STRUCTURAL ANALYSIS

CIVIL ENGINEERING VIRTUAL LABORATORY

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.

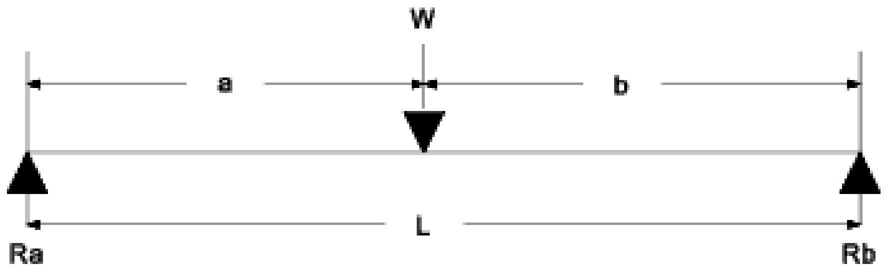
Shear Force: Shear force is an internal force in any material which is usually caused by any external force acting tangent (perpendicular) to the material, or a force which has a component acting tangent to the material.

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.

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

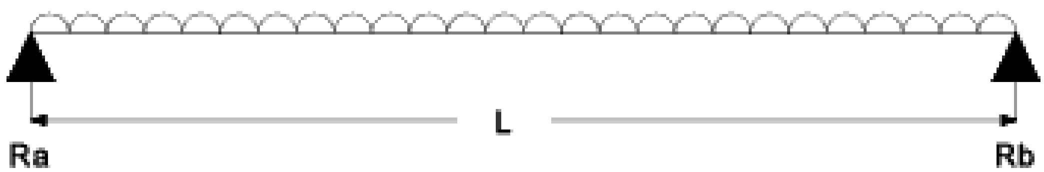
Simply Supported Beam. Concentrated Load



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

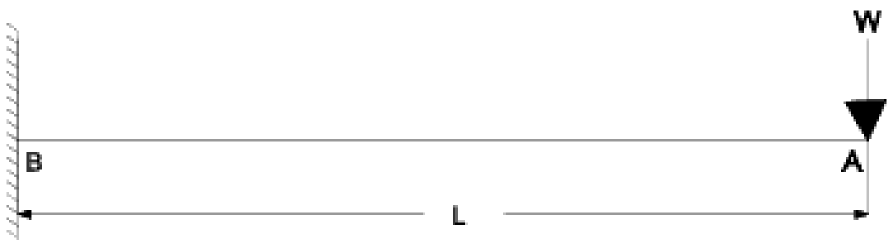
Simply Supported Beam. Uniformly Distributed Load

W = Total Load w = Load / Unit Length



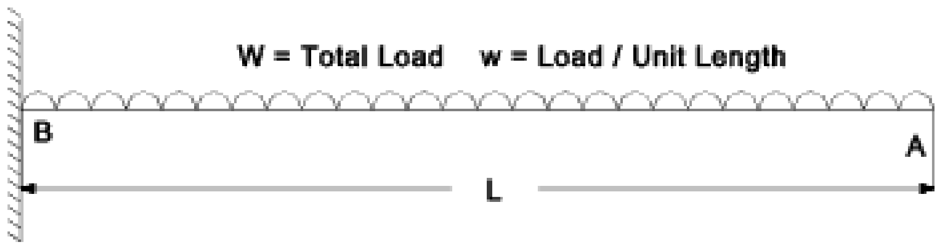
Reactions	Moment	Maximum Deflection
Ra = Rb		
$\frac{W}{2} = \frac{w.L}{2}$	$M = \frac{W.L}{8} = \frac{w.L^2}{8}$	$\delta = \frac{5. W. L^3}{384 . E.I} = \frac{5. w. L^4}{384 . E.I}$

Cantilever. Concentrated Load:



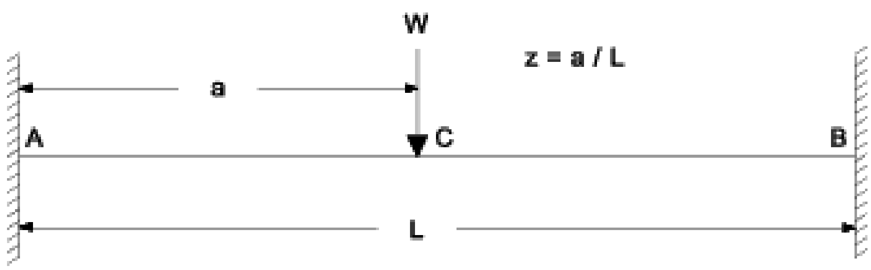
Reaction / Moment	Maximum Deflection
Reaction RB = W Moment MB = W.L	$\delta_A = \frac{W.L^3}{3.E.I}$

Cantilever Uniformly Distributed Load:



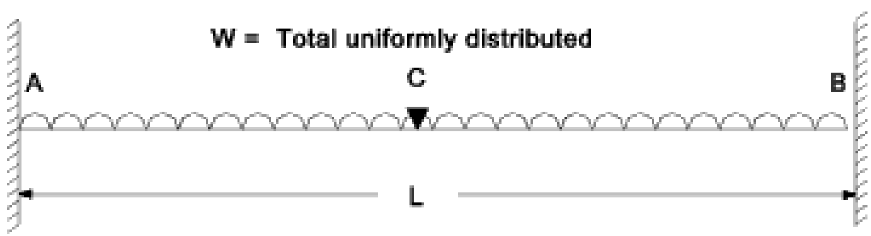
Reaction / Moment	Maximum Deflection
Reaction RB = W = w.L Moment MB = $\frac{W.L}{2} = \frac{w.L^2}{2}$	$\delta_A = \frac{W.L^3}{8.E.I} = \frac{w.L^4}{8.E.I}$

Fixed Beam Concentrated Load:



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

Fixed Beam. Uniformly Distributed Load:



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

SNAP SHOTS:

The snap shots that are hand written those are

1. Simply Supported
2. Fixed beams
3. Cantilever

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:

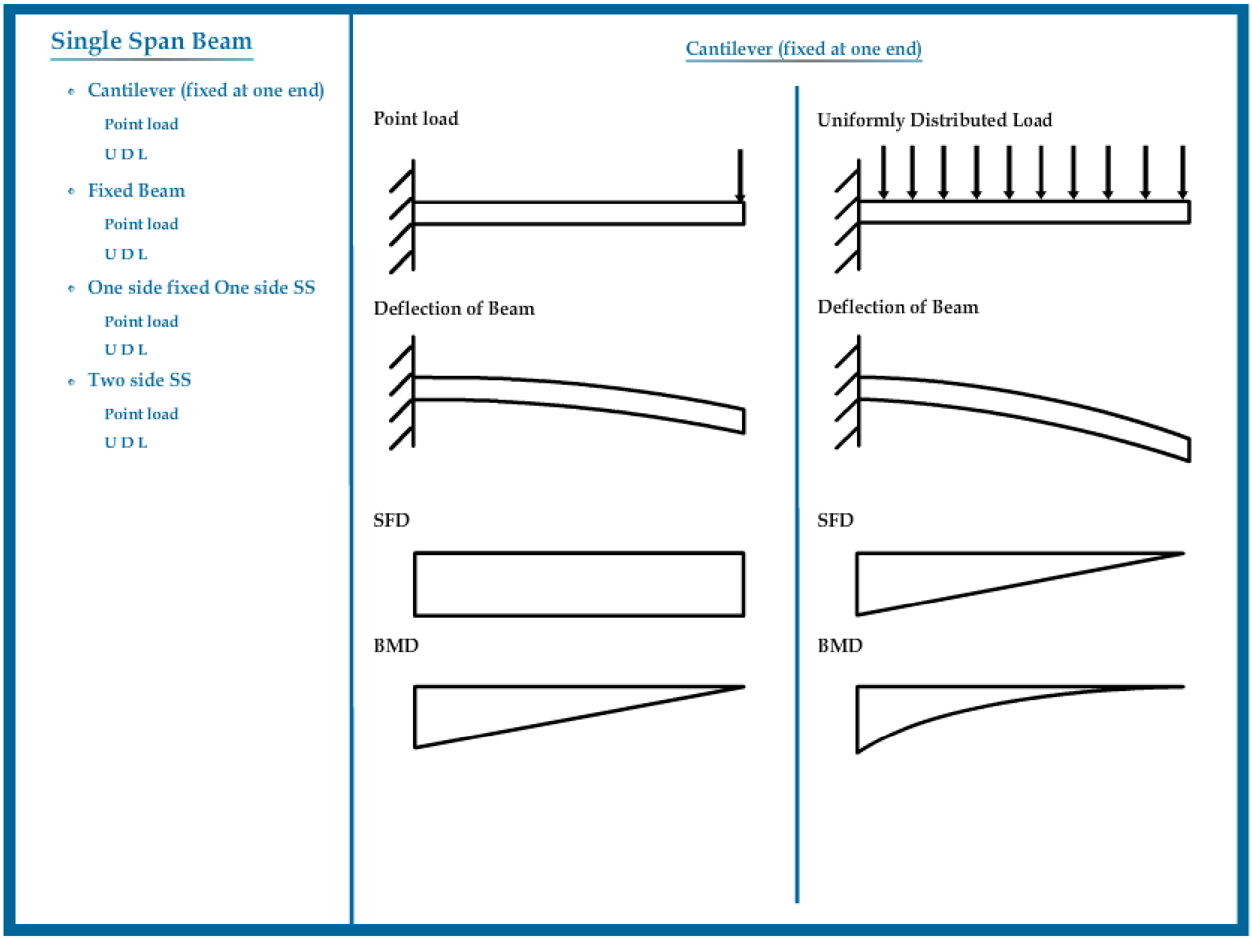
1. What is a beam?
2. What is point of inflection?
3. What is Young's modulus?
4. What is the maximum deflection of a S.S. beam when point load is applied at the center?
5. Bending moment profile for a S.S. beam under U.D.L is parabolic. (T/F)
6. The ratio of change in length to the original length is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

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*