U23MET43 / STRENGTH OF MATERIALS

Syllabus:

UNIT-I STRESS, STRAIN AND DEFORMATION OF SOLIDS	**No. of Periods: 9**
Rigid bodies and deformable solids - Tension, Compression and Shear Stresses - Deformation of simple and compound bars - Thermal stresses - Elastic constants - Volumetric strains –Stresses on inclined planes - principal stresses and principal planes - Mohr's circle of stress.	
UNIT-II TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAM	**No. of Periods: 9**
Beams - types transverse loading on beams - Shear force and bending moment in beams - Cantilevers - Simply supported beams and over - hanging beams. Theory of simple bending, stress distribution - Load carrying capacity - Proportioning of sections - Flitched beams- Shear stress distribution.	
UNIT III TORSION	**No. of Periods: 9**
Torsion formulation stresses and deformation in circular and hollows shafts - Stepped shafts- Deflection in shafts fixed at the both ends - Stresses in helical springs - Deflection of helical springs, carriage springs.	
UNIT-IV DEFLECTION OF BEAMS	**No. of Periods: 9**
Double Integration method - Macaulay's method - Area moment method for computation of slopes and deflections in beams - Conjugate beam and strain energy - Maxwell's reciprocal theorems.	
UNIT-V THIN CYLINDERS, SPHERES AND THICK CYLINDERS	**No. of Periods: 9**
Stresses in thin cylindrical shell due to internal pressure circumferential and longitudinal stresses and deformation in thin and thick cylinders - spherical shells subjected to internal pressure -Deformation in spherical shells - Lame's theorem.	

Objective:

- To apply mathematical knowledge to calculate the deformation behavior of simple structures.
- Critically analyse problem and solve the problems related to mechanical elements and analyse the deformation behavior for different types of loads.
- Have the capability to solve different types of shafts and springs
- Get an exposure to solve deflection of beams

Text Book:

T1. **Bansal, R.K., "Strength of Materials"**, Laxmi Publications (P) Ltd., 2007

Reference Book:

R1 Egor.P.Popov "Engineering Mechanics of Solids" Prentice Hall of India, New Delhi, 2015
R2 Subramanian R.,"Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2016.

UNIT - 1 STRESS, STRAIN AND DEFORMATION OF SOLIDS

PART- A

1. **Define tensile stress and tensile strain.**

The stress induced in a body, when subjected to two equal and opposite pulls, as a result of which there is an increase in length, is known as tensile stress. The ratio of increase in length to the original length is known as tensile strain.

2. **Define compressive stress and compressive strain.**

The stress induced in a body, when subjected to two equal and opposite pushes, as a result of which there is a decrease in length, is known as compressive stress. The ratio of increase in length to the original length is known as compressive strain.

3. **Define shear stress and shear strain.**

The stress induced in a body, when subjected to two equal and opposite forces, which are acting tangentially across the resisting section as a result of which the body tends to shear off across the section is known as shear stress and corresponding strain is known as shear strain.

4. **Give example for ductile, brittle and malleable materials**.

a. Ductile materials steel, copper
b. Brittle materials wrought iron
c. Malleable materials cast iron

5. **Define Poisson‘s ratio**

The ratio of lateral strain to the linear strain is a constant for a given material, when the material is stressed within the elastic limit. This ratio is Poisson‘s ratio and it is generally Poisson‘s ratio

6. **Write the relationship between modulus of elasticity, modulus of rigidity and Poisson‘s ratio**

The relationship between modulus of elasticity, modulus of rigidity and Poisson‘s ratio is given by E=Modulus of elasticity C=Modulus of rigidity.

7. **State Hooke‘s law.**

Hooke‘s law is stated as when a material is loaded within elastic limit, the stress is proportional to the strain produced by stress, or Stress/strain=constant. This constant is termed as modulus of elasticity.

8. Define stress and strain.

Stress: The force of resistance per unit area, offered by a body against deformation is known as stress.

Strain: The ratio of change in dimension to the original dimension when subjected to an external load is termed as strain and is denoted by e. It has no unit.

9. Define modulus of rigidity

The ratio of shear stress to the corresponding shear strain when the stress is within the elastic limit is known as modulus of rigidity or shear modulus and is denoted by C or G or N

10. Define modulus of elasticity.

The ratio of tensile stress or compressive stress to the corresponding strain is known as modulus of elasticity or young‘s modulus and is denoted by E.

11. Define Bulk modulus.

When a body is subjected to an uniform direct stress in all the three mutually Perpendicular directions, the ratio of the direct stress to the corresponding volumetric strain is found to be a constant is called as the bulk modulus of the material and is denoted by K.

12. Define factor of safety

It is defined as the of ultimate stress to the working stress or permissible stress.

13. Give the relationship between modulus of elasticity, bulk modulus and poison‘s ratio.

Where

E = Young‘s modulus

K = Bulk modulus

C= Rigidity modulus

14. What is stability?

The stability may be defined as an ability of a material to withstand high load without deformation.

15. Give example for gradually applied load and suddenly applied load.

Example for gradually applied load

When we lower a body with the help of a crane, the body first touches the platform on which it is to be placed. On further releasing the chain, the platform goes on loading till it is fully loaded by the body. This is the case of gradually applied load.

Example for suddenly applied load

When we lower a body with the help of a crane, the body is first of all, just above the platform on which it is to be placed. If the chain breaks at once at this moment the whole load of the body begins to act on the platform. This is the case of suddenly applied load.

16. **What is resilience?**

The strain energy stored by the body within elastic limit, when loaded externally is called resilience.

17. **Define strain energy.**

Strain energy is the energy absorbed or stored by a member when work is done on it to deform it.

18. **Distinguish between suddenly applied and impact load.**

When the load is applied all of a sudden and not step wise is called is suddenly applied load. The load which falls from a height or strike and body with certain momentum is called falling or impact load..

19. **Define proof resilience?**

The maximum strain energy stored in a body up to elastic limit is known as proof resilience.

20. **Define strain energy density**.

Strain energy density as the maximum strain energy stored in a material within the elastic limit per unit volume. It is also known as modulus of resilience.

UNIT II -TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAM

1. What are the different types of beams?

1. **Cantilever beam**: A beam which is fixed at one end and at the other end is known as cantilever beam.
2. **Simply supported beam**: A beam supported or resting freely on the supports at its both end is known as simply supported beam
3. **Fixed beam:** A beam whose both end are fixed or built-in walls is known as Fixed beam

Overhanging beam: if the end portion of a beam is extended beyond the support is known as overhanging beam.

4. **Continuous beam**: A beam which is having more than two supports is Known as continuous beam.

3. Name the various types of load.

1. concentrated load or point load
2. Uniformly load
3. Uniformly distributed load

4. Define shear force at a section of a beam.

The algebraic sum of the vertical force at any section of a beam to the right or left of the section is known as shear force.

5. Define bending moment at a section of a beam.

The algebraic sum of the moments of all the force acting to the right or left of the section is known as bending of the beam.

6. What is meant by point of contra flexure?

It is the point where the bending moment is zero where it change sign from positive to negative or vice –versa.

7. Mention the different types of supports?

1. Fixed support
2. Hinged support
3. Roller support

8. What will be the shape of bending moment and shear force diagrams for different types of load.

Types of load S.F.D BM.D Point load

Rectangle Triangle Uniformly load

Triangle Second degree curve uniformly distributed load

Second degree curve Third degree curve

9. Define clear span and effective span.

The horizontal distance between the supporting walls is called the clear span of the beam. The horizontal distance between the lines of action of end – reaction is called effective span.

10. What is section modulus?

The ratio of Moment of Inertia of a section about the neutral axis to the distance of the outer most layer from the neutral axis is known as Section Modulus. It is denoted by Z.

11. What is moment of resistance?

The couple produced in a flexural member due to internal forces is called as moment of resistance.

12. State the theory of simple bending?

If a length of a beam is subjected to a constant bending moment and no share force (i.e. zero shear force) then the stresses will be set up in that length of the beam due to B.M. only and that length of the beam is said to be in pure bending or simple bending. The stresses set up in that length of beam are known as bending stress.

13. What are the assumptions made in the theory of simple bending?

1. The material of the beam is perfectly homogeneous and isotropic.
2. The beam material is stressed, within its elastic limit and thus obeys Hooke‘s law.
3. The transverse sections, which were plane before bending, remain plane after bending also.4.b above or below it.

4. Each layer of the beam is free to expand or contract independently about the layer, above or bel

14. What is mean by positive or sagging BM?

BM is said to positive if moment on left side of beam is clockwise or

right side of the beam is counter clockwise.

15. What is mean by negative or hogging BM?

BM is said to negative if moment on left side of beam is counterclockwise or right side of the bea

16. Write the theory of simple bending equation?

M/ I = F/Y = E/R

M - Maximum bending moment

I - Moment of inertia

F - Maximum stress induced

Y - Distance from the neutral axis

E – Young′s modulus

R – Radius of curvature

17. What is shear force and bending moment diagram?

It shows the variation of the shear force and bending moment along the length of the beam.

18. What is shear force?

The algebraic sum of the vertical forces at any section of the beam to the left or right of the section is called shear force.

19. Define shear force and bending moment?

SF at any cross section is defined as algebraic sum of all the forces acting either side of beam. BM at any cross section is defined as algebraic sum of the moments of all the forces which are placed either side from that point.

20. What is uniformly distributed load.

If a load which is spread over a beam in such a manner that rate of loading „w‟ is uniform throughout the length then it is called as udl.

UNIT – III TORSION

1**. Define torsion.**

A shaft is said to be in torsion, when equal and opposite torques are applied at the two ends of the shaft. The torque is equal to the product of the force applied (tangentially to the ends of a shaft) and radius of the shaft.

1. **What are the assumptions made in the theory of torsion?**

(I) The material of the shaft is uniform throughout.

(ii) The twist along the shaft is uniform.

(iii) Normal cross sections of the shaft, which were plane and circular before twist, remain plane and circular after twist.

(iv) All diameters of the normal cross section which were straight before twist, remain straight with their magnitude unchanged, after twist.

2. **Define polar modulus.**

Polar modulus is defined as the ratio of the polar moment of inertia to the radius of the shaft. It is also called torsional section modulus and is denoted by Zp.

3. **Why hollow circular shafts are preferred when compared to solid circular shafts?**

Comparison by strength;

The torque transmitted by the hollow shaft is greater than the solid shaft; thereby hollow shaft is stronger than the solid shaft.

Comparison by weight:

For the same material, length and given torque, weight of a hollow shaft will be less. So hollow shafts are economical when compared to solid shafts, when torque is acting.

4. **Distinguish between close and open helical coil springs.**

If the angle of the helix of the coil is so small that the bending effects can be neglected, then the spring is called a closed –coiled spring. Close –coiled spring is a torsion spring ( ). The pitch between two adjacent turns is small. If the slope of the helix of the coil is quite appreciable then both the bending as well as torsional shear stresses are introduced in the spring, then the spring is called open coiled spring.

5. **Define stiffness of a spring? In what unit it is measured?**

Stiffness of a spring is defined as load per unit deflection. It is denoted by

K and unit is N/mm.

6. **What is a spring? State various types of spring**.

Springs are elastic members which distort under load and regain their original shape when load is removed.

Types of springs:

1. **Helical springs**
   (a) Closed-coiled spring
   (b) open-coiled helical spring
2. **Leaf spring**
   (a) full-elliptic
   (b) Semi elliptic,
   (c) Cantilever
3. **Torsion spring**
4. **Circular spring**

7. **State the types of stresses when a closed-coiled spring is subjected to**

- Axial load: torsion (neglecting the effects of bending and direct shear)
- Axial twisting moment: pure bending

8. **What is the value of maximum shear stress in a close-coiled helical spring subjected to an axial force?**

Where

W- Axial load on the spring R-mean radius of spring coil d- Diameter of spring wire.

9. **What kind of stress introduced when an axial load acts on a close and open coiled spring.**

Close coiled helical spring —shear stress

Open coiled helical spring —bending stress shear stress

10. **What is meant by spring constants or spring index?**

Ratio of mean diameter of the spring to the diameter of the wire.

11. **The stiffness of the spring is 10N/mm and the axial deflection is 10mm. what is the axial load on the spring?**

Stiffness,

K = load/deflection\

10=W/10

W= 100N.

12. Write down the expression for torque transmitted by hollow shaft

T= (/16) (D4-d4)/d4

T-torque

q- Shear stress

D-outer diameter d- Inner diameter

13. Write torsion equation

T/J=Cθ/L=q/R

T-Torque, θ-angle of twist in radians J- Polar moment of inertia

C-Modulus of rigidity L- Length

q- Shear stress R- Radius

14. Define spring rate (stiffness).

The spring stiffness or spring constant is defined as the load required per unit deflection of the spring. K= W/y

Where W –load and y – Deflection

15. Define pitch.

Pitch of the spring is defined as the axial distance between the adjacent coils in uncompressed state. Mathematically

Pitch=free length/ n-1

16. State any two functions of springs.

1. To measure forces in spring balance, meters and engine indicators.

2. To store energy.

17. What is composite shaft?

Sometimes a shaft is made up of composite section i.e. one type of shaft is sleeved over other types of shaft. At the time of sleeving, the two shafts are joined together, that the composite shaft behaves like a single shaft.

18. What is solid length?

The length of a spring under the maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire. $Ls = nt \times d$ Where, nt = total number of coils.

19. Define tensional rigidity

Product of rigidity modulus and polar moment of inertia is called torsional rigidity

20. What are the differences between closed coil & open coil helical Springs?

The spring wires are coiled very closely, each turn is nearly at right angles to the axis of helix the wires are coiled such that there is a gap between the two consecutive turns. Helix angle is less than 10o Helix angle is large (>10o)

UNIT - IV BEAM DEFLECTION

1. **Write the maximum value of deflection for a cantilever beam of length of length L, constant EI and carrying concentrated load W at the end.**

Maximum deflection at the end of a cantilever due to the load =WL3/3El

2. **Write the maximum value of deflection for a simply supported beam of a length L, constant EI and carrying a central concentrated load W.**

Maximum deflection at a mid span of simply supported beam due to a central load

3. What are the different methods used for finding deflection and slope of beams?

(i) Double integration method

(ii) Mecaulay‘s method

(iii) Strain energy method

(iv) Moment area method

(v) Unit load method

4. **State the two theorems in moment area method**.

Mohr‘s Theorem-I: the angle between tangents at any two points A and B on The bend beam is equal to total area of the corresponding position of the bending moment diagram divided by

Mohr‘s Theorem-II: The deviation of B from the tangent at A is equal to the statically moment of the B.M.D. area between A and B with respect to B divided by EI.

5. What is meant by elastic curve?

Within elastic limit. The deflected shape of a beam under load is called elastic curve of the beam,

6. When Mecaulay's method is preferred?

This method is preferred for determining the deflections of a beam subjected to several concentrated loads or a discontinuous load.

7. What are the boundary conditions for a simply supported end?

The boundary conditions for a simply supported end beam are:

(i) Deflection at the support is zero.

(ii) Slop exists at all points except at the point where deflection is maximum.

(iii) Bending moment is zero at the support.

8. What are the boundary conditions for a fixed end?

Both deflection and slope at the fixed support are zero.

9. Define the term slope.

Slope at any point on the bent beam is the angle through which the tangent at That point makes with the horizontal.

10. What is meant by deflection of beams?

When a flexural member is subjected to transverse loads, the longitudinal axis of the beam deviates from its original position because of the bending of the beam. This deviation at any cross section is called as deflection.

11. What are the points to be worth for conjugate beam method?

1. This method can be directly used for simply supported Beam

2. In this method for cantilevers and fixed beams, artificial constraints need to be supplied to the conjugate beam so that it is supported in a manner consistent with the constraints of the real beam.

12. What is the formula to find a shear stress at a fiber in a section of a beam?

The shear stress at a fiber in a section of a beam is given by

F = shear force acting at a section

A = Area of the section above the fiber

Y = Distance of C G of the Area A from Neutral axis

I = Moment of Inertia of whole section about N A

b = Actual width at the fiber

13. What is the shear stress distribution for I-section?

The shear stress distribution I-section is parabolic, but at the junction of web and flange, the shear stress changes abruptly.

It changes from F/8I [D2 –d2] to B/b x F/8I [D2 –d2]

Where

D = over all depth of the section

d = Depth of the web

b = Thickness of web

B = Over all width of the section.**How the differential equation is written for the beams of varying cross section?**

If a beam is of varying cross-section and varies uniformly according to some law, the expression EI = Mx can be arranged in the form = in which Mx and Lx are functions f x.

14. When do you prefer Moment Area Method?

Even though the moment area method can be used for problems on slopes and deflections, it is convenient to use this method for the following types of problems (with varying cross-section)

(i) Cantilever beams

(ii) Simply supported beams carrying symmetrical loading

(iii) Beams fixed at both ends.

15. What is meant by determinate beams?

The beams whose external reacts can be determined with the help of equations of static equilibrium alone are called determinate beams.

16. What is meant by indeterminate beams?

The beams whose support reactions cannot be obtained with the help of static equations of equilibrium alone are called indeterminate beams.

17. Give examples for determinate and indeterminate beams.

Determinate beams: cantilever and simply supported beams

Indeterminate beams: fixed end beams, continuous beams and ropped cantilever beams.

19. Explain the Theorem for conjugate beam method.

Theorem I: "The slope at any section of a loaded beam, relative to the Original axis of the beam is equal to the shear in the conjugate beam at the corresponding section" Theorem II: "The deflection at any given section of a loaded beam,relative to the original position is equal to the Bending moment at the corresponding section of the conjugate beam"

20. **What are the different sections in which the shear stress distribution is to be obtained?**

Rectangular section, Circular section, I- section, T- section, miscellaneous section

UNIT V THIN CYLINDERS, SPHERES AND THICK CYLINDERS

1. **Distinguish between thin walled cylinder and thick walled cylinder**?

In thin walled cylinder, thickness of the wall of the cylindrical vessel is less than 1/15 to 1/20 of its internal diameter. Stress distribution is uniform over the thickness of the wall. If the ratio of thickness to its internal diameter is more than 1/20, then cylindrical shell is known as thick cylinders. The stress distribution is not uniform over the thickness of the wall.

2. **What are the two type of stress developed in thin cylinder subjected to internal pressure.**

1. Hoop stress

2. Longitudinal stress

3. Define hoop and longitudinal stress

Hoop stress:

The stress acting along the circumference of the cylinder is called circumference or hoop stress

Longitudinal stress:

The stress acting along the length of the cylinder is known as longitudinal.

3. **For what purpose are the cylindrical and spherical shells used?**

The cylindrical and spherical shells are used generally as containers for storage of liquids and gases under pressure.

4. **When the longitudinal stress is in a thin cylinder is zero?**

In case of cylinders with open ends, e.g. in a pipe with water flowing through it Under Pressure, longitudinal stress is zero.

5. **What are assumptions made in the analysis of thin cylinders?**

Radial stress is negligible. Hoop stress is constant along the thickness f the shell. Material obeys Hooke‘s law. Material is homogeneous and isotropic.

6. **What is the operating pressure in a thin cylinder and thick**

cylinder?

For thick cylinder the operating pressure is up to $250MN/m^2$ or more.
For thin cylinder the operating pressure is up to $30MN/m^2$

7. **Define principal planes.**

The planes on which no tangential or shear stresses are acting are called as principal planes.

8. **Define principal stress**.

The normal stress acting on principal planes is called principal stress.

9. **What is the radius of Mohr's?**

Radius of Mohr's circle is the maximum shear stress.

10. **Give two methods to compute principal stresses.**

1. Analytical method
2. Graphical method

11. **What are the formula for finding principal stresses of a thin cylindrical shell Subjected to internal fluid pressure p and a torque?**

Major Principal Stress = f1 + f2 / 2+ {(f1 - f2 /2)2 + fs2}

Minor Principal Stress = f1 + f2 / 2 + {(f1 - f2 /2)2 + fs2}

Maximum shear stress = ½

[Major Principal Stress - Minor Principal Stress]

Where

f1 = Circumferential stress,
f2=Longitudinal stress,

fs =shear stress due to torque.

12. **What are the formula for finding change in diameter, change in length and change volume of a cylindrical shell subjected to internal fluid pressure p?**

d = pd2 /2tE (1 – 1/2m),

L = pdL /2tE (1/2 – 1/m),

V = pd /2tE (5/2 – 2/m) x volume

13. What are maximum shear stresses at any point in a cylinder?

Maximum shear stresses at any point in a cylinder, subjected to internal fluid pressure is given by f1 –f2 / 2 = pd / 8t

14. What is mean by Circumferential stress (or hoop stress) and Longitudinal stress?

The stress acting along the circumference of the cylinder is called circumferential stress (or hoop stress) whereas the stress acting along the length of the cylinder is known as longitudinal stress.

15. For what purpose are the cylindrical and spherical shells used?

The cylindrical and spherical shells are used generally as containers for storage of liquids and gases under pressure.

16. When the longitudinal stress is in a thin cylinder is zero?

In case of cylinders with open ends, e.g. in a pipe with water flowing through it under pressure, longitudinal stress is zero.

17. What are assumptions made in the analysis of thin cylinders?

- Radial stress is negligible.
- Hoop stress is constant along the thickness of the shell.
- Material obeys Hooke's law.
- Material is homogeneous and isotropic.

18. Write the volumetric strain 1. Thin cylindrical shell 2. Thin spherical shell

1. Thin cylindrical shell Volumetric strain: jV/V == pd $2tE$ [5 2 − 2 m]
2. Thin spherical shell Volumetric strain: jV/V == 3$XpXd$ 4tE [l − l m]

19. What is the value of value maximum shear stress when the principal stresses are P1 and P2?

Maximum shear stress, tmax = $p1-p2/2$

Where p1 and p2 are tensile or compressive principal stresses If p1 is compression and p2 is tension then Maximum shear stress, tmax = $p1+p2/2$

20. What is the radius of Mohr's?

Radius of Mohr's circle is the maximum shear stress.

UNIT I – Stress, Strain and Deformation of Solids

1. Define **stress and strain**. Explain different types of stresses and strains with suitable examples.
2. Explain the **deformation of simple and compound bars** subjected to axial loads with derivations.
3. Derive the expression for **thermal stresses in bars** when:
    (i) Expansion is prevented
    (ii) Expansion is partially prevented.
4. Explain the **elastic constants** and derive the relation between **Young's modulus, Bulk modulus, and Poisson's ratio**.
5. Derive the expression for **volumetric strain** and explain its significance.
6. Explain the **stresses acting on an inclined plane** when a body is subjected to direct stress.
7. Define **principal stresses and principal planes** and derive the expressions for them.
8. Explain **Mohr's Circle of Stress** and show how it is used to determine principal stresses.
9. A bar is subjected to **tensile and compressive forces**. Determine the resulting stresses and deformation.
10. Discuss the **difference between rigid bodies and deformable bodies** with examples.

UNIT II – Transverse Loading on Beams and Stresses in Beams

1. Define **beams** and explain different **types of beams** with diagrams.
2. Explain **shear force and bending moment** and derive their relationships.
3. Draw **Shear Force Diagram (SFD)** and **Bending Moment Diagram (BMD)** for a **cantilever beam** subjected to point load and UDL.
4. Draw **SFD and BMD for a simply supported beam** subjected to various loads.
5. Explain **overhanging beams** and draw SFD and BMD for typical loading conditions.
6. Derive the **theory of simple bending (bending equation)**.
7. Explain the **stress distribution in beams under bending** with diagrams.
8. Explain the **load carrying capacity of beams** and factors affecting it.
9. Explain the **concept and construction of flitched beams** and their advantages.
10. Derive the expression for **shear stress distribution in rectangular beam sections**.

UNIT III – Torsion

1. Derive the **torsion equation for circular shafts**.
2. Explain the **torsional stresses and deformation in solid circular shafts**.
3. Derive expressions for **torsion in hollow circular shafts**.
4. Compare **solid and hollow shafts** based on strength and weight.
5. Explain the **analysis of stepped shafts subjected to torsion**.
6. Derive the expression for **angle of twist in shafts**.
7. Explain **torsion in shafts fixed at both ends** with suitable examples.
8. Derive the expression for **stresses in helical springs** subjected to axial loads.
9. Derive the formula for **deflection of close-coiled helical springs**.
10. Explain the **working and stress analysis of carriage springs**.

UNIT IV – Deflection of Beams

1. Explain the **double integration method** for finding slope and deflection in beams.
2. Determine the **slope and deflection of a simply supported beam** using the double integration method.
3. Explain **Macaulay's method** for determining beam deflection.
4. Solve beam deflection problems using **Macaulay's method**.
5. Explain the **area moment method** for calculating slopes and deflections.
6. State and prove the **first and second moment area theorems**.
7. Explain the **conjugate beam method** with examples.
8. Explain the concept of **strain energy in beams**.
9. State and explain **Maxwell's reciprocal theorem**.
10. Compare different **methods used to determine beam deflection**.

UNIT V – Thin Cylinders, Spheres and Thick Cylinders

1. Derive expressions for **circumferential (hoop) stress and longitudinal stress in thin cylindrical shells**.
2. Derive the expression for **deformation in thin cylindrical shells** due to internal pressure.
3. Explain the **assumptions made in thin cylinder theory**.
4. Derive the **stress expressions in spherical shells subjected to internal pressure**.
5. Derive the **deformation equation for spherical shells**.
6. Explain the **difference between thin and thick cylinders**.
7. State and derive **Lame's equations for thick cylinders**.
8. Explain the **stress distribution in thick cylinders subjected to internal pressure**.
9. Derive the **expressions for radial and circumferential stresses in thick cylinders**.
10. Explain the **applications of thick cylinders in engineering structures**.