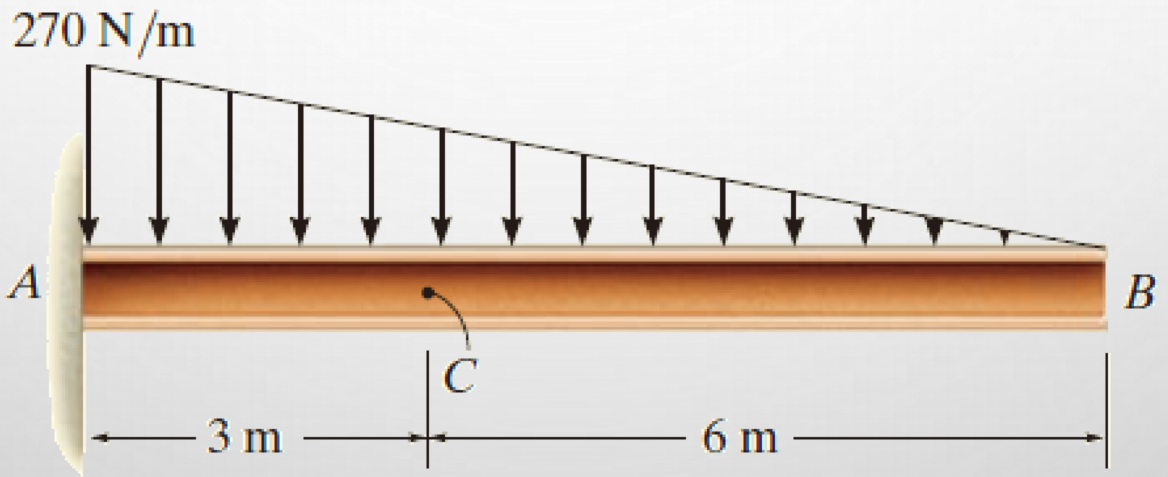
§ 1.8 Internal resultant loadings – coplanar (2D)



If the body is subjected to a coplanar system of forces, then only normal-force, shear-force, and bending moment components will exist at the section.

Example 1.2

Determine the resultant internal loadings acting on the cross section at C of the cantilevered beam.

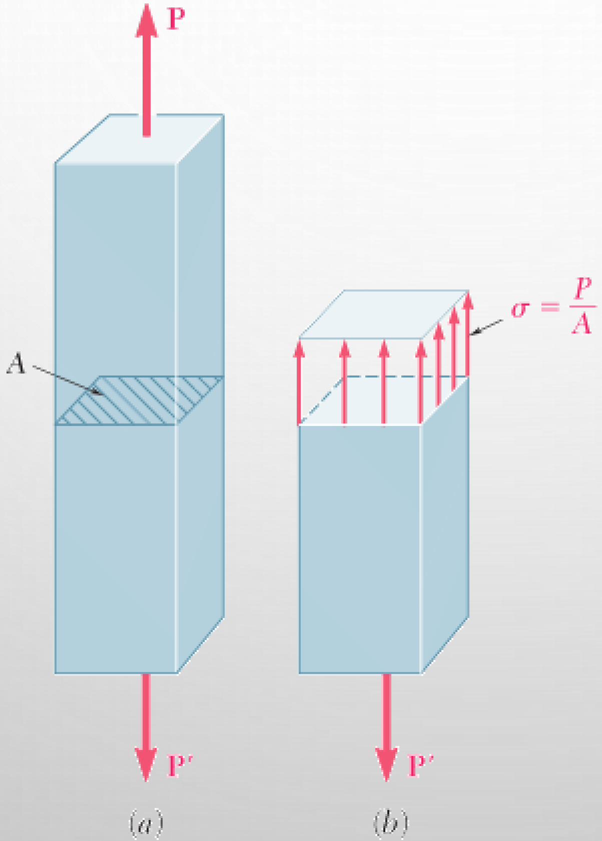


§ 1.9 Normal stress

- **Average normal stress**

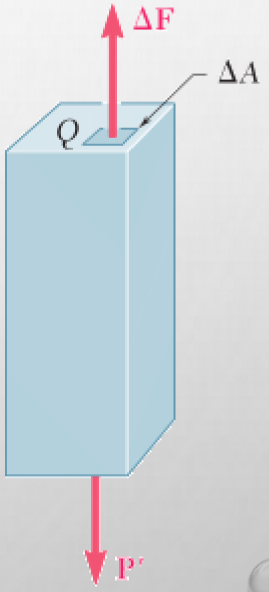
$$\sigma_{avg} = \frac{P}{A}$$

unit, Pa = N/m^2



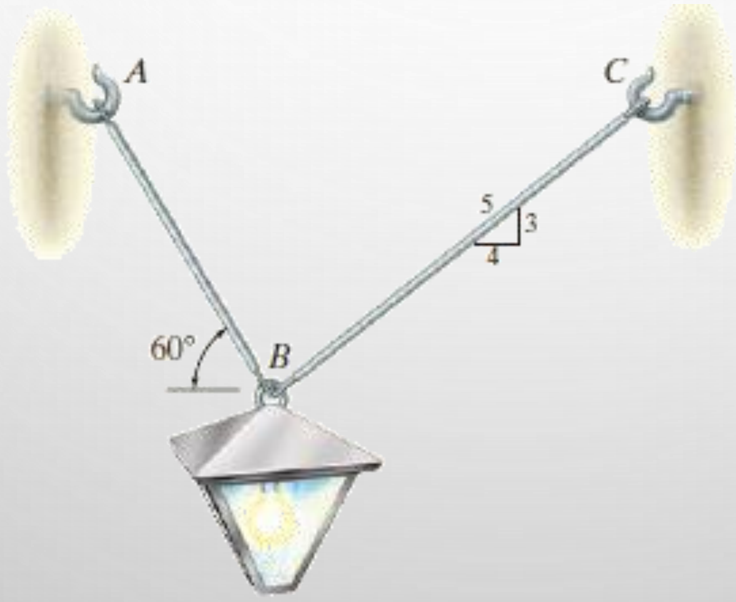
- **Local normal stress**

$$\sigma = \lim_{\Delta A \to 0} \frac{\Delta F}{\Delta A}$$



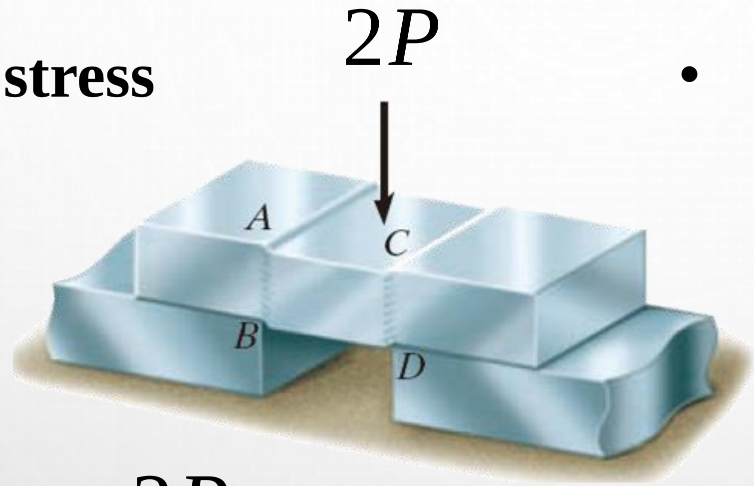
Example 1.3

The 80-kg lamp is supported by two rods AB and BC as shown. If AB has a diameter of 10 mm and BC has a diameter of 8 mm, determine the average normal stress in each rod.

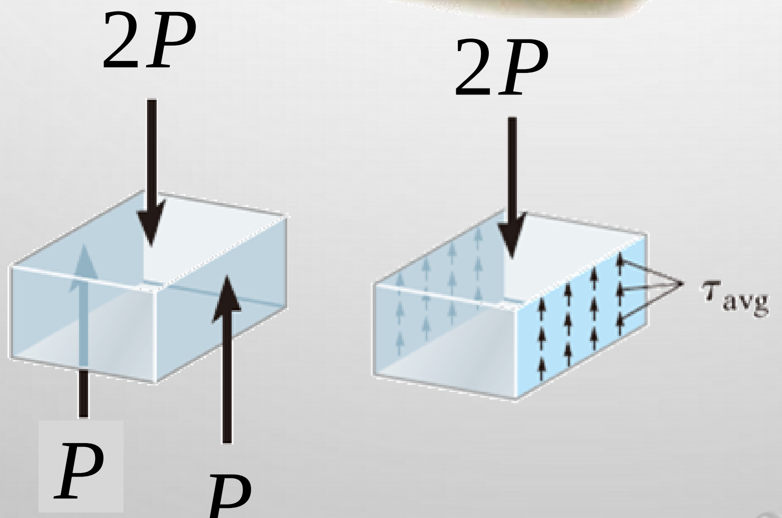


§ 1.10 Shear stress

- **Average shear stress**

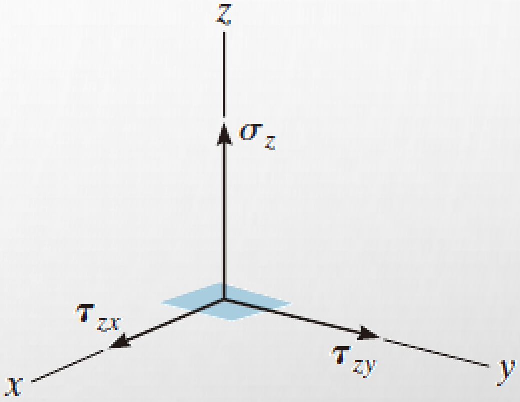


$$\tau_{\text{avg}} = \frac{P}{A}$$



unit, Pa = N/m^2

- **Local shear stress**

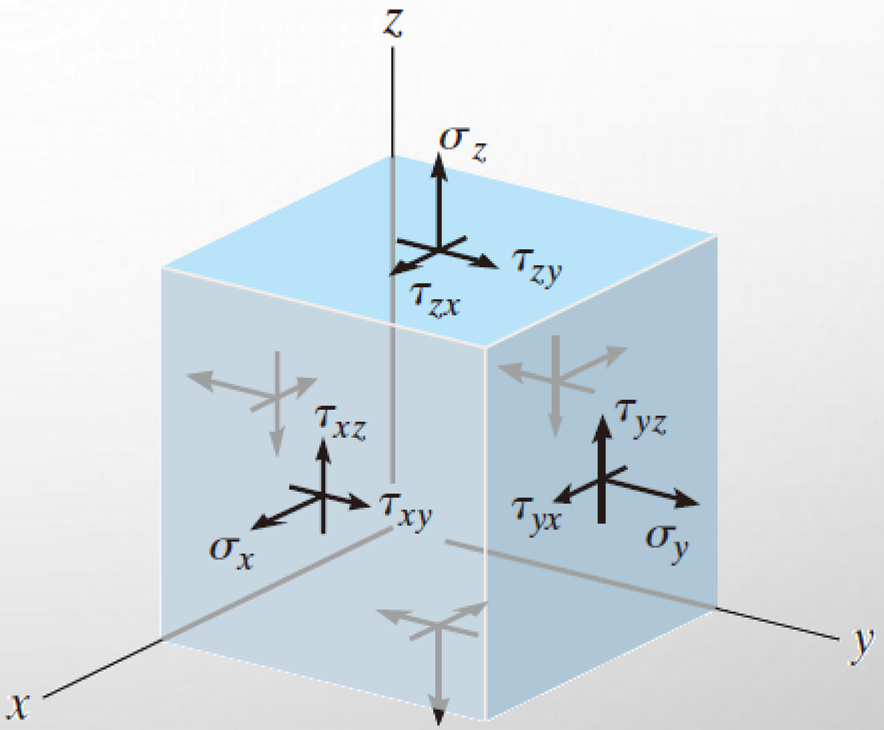


$$\tau_{zx} = \lim_{\Delta A \to 0} \frac{\Delta F_x}{\Delta A}$$

$$\tau_{zy} = \lim_{\Delta A \to 0} \frac{\Delta F_y}{\Delta A}$$

§ 1.11 General state of stress

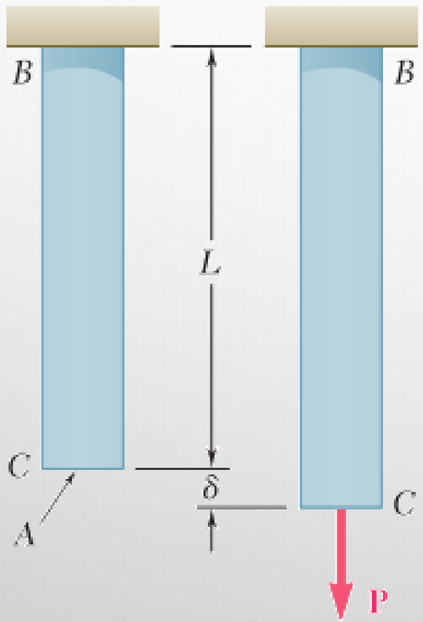
- Each face of the element has three components: **One normal stress (σ) and two shear stresses (τ)**



§ 1.12 Normal strain

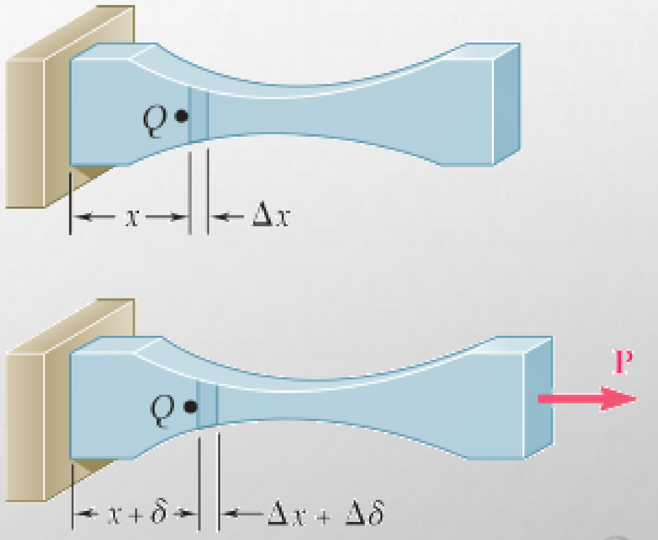
- **Average normal strain**

$$\varepsilon_{\text{avg}} = \frac{\delta}{L}$$



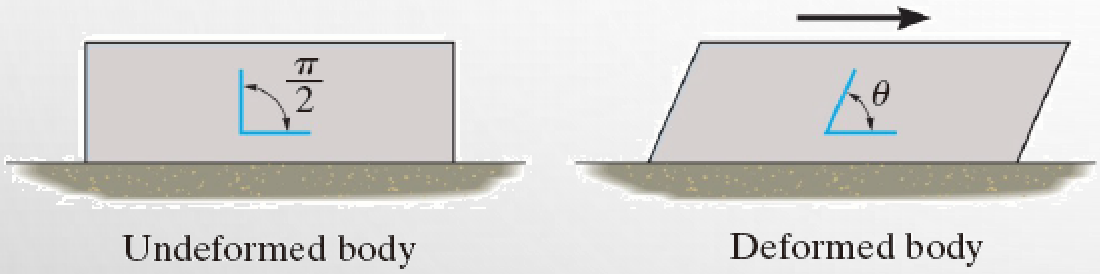
- **Local normal strain**

$$\varepsilon = \frac{\Delta\delta}{\Delta x}$$



§ 1.13 Shear strain

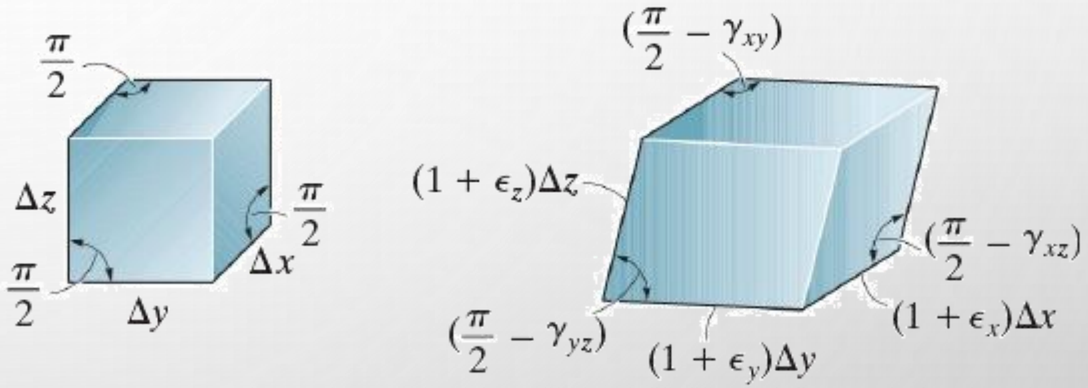
- **Average shear strain**



$$\gamma_{\text{avg}} = \frac{\pi}{2} - \theta$$

unit, rad

- **Local shear strain**



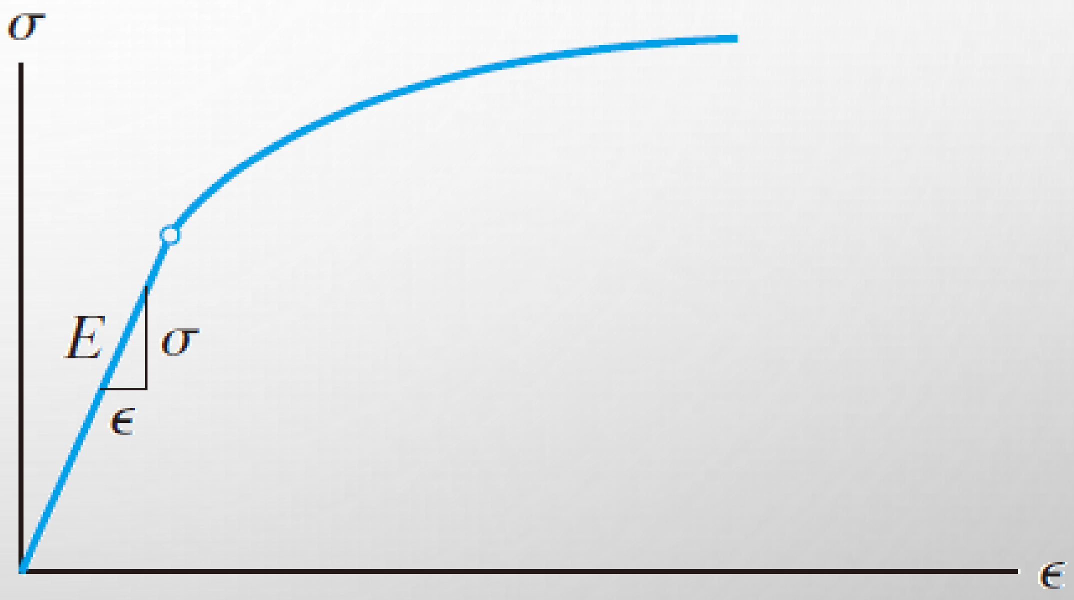
$$\gamma_{xy} = \frac{\pi}{2} - \theta$$

§ 1.14 Hooke's Law

- In the elastic regime with small deformation, **the stress is proportional to the strain**,

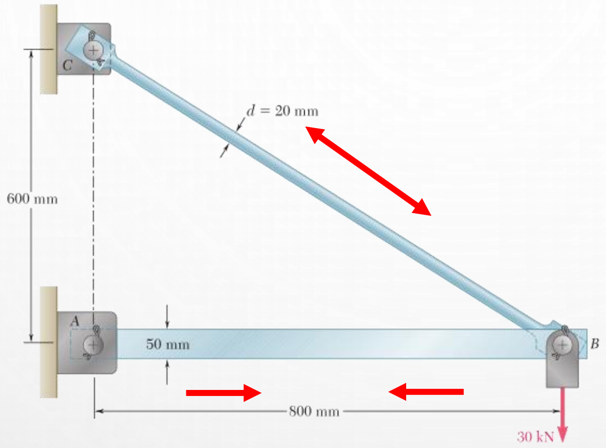
$$\sigma = E\varepsilon$$

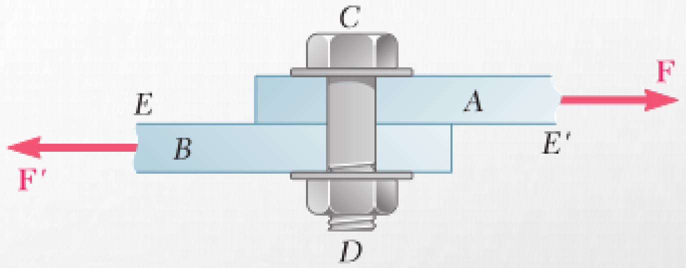
E, modulus of elasticity.



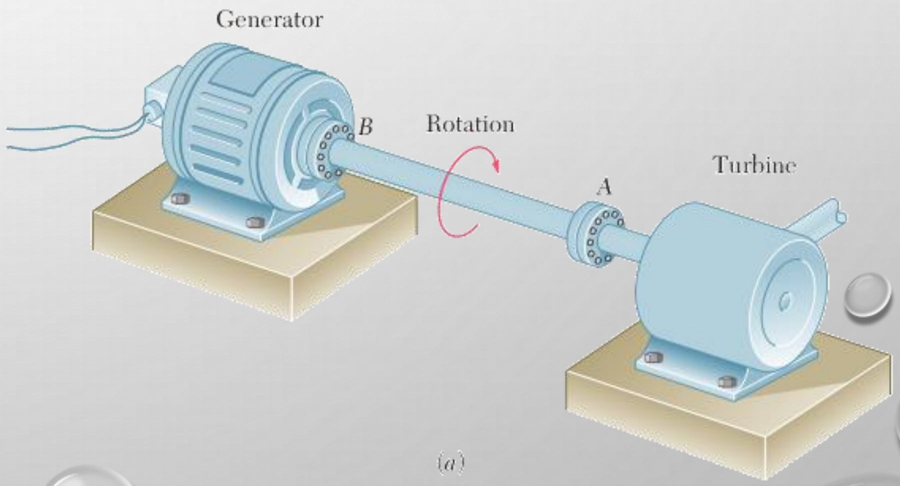
§ 1.15 Basic deformation of rod members

- **Axial load**
- **Shear**
- **Bending**
- **Torsion**





Simply supported beam



§ 1.16 Summary

- **The objective** is to optimize the structure to satisfy the strength, stiffness and stability requirements.
- **Basic assumptions:** continuous, homogenous, and isotropic, and elastic
- **Body equilibrium:** External loads, internal resultant loadings, and support reactions
- **Stress and strain:** normal and shear, average and local
- **Basic deformation of rod members:** axial load, shearing, torsion and bending