INTRODUCTION:

A beam is a structural element that is capable of withstanding load primarily by resisting bending. The bending force induced into the material of the beam as a result of the external loads, own weight and external reactions to these loads is called a bending moment. Beams generally carry vertical gravitational forces but can also be used to carry horizontal loads (i.e., loads due to an earthquake or wind). The loads carried by a beam are transferred to columns, walls, or girders, which then transfer the force to adjacent structural compression members. In Light frame construction the joists rest on the beam.

Beams are characterized by their profile (the shape of their cross-section), their length, and their material. In contemporary construction, beams are typically made of steel, reinforced concrete, or wood. One of the most common types of steel beam is the I-beam or wide-flange beam (also known as a "universal beam" or, for stouter sections, a "universal column"). This is commonly used in steel-frame buildings and bridges. Other common beam profiles are the C-channel, the hollow structural section beam, the pipe, and the angle.

OBJECTIVE:

To Study the beam under different loads acting on it.

THEORY:

In General when the beam is subject to the loading on it deflects and some of the moments and reactions occur in that beam. By determining the loads and member at particular distance the bending moment and shear force can be known.

Shear Force: Shear force is an internal force in any material which is usually caused by any external force acting tangent (perpendicular) to the material, or a force which has a component acting tangent to the material.

Bending Moment: Bending moment is the algebraic sum of moments to the left or right of the section. In each case, by considering, either for forces or moments the resultants caused by applied forces to one side of the section is balanced by bending moment and shear force acting on the section.

A beam with a moment of inertia I and with Young's modulus E will have a bending stress f at a distance from the Neutral Axis (NA) y and the NA will bend to a radius R, in accordance with the following formula.

$$M / I = \sigma / y = E / R$$

Where M = Moment at the section

I = Moment of Inertia

Sigma = Bending stress

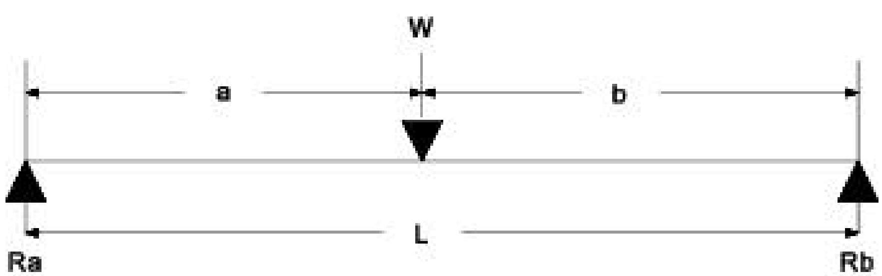
y = distance from the neutral axis to the point of interest

E= Youngs Modulus

R= Radius of curvature

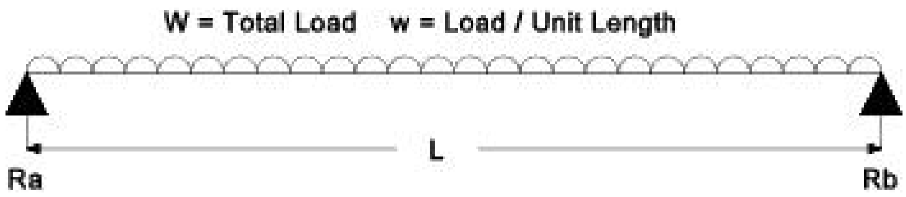
FORMULATION:

Simply Supported Beam. Concentrated Load



Reactions		Moment	Maximum Deflection
Ra	Rb		
$\frac{W.b}{L}$	$\frac{W.a}{L}$	$M = \frac{W.a.b}{L}$	$\delta = \frac{W.a.b}{E.I.L}\sqrt{\frac{a.(L+b)}{243}}^{\,3}$

Simply Supported Beam. Uniformly Distributed Load

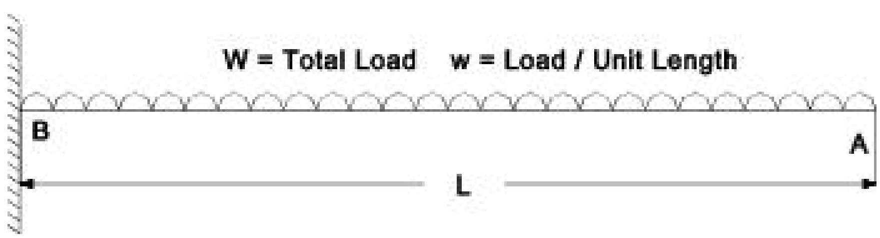


Reactions	Moment	Maximum Deflection
Ra = Rb		
$\frac{W}{2} = \frac{w.L}{2}$	$M = \frac{W.L}{8} = \frac{w.L^2}{8}$	$\delta = \frac{5.W.L^3}{384.E.I} = \frac{5.w.L^4}{384.E.I}$

Cantilever. Concentrated Load:

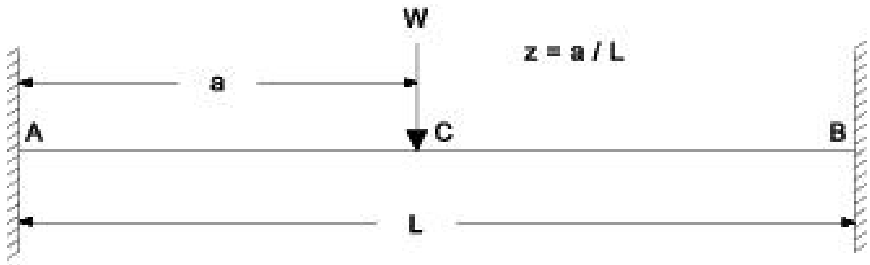
Reaction / Moment	Maximum Deflection
Reaction RB = W Moment MB = W.L	$\delta_A = \frac{W.L^3}{3.E.I}$

Cantilever Uniformly Distributed Load:



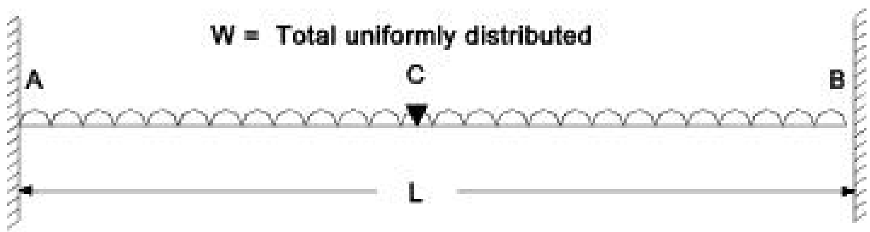
Reaction / Moment	Maximum Deflection
Reaction RB = W = w.L Moment MB = $\frac{W.L}{2} = \frac{w.L^2}{2}$	$\delta_A = \frac{W.L^3}{8.E.I} = \frac{w.L^4}{8.E.I}$

Fixed Beam Concentrated Load:



Reaction at B	Moment			Maximum Deflection
	MA	MB	MC	
$W \cdot z^2 (3 - 2 z)$	$MA = W \cdot L \cdot z \cdot (1 - z)^2$ $MB = W \cdot L \cdot z^2 (1 - z)$ $MC = 2 W \cdot L \cdot z^2 (1 - z)^2$			$\delta = \dfrac{2 W L^3 z^3 (1 - z)^2}{3 E I \, (1 + 2 z)^2}$

Fixed Beam: Uniformly Distributed Load:



Reaction at B	Moment			Maximum Deflection
	MA	MB	MC	
$\dfrac{W}{2}$	$MA = W \cdot L / 12$ $MB = W \cdot L \cdot / 12$ $MC = W \cdot L / 24$			$\delta = \dfrac{W L^3}{384 \cdot E \cdot I}$

LAB APPARATUS

a. Simply-supported and Cantilever rectangular beams
b. Weights
c. Micrometer
d. Ruler
e. Dial Gauges

PROCEDURE

A. SIMPLY SUPPORTED BEAM

- Record the beam dimensions and calculate the area moment of inertia (I) using:
  - $I = bh^3/12$
- Calculate the maximum permissible loads for mid-span and quarter-span loading using Equation 1.3, where maximum allowable stress is 18,000 psi.
- Load the beam at the mid-span in 5 lb. increments, until the maximum load limit is reached. Record the deflection at the point of loading at each incremental load. Small divisions on the dial gage are 0.001 inch. One full revolution of the dial is 0.1 inch (100 small divisions).
- Repeat the above procedure at the quarter-span.

B. CANTILEVER BEAM

- Record the beam dimensions and calculate the area moment of inertia (I) using:
  - $I = bh^3/12$
- Calculate the safe loads at the mid-span and end of the cantilever beam using Equation $Sigma_{max} = Mc/I$ (where M = moment at the section, I = moment of inertia), and a maximum allowable stress of 18,000 psi.
- Load the beam at the mid-span in 2 lb. increments, until the maximum load limit is reached. Record the deflection at the point of loading at each increment.
- Repeat the Repeat the above procedure at the free end of the beam. Care must be taken so that the displacement does not exceed the maximum travel of the dial gage.

Observation Table:

Section Type	Types of loads acting	Length of member(L)	Breadth(b)	Depth(d)	Weight(w)	At section 'x' the distance	Bending moment (Knm)	Shear force (kn)	Deflection (Yc)
Simply Supported	1)U.D.L 2)Point load								
Fixed	1)U.D.L 2)Eccentric Point load								
Cantilever	1)U.D.L 2)With an end load 3)Concentrated load								
Uniformly Varying									

Output:

1. Bending moment ________ (Knm)
2. Shear Force _________ (KN)
3. Deflections _________ (Yc)

QUIZ:

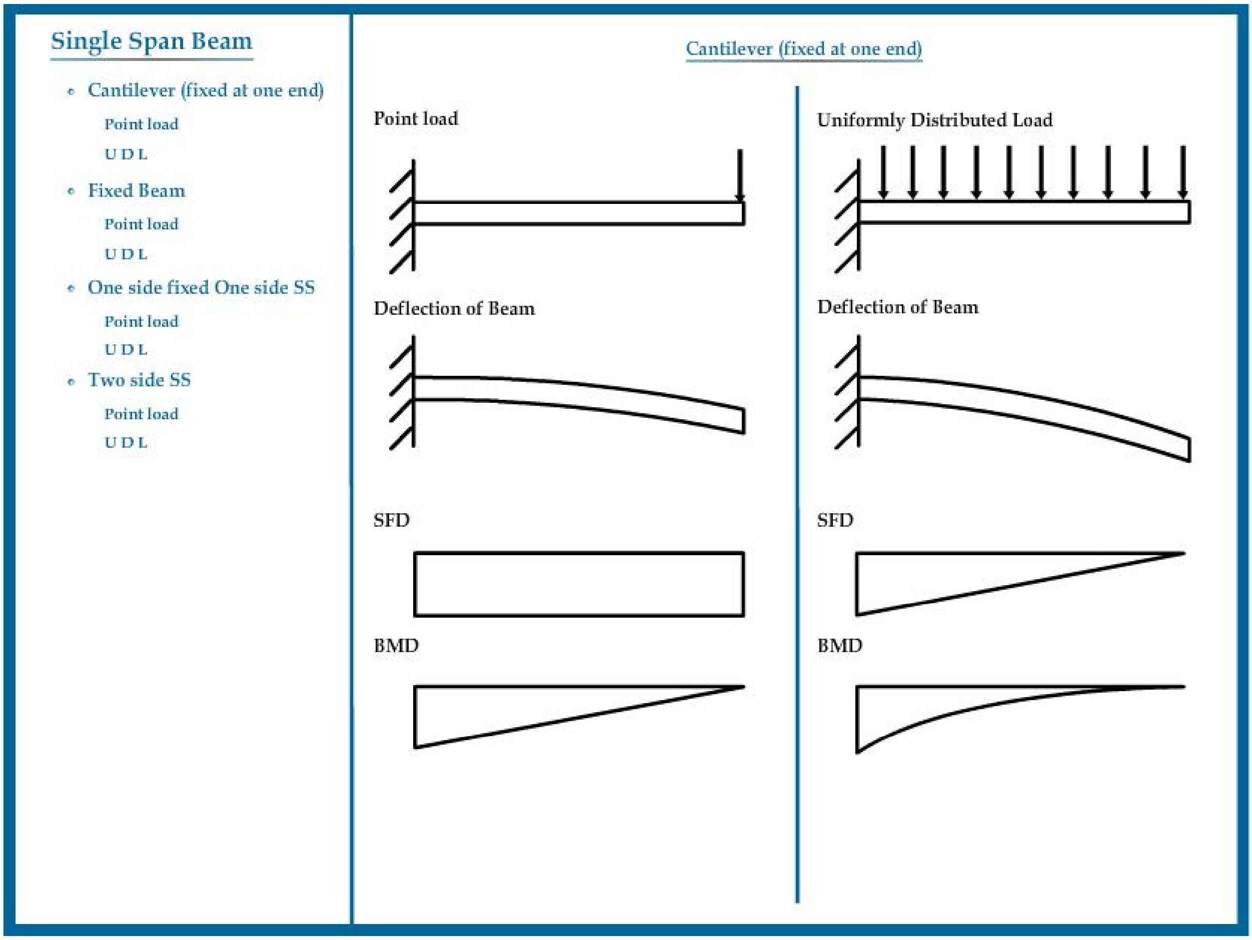
1. What is a beam?
2. What is point of inflection?
3. What is Young's modulus?
4. What is the maximum deflection of a S.S. beam when point load is applied at the center?
5. Bending moment profile for a S.S. beam under U.D.L is parabolic. (T/F)
6. The ratio of change in length to the original length is ___________.
7. Tension occurs at bottom of the cantilever beam when point load is applied at the center. (T/F)

REFERENCES:

1. Theory of structures Volume: 1 by S.P.Gupta and G.S.Pandit
2. Reference from √X MATHalino.Com
3. Mechanics of Materials by B.C.Punmia
4. Statics and Strength Materials, Hibler
5. Introduction to Mechanics of Solids, Popov
6. Statics and Strength for Materials, Stevens, Karl K.
7. Design Analysis of Beams and Shafts, Hopkins, R. Bruce

PART – 2

ANIMATION STEPS



PART – 3

VIRTUAL LAB FRAME

LABORATORY ROOM CONSISTS:

1. *Columns*
2. *Beams*
3. *Loads*

INPUT:

1. *Dimensions of Beam (Length, Breadth, Depth)*
2. *Boundary (Fixed, Simply Supported, Cantilever)*
3. *Concrete Grade (M20, M25, …., M50)*
4. *Loading type (Point Load, UDL)*
5. *Location of Load*

OUTPUT:

1. *Deflection*
2. *SFD*
3. *BMD*