Structural Analysis

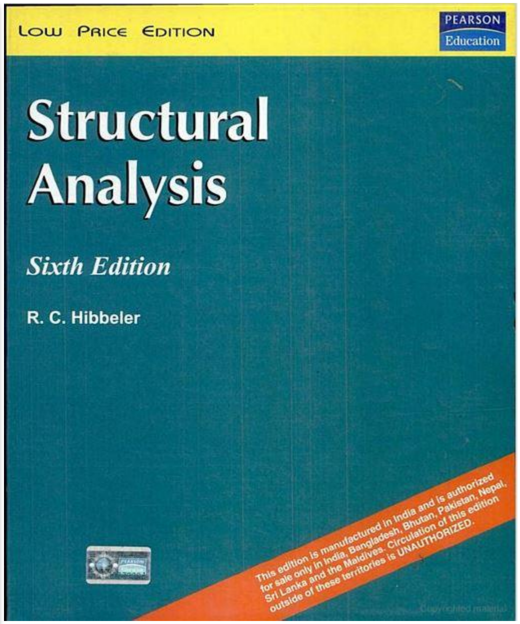
- Course No. CE-311
- Total Marks 100
- MID MARKS (30+10)
- END SEMESTER MARKS (40+10)
- ATTENDANCE MARKS (10)

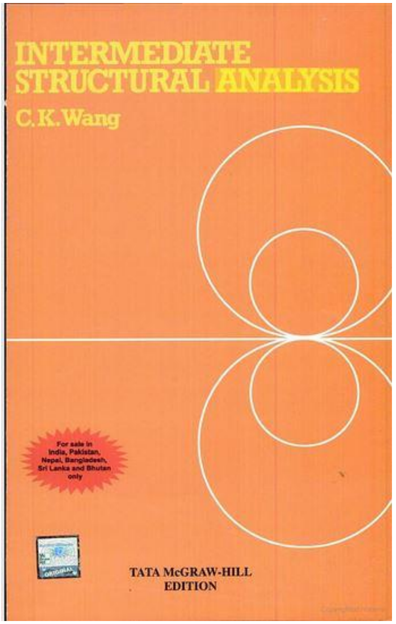
Structural Engineering-COURSE OUTLINE

- Review of Basics
- Force / Flexibility Method for Indeterminate structures
  - Truss
  - Beams
  - Frames
- Slope deflection method for beams and frames.
  - Beams
  - Frames
- statically Indeterminate Circular Arches
- statically Indeterminate Parabolic Arches

Structural Engineering

- Structural Analysis by R.C. HIBBLER
- Intermediate structural analysis by C.K. Wang
- Any other book regarding structural analysis for reference purpose.





Structural Analysis-Review

Equilibrium condition for 2D analysis

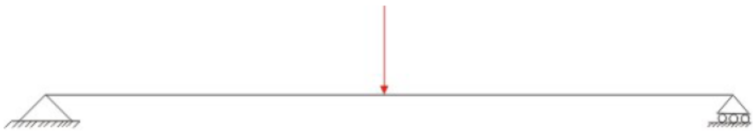
- $\Sigma F_x = 0 : \Sigma F_y = 0$ and $\Sigma M_z = 0$

Equilibrium condition for 3D analysis

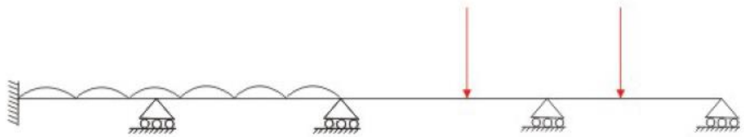
- $\Sigma F_x = 0 : \Sigma F_y = 0$ and $\Sigma F_z = 0$
- $\Sigma M_x = 0 : \Sigma M_y = 0$ and $\Sigma M_z = 0$

Structural Analysis-Review

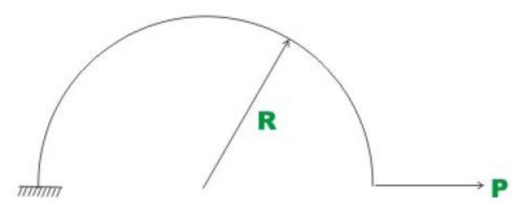
- Simply supported Beam (Stat. Det.)



- Continuous beam (Stat. Indeterminate)

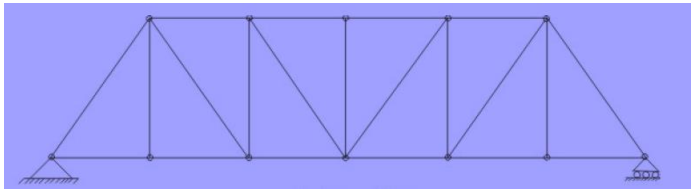


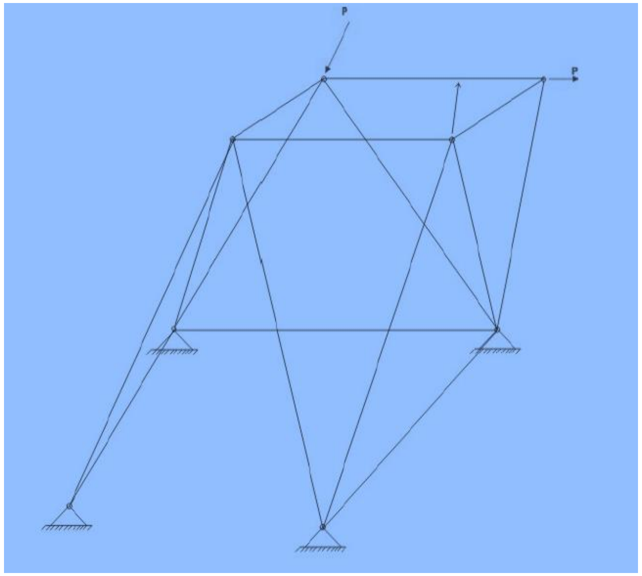
- Circular Beam (Stat. Determinate)



Structural Analysis-Review

- Truss
- (Statically Determinate)



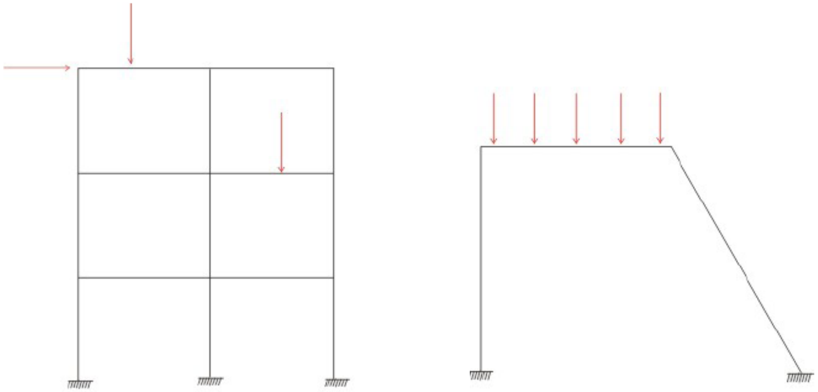


- Space Truss

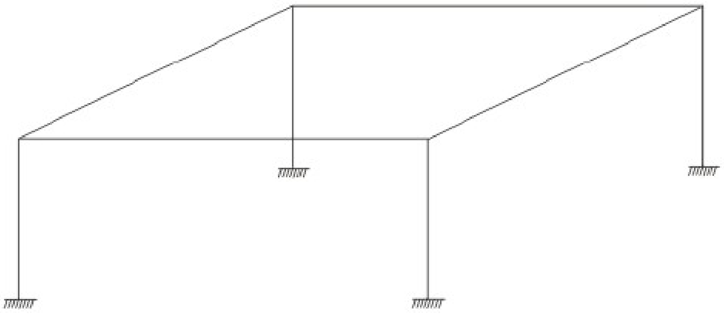
  (Statically Ind.)

Structural Analysis-Review

- Plane Frame (2D Frame)

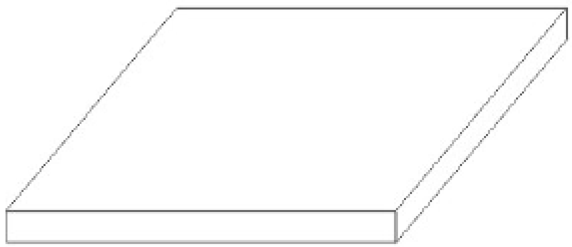


- Space Frame (3D)

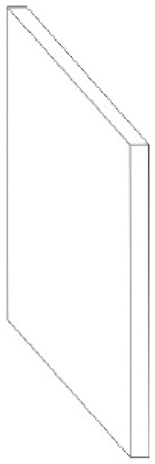


Structural Analysis-Review

- Plate (2D)

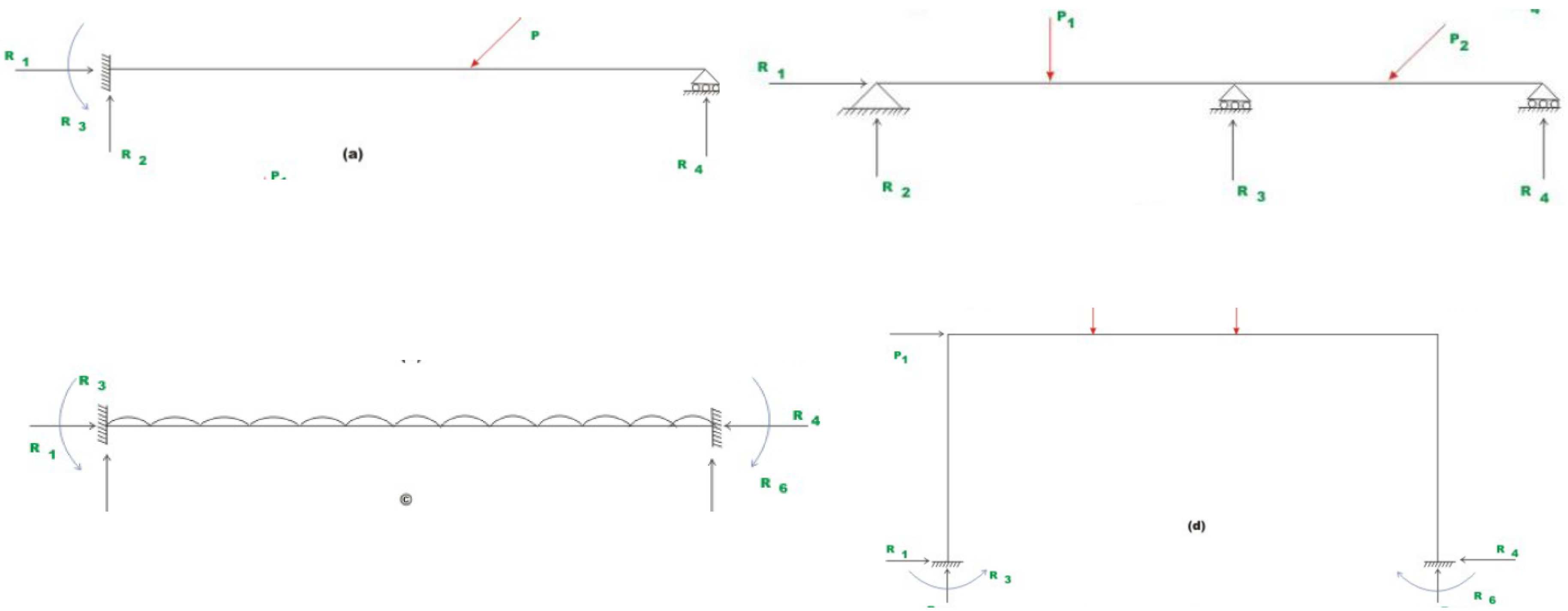


- Wall 2D



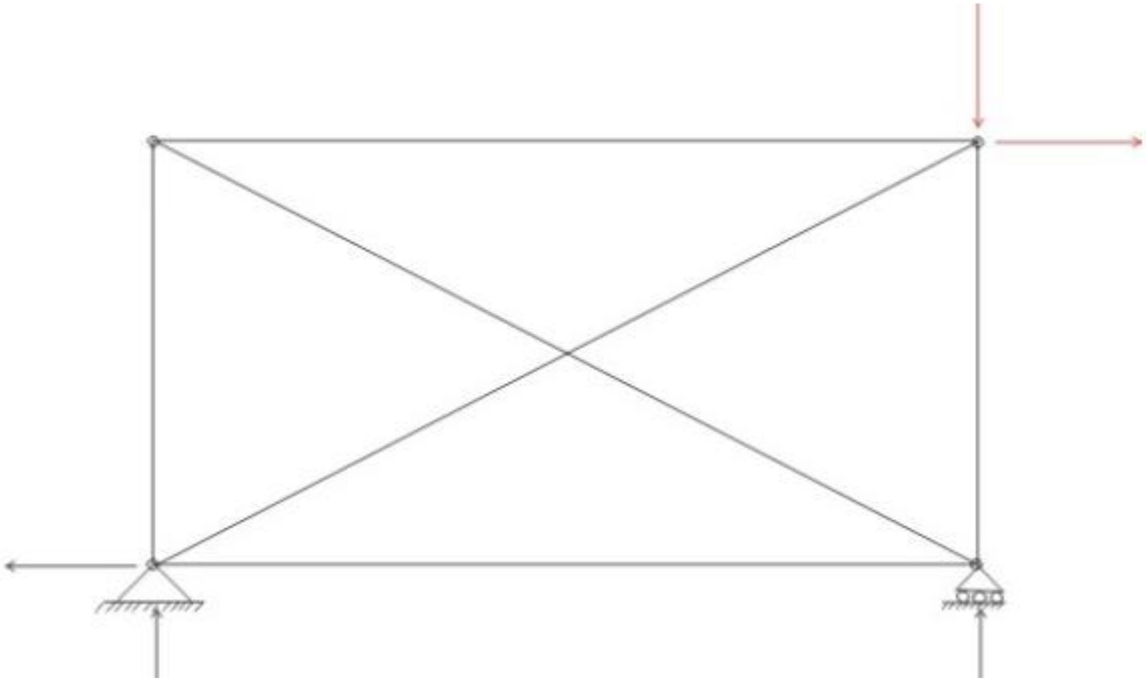
Structural Analysis-Review

- Externally statically determinate structures



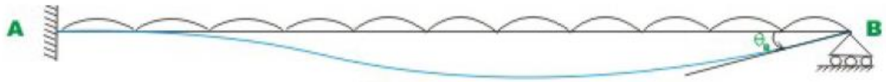
Structural Analysis-Review

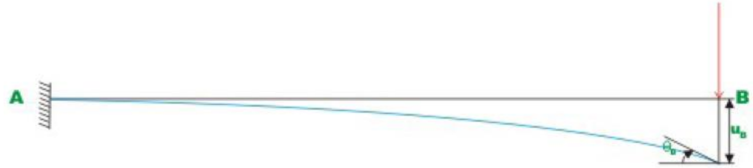
- Internally statically determinate structures



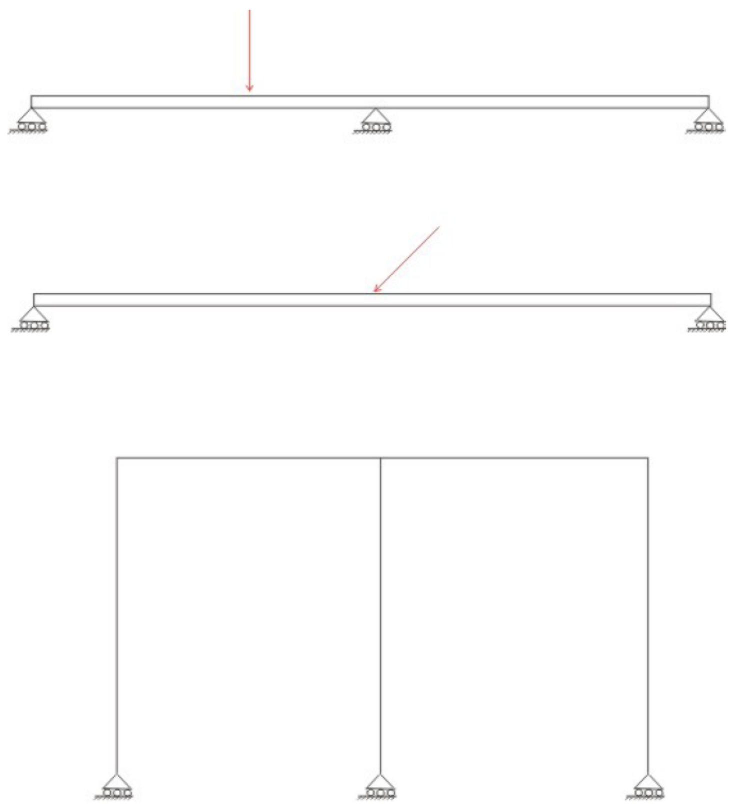
Structural Analysis-Review

- Kinematic indeterminacy
  - The rotation or displacement at a particular joint is called Kinematic Indeterminacy.
  - In propped cantilever beam, K.I is equal to 1
  - In simply supported beam, K.I is equal to 2
  - In Cantilever beam, K.I is equal to 2.





- Unstable structures

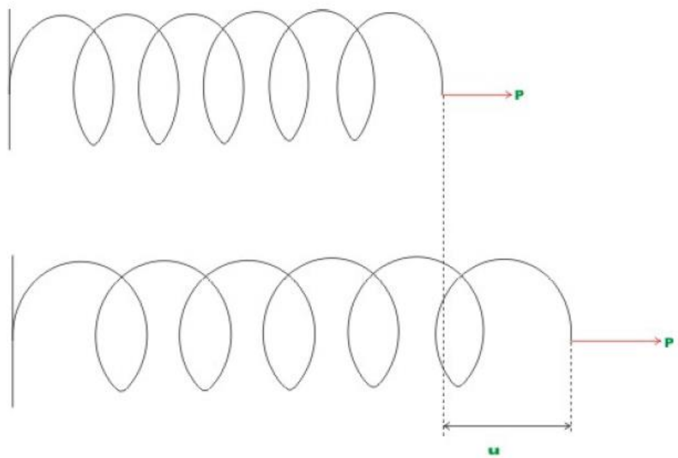


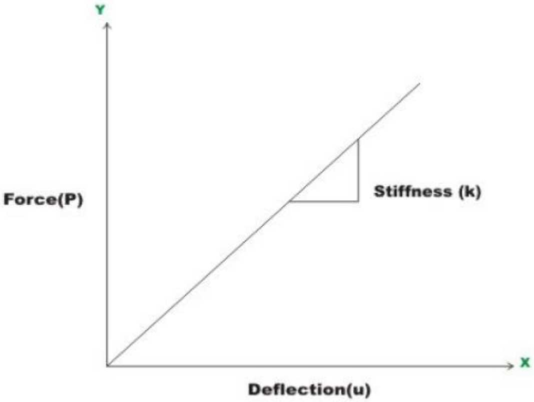
Structural Analysis-Review

- Compatibility Conditions/ Equations
  - A structure satisfying equilibrium conditions should also satisfy all the compatibility conditions
  - These conditions require that the displacements and rotations be continuous throughout the structure and compatible with the nature support conditions.
  - For. e.g In case of fixed support, displacement and slope shall be zero.

Structural Analysis-Review

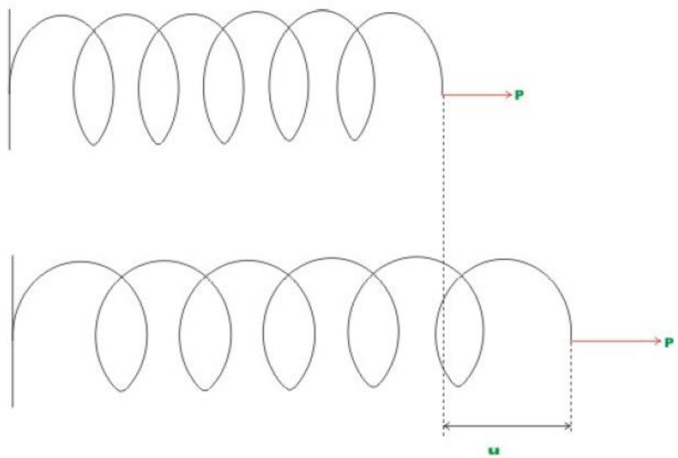
- Consider a spring with load "P"
- For each value of Load , displacement "u" will be changed and if both the values are plotted then we may obtain the relation in the form of a graph as shown.
- The slope of this graph can be obtained as follows:
- $K = \frac{P_2 - P_1}{u_2 - u_1} = \frac{P}{u}$
- Or P = Ku
- The spring stiffness "K" may be defined as force required for the unit deformation of the spring. The stiffness has a unit of force per unit elongation.

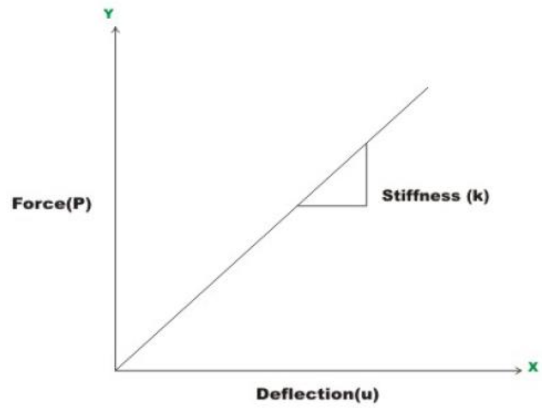




Structural Analysis-Review

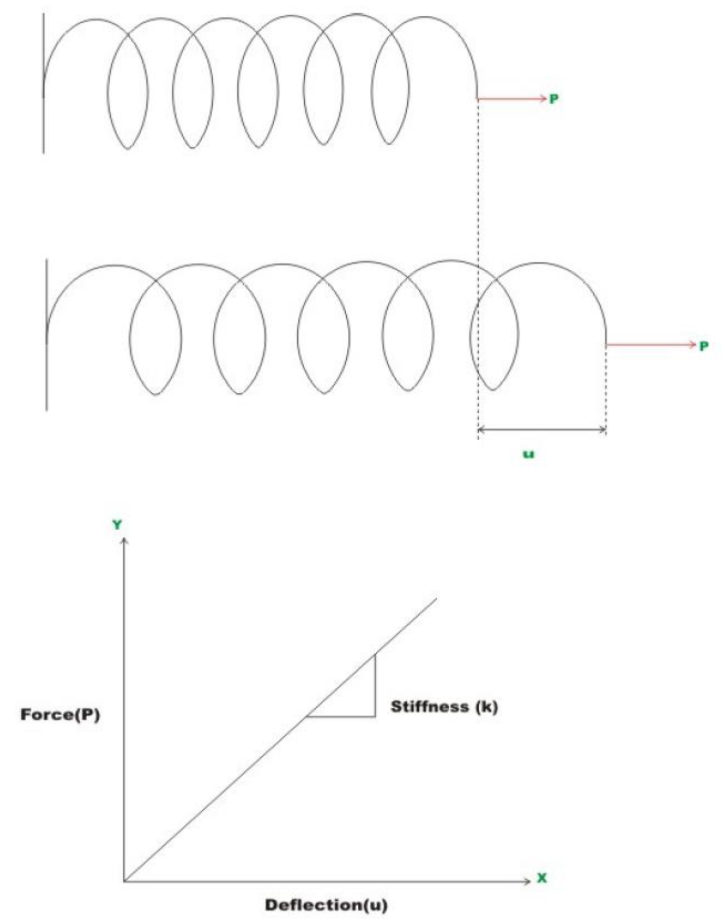
- The inverse of the stiffness is known as flexibility. It is usually denoted by "f".
- f = (1/K)
- The equation on previous slide may be written as follows:
- u = P / K or u = f x P
- The above equation holds good for linearly elastic structures
- For e.g. Consider a simply supported beam subjected to a unit concentrated load at the center.
- The deflection at center is as follows
- $u = \frac{PL^3}{48EI}$ or $P = \left(\frac{48EI}{L^3}\right) x\, u$





Structural Analysis-Review

- The stiffness of a structure is defined as the force required for the unit deformation of the structure.
- Hence, the value of stiffness for the beam is as follows
- $K = \left(\frac{48EI}{L^3}\right)$
- And flexibility is equal to $\left(\frac{L^3}{48EI}\right)$



Review

Example

A rod made of aluminium alloy (E = 72 GPa) has length 500 mm and diameter 10 mm. What are its tensile stiffness and flexibility?

$$k = \frac{P}{\delta} = \frac{EA_o}{L_o} = \frac{\left(72 \times 10^9\right)\left(\pi \,(0.01/2)^2\right)}{0.5} = 11.3 \times 10^6 \, \frac{\text{N}}{\text{m}}$$

$$\text{units} \quad \frac{\left(\text{N/m}^2\right)\left(\text{m}^2\right)}{\text{m}} = \frac{\text{N}}{\text{m}}$$

$$f = \frac{1}{k} = 88.4 \times 10^{-9} \, \frac{\text{m}}{\text{N}}$$