WELCOME TO CEE 3211

MECHANICS OF MATERIALS - 2021

TIMETABLE

- Tuesday 08:00 – 10:00
- Thursday 10:00 – 12:00

LECTURER

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COURSE Contents

Flexural members

Types of load. Classification of beams. Review of statics. Relation between the intensity of loading, shearing force, and bending moment in a straight beam.

Pure bending of beams. Shearing stresses in Beams. Distribution of shear stresses in a thin-walled section. Shear centre. Analysis of stresses and strains at a point. Elastic strain energy of bending Beams of composite materials.

Torsion

Deformations and stresses in circular shafts. Solid non-circular members. Deflection and stresses in closely coiled helical springs. Strain energy of elastic torsion.

Compound Stresses

Superposition of stresses and its limitations. Unsymmetrical bending. Combined bending and direct stresses. Thin-walled pressure vessels. Combined bending and torsion.

COURSE Contents cont'd

Structural connections

Eccentrically bolted and welded connections

Theories of failure

Maximum Principal stress theory (Rankine), Maximum shear stress (Tresca and Haigh), Strain Energy Theory (Haigh), Shear Strain Energy Theory (Von Mises and Hencky), and Maximum Principle Strain Theory (St. Venant).

Deflection of beams

Differential equations for deflection of elastic beams. Solution of beam deflection problems by direct integration, Virtual work/unit load method, Moment-Area Method, Conjugate-beam method. Simple statically indeterminate beams. Impact loads. Deflection of trusses.

COURSE Contents cont'd

Elastic buckling of columns

Stability of equilibrium. Analysis of buckling behaviour. Flexural Buckling of a pin-ended strut. Generalised Euler formula and limitations. Strut with eccentric load. Secant formula. Perry-Robertson formula. Strut with lateral load.

Plastic theory of bending

Assumptions in the plastic theory, Plastic hinge, Moment of resistance at a plastic hinge. Collapse load and Load Factor. Regions of plasticity. Combined bending and direct stress. Limit analysis of beams.

Component of assessment	Number	Contribution overall grading (%)
QUIZES		10
Laboratory	5	10
Test	1	20
Continuous assessment		40
Final examination	1	60

Prescribed Books

1. Hibbeler CR, 2076, Mechanics of Materials, 10th Edition, Pearson,ISBN-10 : 0134518128, ISBN-13 : 978-0134518121

2. Gere JM and Goodno BJ, 2017, Mechanics of Materials, 9th Edition, Cengage Learning, ISBN 13:978-1337093347, ISBN 10: 1337093343

Recommended Books

1. Case J. and Chilver, A.H. Strength of materials and structures, 2nd edition, Edward Arnold, 1988.
2. Popov, E.P., Mechanics of materials, 2nd edition, Prentice Hall International Editions, 2015
3. Ryder G.H., Strength of Materials 3rd Edition, Macmillan (ELBS), 1983, London.
4. Todd J D., Structural Theory and Analysis 2nd Edition, Macmillan, 1981

LECTURE 1

MECHANICS

The physical science that deals with the conditions of rest or motion of bodies acted on by forces or by thermal disturbances

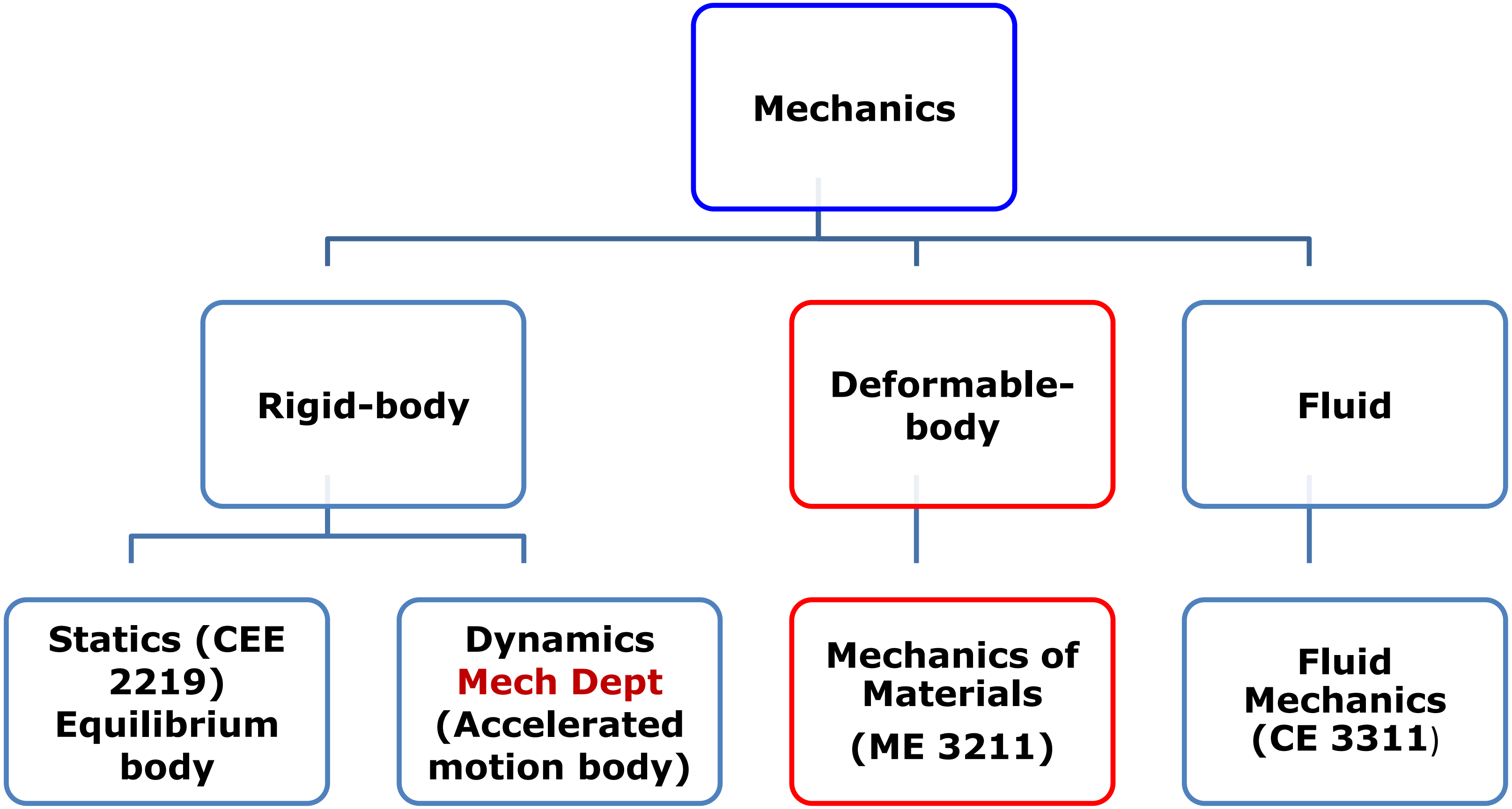
MECHANICS of MATERIALS

A branch of mechanics that studies the internal effects and strain in a solid body that is subjected to an external loading

MECHANICS of MATERIALS is a topic that is also known by several other names, including:

- ***STRENGTH OF MATERIALS***
- ***MECHANICS OF SOLIDS***
- ***MECHANICS OF DEFORMABLE BODIES***

AREAS OF MECHANICS



The mechanics of deformable solids is more concerned with the internal forces and associated changes in the geometry of the components involved.

A **deformable body** is a solid that changes size and/or shape as a result of loads that are applied to it or as a result of temperature changes.

Concept of Stress

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

- Both the analysis and design of a given structure involve the determination of ***stresses*** and ***deformations***.

- The two most important concepts in Mechanics of Materials are the concepts of **stress** and **strain**.

Concept of Stress

Three ***fundamental types of equations*** that are used in solving strength and stiffness problems of deformable-body mechanics will be stressed repeatedly. They are:

1. The **equilibrium** conditions must be satisfied.

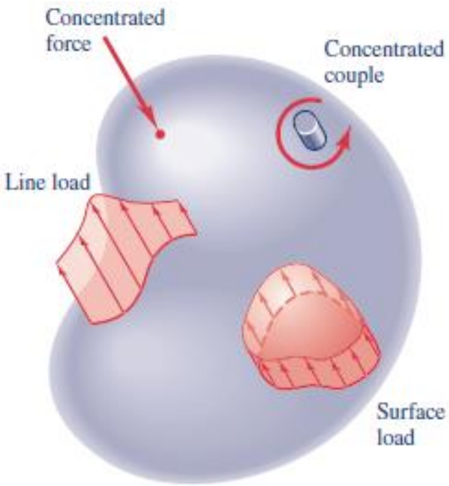
2. The **geometry of deformation** must be described.

3. The **material behaviour** (i.e., the force-temperature-deformation relationships of the materials) must be characterized.

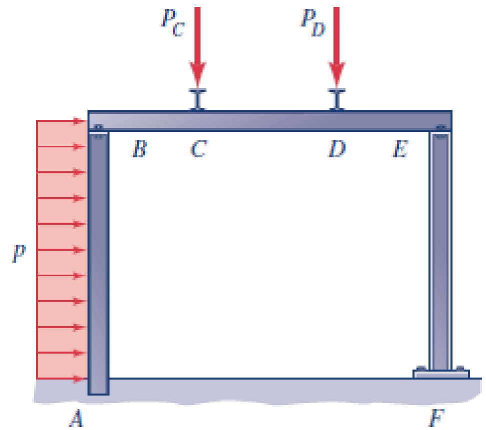
TYPES OF LOADS

External Loads. The **external loads** acting on a deformable body are known as force and moments. They may be classified in four categories, or types. These types, together with their appropriate dimensions, are:

- ***Concentrated loads*, including *point forces* (*F*) and *couples* (*F L*)** (If area is small in comparison to total surface area of body)
- ***Line loads* (*F/L*) –** (if the load is applied along a narrow strip of area)
- ***Surface loads* (*F/L^2*) –** (due to direct contact of one body with surface of another)
- ***Body forces* (*F/L^3*) –** (exertion of force on a body by another without direct physical contact)



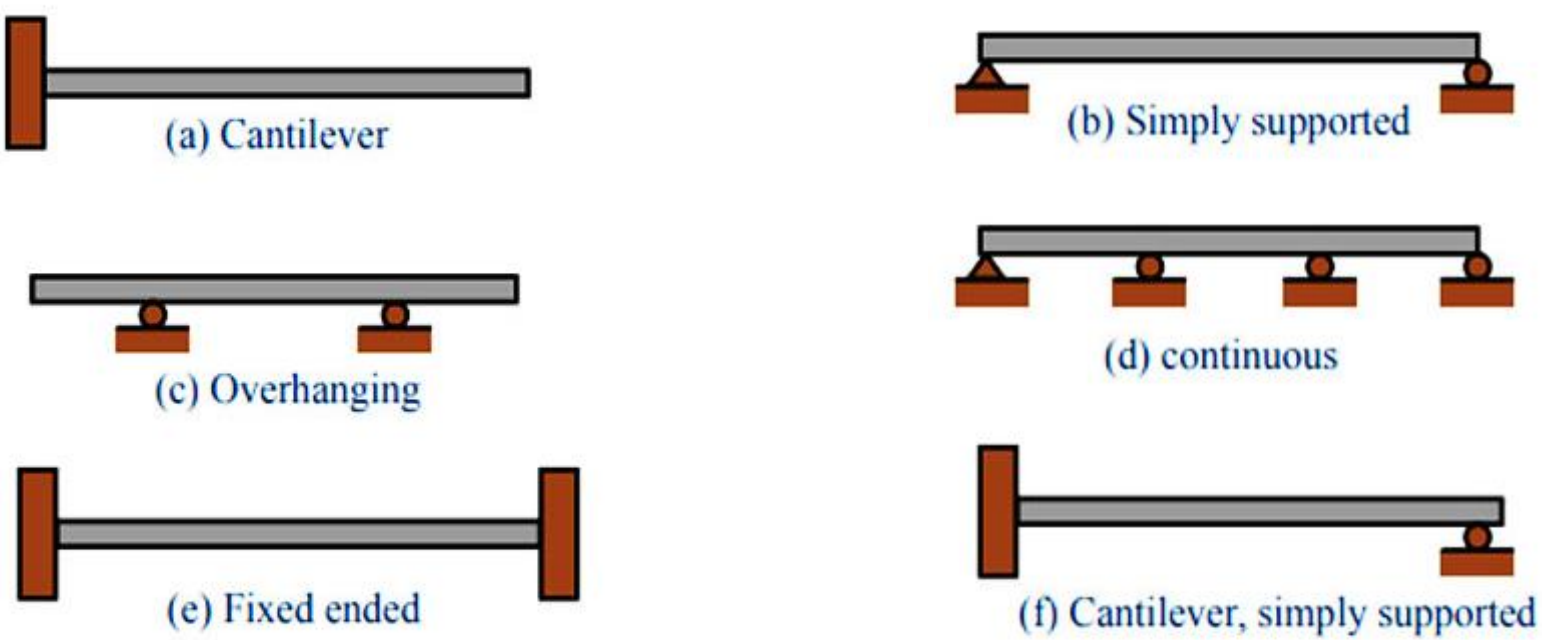
(*a*) A generic deformable body.



(*b*) A portal frame.

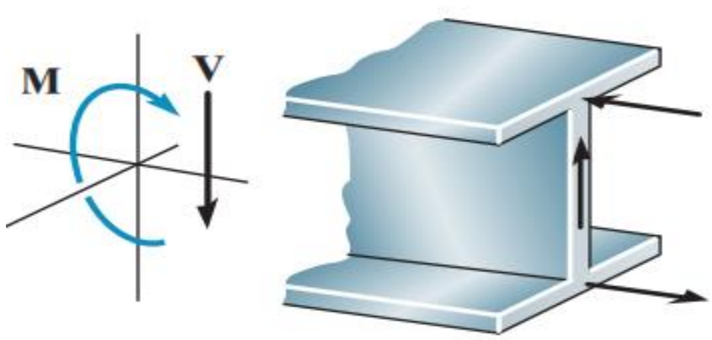
CLASSIFICATION OF BEAMS

- **Beams** are usually straight horizontal members used primarily to carry vertical loads.
- Beams are primarily designed to resist bending moment;
- They are classified according to the way they are supported as shown:

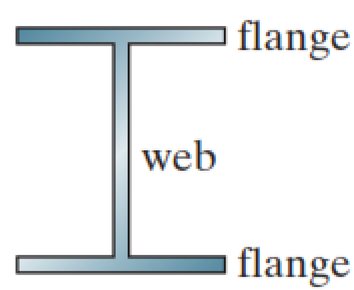


CLASSIFICATION OF BEAMS

- When the material used for a beam is a metal such as steel, the cross section is most efficient when it is shaped as shown in Fig. below.
- Here the force developed in the top and bottom ***flanges of the beam form the necessary*** couple used to resist the applied moment **M, whereas the *web is effective*** in resisting the applied shear **V. This cross section is commonly referred** to as a “wide flange,”
- If shorter lengths are needed, a cross section having tapered flanges is sometimes selected.
- When the beam is required to have a very large span and the loads applied are rather large, the cross section may take the form of a ***plate girder.***



wide-flange beam



REVIEW OF STATIC EQUILIBRIUM; EQUILIBRIUM OF DEFORMABLE BODIES

Consider deformable bodies at rest. In your previous CEE2219 course, you learned the equations of equilibrium and you learned how to apply these equations to particles and to rigid bodies through the use of free-body diagrams.

$$\sum Fx = 0, (\Sigma M)_0 = 0$$

That is, if a body is in equilibrium,

• the sum of the external forces acting on the body is zero, and

• the sum of the moments, about any arbitrary point *O*, of all the external forces acting on the body is zero.

In order to apply equilibrium equations to a body, it is always wise to draw a FBD

$$\sum Fx = 0, (\Sigma Mx)_0 = 0$$

$$\sum Fy = 0, (\Sigma My)_0 = 0$$

$$\sum Fz = 0, (\Sigma Mz)_0 = 0$$