# CE8395 Strength of materials for Mechanical Engineers

## TWO MARK QUESTIONS & ANSWERS

**CE8395 Strength of materials for Mechanical Engineers**

**Syllabus**

**OBJECTIVES:**

- To understand the concepts of stress, strain, principal stresses and principal planes.
- To study the concept of shearing force and bending moment due to external loads in determinate beams and their effect on stresses.
- To determine stresses and deformation in circular shafts and helical spring due to torsion.
- To compute slopes and deflections in determinate beams by various methods.
- To study the stresses and deformations induced in thin and thick shells.

**UNIT I STRESS, STRAIN AND DEFORMATION OF SOLIDS 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 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– bending stress distribution – Load carrying capacity – Proportioning of sections – Flitched beams – Shear stress distribution.

**UNIT III TORSION 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 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.

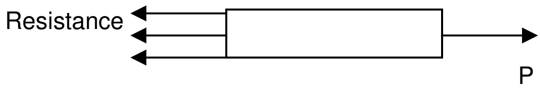
**UNIT V THIN CYLINDERS, SPHERES AND THICK CYLINDERS 9**

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.

## UNIT 1 STRESS, STRAIN AND DEFORMATION OF SOLIDS

1. What is stress?

   The internal resistance offered by a body per unit area against deformation is known as stress. The unit of stress is $N/mm^2$ or $N/m^2$ When an external force acts on a body, the body tends to undergo deformation. Due to cohesion between molecules the body resist the force. This resistance offered by the body is known as strength of material.

   Mathematically stress or intensity of stress is written as

   $\sigma = \frac{P}{A}$ where σ is stress and P is load and A is area ofcross section

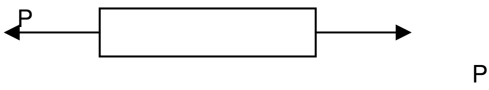
   Note: $1\ N/m^2 = 1$ Pascal

   $1\ N/mm^2 = 10^6 N/m^2$

   $1\ bar = 1 \times 10^5 N/m^2$

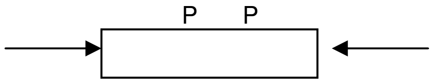
2. What is tensile stress?

   **Tensile stress**: The resistance offered by a body per unit area when it is subjected to a force which acts away from its point of application is called tensile stress.

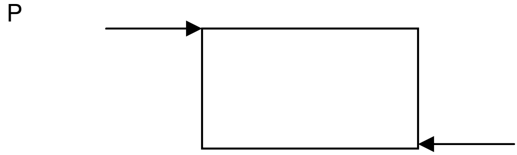
3. What is compressive stress?

   Compressive stress: The resistance offered by a body per unit area when it is subjected to a force which acts towards its point of application is called compressive stress.




4. What is shear stress?

**Shear Stress:**The resistance offered by a body per unit area when the applied load on the body consists of two equal and opposite forces not in the same line is called shear stress.




$\tau = P/A$

where $\tau$ is shear stress, P is tangential force and A is area of shearing

5. What is strain?

when a body is subjected to some external force, there is some deformation of the body. The ratio of change of dimension of the body to the original dimension is known as strain. It has no unit.

$$\text{Strain} = \frac{\text{change in length } (\delta\ell)}{\text{original length } (\ell)}$$

**6. What is Tensile strain?**

The length of the bar increases by an amount under the action of external force P then tensile strain = $\frac{\text{increase in length}}{\text{original length}}$

**7. What is compressive strain?**

The length of the bar decreases by an amount under the action of external force P then compressive strain = $\frac{\text{decrease in length}}{\text{original length}}$

**8.What is Shear strain?**

The distortion produced by shear stress on an element or rectangular block is known as shear strain. It can also be defined as the change in the right angle.

**9.What is volumetric strain?**

The ratio between the change in volume and the original volume is known as volumetric stain.

Volumetric strain = $\dfrac{\text{change in volume}}{\text{original volume}}$

10. Define True stress and True Strain

The true stress is defined as the ratio of the load to the cross section area at any instant.

$$(\varepsilon_T) = \int_{L_o}^{L} \frac{dl}{l} = \ln\left(\frac{L}{L_o}\right) = \ln(1+\varepsilon) = \ln\left(\frac{A_o}{A}\right) = 2\ln\left(\frac{d_o}{d}\right)$$

or engineering strain $(\varepsilon) = e^{\varepsilon_T} - 1$

11. Define Hooke's law?

Within the elastic limit, when a body is loaded, then stress induced is proportional to the strain. This is called as Hook's law.

12. What is linear strain?

The ratio of increase or decrease in length to the original length is called as linear strain.

13. What is lateral strain?

The ratio of increase or decrease in lateral dimensions to the original lateral dimensions is called as lateral strain.

14.What are the types of elastic constants?

- Modulus of elasticity or Young's modulus
- Modulus of rigidity or shear modulus
- Bulk modulus

15. What is poison's ratio?

When a member is stressed with in elastic limit, the ratio of lateral strain to its corresponding linear strain remains constant throughout the loading. This constant is called as poison's ratio. It is the ratio of lateral strain to longitudinal or linear strain.

16. What is the inter relationship between the three constants?

$$E = 2G(1+\mu) = 3K(1-2\mu) = \frac{9KG}{3K+G}$$

Where, E = Young's modulus in $N/mm^2$
K = Bulk modulus in $N/mm^2$
G = Modulus of rigidity in $N/mm^2$   μ   Poisson's ratio

17. Define bulk modulus?

When a body is stressed the ratio of direct stress to the corresponding volumetric strain is constant with in elastic limit. This constant is called as bulk modulus. Bulk modulus is the ratio of direct stress to volumetric strain.

18. Define modulus of elasticity?

Modulus of elasticity is the ratio of stress to strain.

19. Define factor of safety?

Factor of safety is defined as the ratio of ultimate stress to the working stress (permissible stress).

20.What is elasticity?

The deformation produced due to the application of external load disappears completely with the removal of the load. This property of the material is called as elasticity.

21.What is elastic limit?

Elastic limit is the limiting value of the load up to which the material returns back to its original position. Beyond this load, the material will not return back to its original position.

22What are thermal stresses and strain?

Whenever there is increase or decrease in the temperature of the

body, the body tends to expand or contract. If this deformation is prevented, some stresses are induced in the body, these stresses are called as thermal stresses or temperature stresses. The corresponding strains are thermal strain or temperature strains.
Thermal stress is $\sigma_t = \alpha T E$ where α is co-efficient of linear expansion, T is rise in temperature E is young's modulus

$$\text{Temperature stain or thermal strain} = \frac{\text{Extension prevented}}{\text{original length}}$$

Extension prevented $= \alpha T L$
So thermal strain is $e_t = \alpha T$

23.If the values of E and μ for an alloy body is 150 GPa and 0.25 respectively, find out the value of bulk modulus for the alloy?

Bulk modulus, $K = (mE) / [3(m-2)] = 100 \times 10^3 \text{ N/mm}^2$

24. Differentiate between Ultimate stress and working stress?

Ultimate stress is the maximum value of stress up to which the material withstand its failure. Working stress is the maximum stress allowed to setup in a material in actual practice.

25. What is a compound or composite bar?

A bar made of two or more different materials, joined together is called a compound or composite bar.

**26. Write the Compatibility equation for solving compound bar problems**
The extension or contraction in each bar is equal. Hence deformation per unit length i.e. strain in each bar is equal.

$$\delta\ell = \delta\ell_1 = \delta\ell_2 = \delta\ell_3$$

$$\delta\ell = \frac{P\ell}{AE}$$ Where P is load ℓ is length of the section
A is area of cross section, E is young's modulus
2. The total external load on the composite bar is equal to the sum of the loads carried by each different material
$P = P_1 + P_2 + P_3$
$P_1 = \sigma_1 A_1$ Where σ is stress induced and $A_1$ is area of cross section

**27. Write Thermal stresses in composite bars( Procedure for finding thermal stresses in composite bar)**

1. If a compound bar made up of different materials is subjected to a change in temperature there will be a tendency for the compound parts to expand different amounts due to the unequal coefficients of thermal expansion. If the parts are constrained to remain together then **the actual change in length must be the same for each**. This change is the resultant of the effects due to temperature and stress conditions.

$$\alpha_1 T\,L + \frac{\sigma_1}{E_1} L = \alpha_2 T\,L - \frac{\sigma_2}{E2} L$$

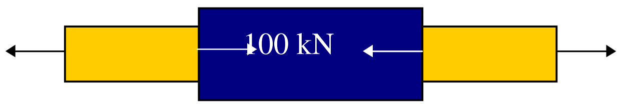
1. For equilibrium the resultant force acting over any cross section must be equal.

$$\sigma_1 A_1 = \sigma_2 A_2$$

28 .What is principle of super position?

When a body is subjected to number of forces acting on different sections along the length of body, then the resulting deformation of the body is equal to the algebraic sum of the deformations of the individual sections. This is called principle of super position.

29.Find the magnitude of 'P' of a compound bar?




100

Sum of all the forces acting in left direction = Sum of all the forces acting in right direction.

Therefore, 100 + P = 100 + 50

P = 50 kN.

30. How will you calculate the total elongation of a compound bar which is connected in series?

The total elongation of a compound bar connected in series can be computed by the relation

$$= \delta l_1 + \delta l_2 + \delta l_3 + \ldots + \delta l_n$$

$$\delta l = \frac{P_1 L_1}{A_1 E_1} + \frac{P_2 L_2}{A_2 E_2} + \ldots + \frac{P_n L_n}{A_n E_n}$$

where, □$l_i$ is the deformation on individual bar in the system.

**31.what do you mean by a bar of uniform strength:**
A bar having uniform stress when it is subjected to its own weight is known as a bar of uniform strength.

**32. Expression for the total elongation of uniformly tapering rectangular bar when it is subjected to an axial load P**

$$\delta \ell = \frac{PL}{Et(a-b)} \log_e \frac{a}{b}$$

where L- Total length of the bar t- thickness of the bar a – width at bigger bar b- width at smaller end **E-** Young's modulus

33.What is meant by free body diagram?

A free body diagram is a complete diagram or a simplified sketch that shows all the external forces with the direction and the point of application of external load. This includes all the reactive forces by the supports and the weight of the body due to its mass.

34.Define elastic strain energy?

If the material is loaded within the elastic limit and then unloaded to zero stress, the strain also becomes zero and the strain energy stored in the body in straining the material is recoverable. However, when the material is loaded beyond the elastic limit and then unloaded, some permanent deformations will be setup in the body even after unloading. Therefore, only the partial strain energy will be recoverable and is called elastic strain energy.

36.What do you mean by strain energy density?

Strain energy density is defined as the strain energy per unit volume of the material. It is actually the area under the stress-strain curve.

37.Define Proof load.

The maximum load which can be applied to a body without permanent deformation is called proof load.

38.Define resilience.

Resilience is defined as the capacity of a material to absorb energy upon loading.

39.Define modulus of resilience.

Modulus of resilience is defined as the energy per unit volume that the material can absorb without yielding.

40.Define toughness of a material.

Toughness is defined as the maximum strain energy that can be absorbed per unit volume till rupture.
The modulus of toughness is a measure of the resistance of the structure to impact loading and is dependent on the ductility of the material.

41.What are the major types of deformation?

Elastic deformation (deformation due to loads)
Thermal deformation (deformation due to temperature variation)

42.What is meant by residual stresses?

In reality, when materials are being manufactured, they are often rolled, extruded, forged, welded and hammered. In castings, materials may cool unevenly.
These processes can setup high internal stresses called residual stresses. Note:
This process causes the development of larger normal stresses

near the outer surface than in the middle.
These residual stresses are self-equilibrating. i.e. they are in equilibrium without any externally applied forces.
In real world problems, such residual stresses may be large and should be carefully investigated and then added to the calculated stresses for the initially stress-free material.

**43.Strain Energy**

The energy required to deform an elastic body is known as strain energy.

U = $\frac{1}{2}$ P x

U = $\frac{\sigma^2}{2E}AL$ Where AL is the volume of the bar

**44. Resilience:** The strain energy stored per unit Volume is usually known as Resilience

**45. Proof Resilience:** The strain energy stored per unit volume upto elastic limit is known as proof resilience.

**46. Expression for strain energy stored in a body when the load is applied gradually**

U = $\frac{\sigma_1^2}{2E}AL$

**47. Expression for strain energy stored in a body when the load is applied suddenly**

U = $\frac{\sigma^2}{2E}AL$ where $\sigma = 2\sigma_1$ i.e., the maximum stress induced due to suddenly applied load is two times gradually applied load.

**48. Expression for strain energy stored in a body when the load is applied with impact**

U = $\frac{\sigma^2}{2E} AL$ where

σ = $\frac{P}{A}\left(1+\sqrt{1+\frac{2AEh}{PL}}\right)$ Where P – load dropped or impact load, L- Length of the rod A area of cross section, h- height through which load is dropped

**49. Expression for strain energy stored in a body due to shear.**

U = $\frac{\tau^2}{2C} AL$ Where $\tau$ is shear stress,C is rigidity modulus

50. How will you calculate major principal stress on member subjected to like principal stresses and shear stress?

Major normal principal stresses

$$,\sigma_{n_1} = \frac{\sigma_1+\sigma_2}{2} + \sqrt{\left(\frac{\sigma_1-\sigma_2}{2}\right)^2 + \tau^2}$$

51. How will you calculate minor principal stress on member subjected to like principal stresses and shear stress?

Minor normal principal stresses

$$,\sigma_{n2} = \frac{\sigma_1+\sigma_2}{2} - \sqrt{\left(\frac{\sigma_1-\sigma_2}{2}\right)^2 + \tau^2}$$

52. What is the use of Mohr's circle?

This is a graphical method which is frequently used to find out the normal, tangential, resultant stresses, and principal planes for the given stresses on oblique plane.

53.What do you mean by limit of proportionality or elastic limit?

*Limit of proportionality or elastic limit is a point in the stress-strain curve at which the linear relation between them ceases*. (i.e. the point at which the straight line changes to a curve). Thereafter the stress is not directly proportional to strain and therefore *Hooke's law is not valid after the elastic limit*. Also this is the point at which material undergoes rearrangement of molecular structure, in which atoms are being shifted to some other stable configuration.

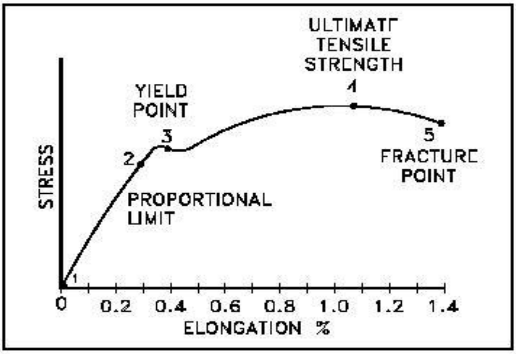



Figure 1.1 Stress-Strain Curves

54. What do you mean by the term “necking”?
When a material is being loaded to its yield point, the specimen begins to “neck” (i.e. the cross sectional area of the material start decreasing) due to plastic flow. Therefore Necking can be defined as the mode of ductile flow of material in tension. Necking usually occurs where the surface imperfections are predominant.

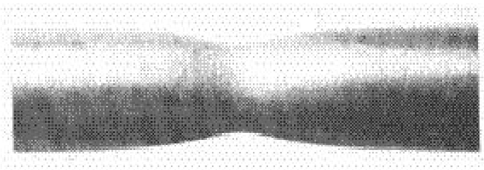


Figure 1.2 Necking

UNIT – II

Transverse Loading on Beams and Stresses in Beam

1. What is a beam?

A beam is a structure member supported along its length and subjected to various types of loadings acting vertically downwards (perpendicular to the centre of the beam).

2. Classify beams based upon its supports?

- Cantilever beam
- Simply supported beam
- Overhanging beam
- Fixed beam
- Continuous beam
- Propped cantilever beam
-

3. What is cantilever beam?

A beam which is fixed at one end and free at other end is called a cantilever beam.

4. What is simply supported beam?

A beam which is resting freely on the supports at both the ends is called a simply supported beam.

5. What are the various types of loading?

- Point or concentrated load
- Uniformly distributed load (UDL)
- Uniformly Varying load (UVL)

6. What is fixed beam?

A beam which is fixed at both the ends or built up in halls is called as a fixed beam.

7. What is overhanging beam?

A beam in which one or both the ends are extended beyond the supports is called as a overhanging beam.

8. What is continuous beam?

A beam which is supported by more than two supports is called continuous beam.

9. What is point load?

A load which is applied at particular point is called as point or concentrated load.

10. What is mean by uniformly distributed load?

Uniformly distributed load is a load which is uniformly spread over the given span or length of the beam, at the rate of loading w in N/m.

11. What is mean by uniformly varying load?

Uniformly varying load which is spread over a beam in such a manner that the rate of loading uniformly increases from zero to N/m through the span or length at a constant rate.

12. What is shear force?

Shear force at a cross section is defined as the algebraic sum of all the forces acting either side of beam.

13. What is Bending moment?

Bending moment at a cross section is defined as the algebraic sum of moments of all the forces which are placed either side from the point.

14. What is meant by Sagging moment?

A bending moment in which the force in left side of beam is clockwise and right side of the beam is counter clockwise is called Sagging or positive moment.

15. What is meant by Hogging moment?

A bending moment in which the force in left side of beam is counter clockwise and right side of the beam is clockwise is called Hogging or negative moment.

16. What are shear force diagram (SFD) and Bending moment diagram (BMD)?

Shear force diagram (SFD) is a diagram which shows the variation of shear force along its length of beam.
Bending moment diagram (BMD is a diagram which shows the variation of bending moment along its length of beam.

17. What is meant by point of contraflexure?

Point of contraflexure is a point on a loaded beam at which the bending moment changes its sign or is zero.

18. Give the relationship between shear force and bending moment?
The rate of change of bending moment equals to the shear force at the section. Mathematically, $\frac{dM}{dx} = -F$

19. State any two assumptions made in theory of bending?

- The material is perfectly homogeneous and isentropic.
- The Young's modulus is same in tension as well as compression.

20. Write bending equation and explain the terms?

The bending equation is given as $\frac{M}{I} = \frac{\sigma_b}{y} = \frac{E}{R}$

Where, M = Bending moment in N mm
I = Moment of inertia in $mm^4$
$\sigma_b$= Bending stress in $N/mm^2$
y = Distance from neutral axis in mm
E = Young's modulus in $N/mm^2$
R = Radius of curvature in mm.

21. What is section modulus?

Section modulus is the ratio of moment of inertia of the section to the distance from the neutral axis.

Section modulus (Z) = $\frac{I}{y}$

Where, I = Moment of inertia in $mm^4$
y = Distance from neutral axis in mm.

$$Z = \frac{\pi d^3}{32} \text{ (for solid circular sections)}$$

$$Z = \frac{\pi (D^4 - d^4)}{32 D} \text{ (for hollow circular sections)}$$

22. What are flitched or composite beam?

A beam which is constructed by two different materials and behave as a single unit during loading is called a flitched or composite beam.

23. What is simple or pure bending?

If a beam is bent only due to application of constant bending moment and not due to shear then it is called simple or pure bending.

24. What do you mean by beam of uniform strength?

A beam in which bending stress developed is constant and is equal to the allowable stress at every section is called beam of uniform strength.

**25. When will bending moment be maximum?**

Bending Moment will be maximum when shear force is zero.

**26. What is maximum bending moment in a simply supported beam of span 'L'**
**subjected to UDL of 'w' over entire span?**

Max BM = $\frac{WL^2}{8}$

**27. In a simply supported beam how will you locate point of maximum bending**
**moment?**

The bending moment is max. When Shear Force is zero. Write SF equation at that point
and equate to zero, the distance ‘x’ from one end can be found. Substituting the value of x in moment equation the maximum moment can be found

**28. What is shear force and bending moment diagram?**

The digram which shows the variation of the shear force and bending moment along the length of the beam.

**29. Write the assumption in the theory of simple bending?**

1. The material of the beam is homogeneous and isotropic.
2. The beam material is stressed within the elastic limit and thus obeys Hook’s law.
3. The transverse section which was plane before bending remains plains after bending also.
4. Each layer of the beam is free to expand or contract independently about the layer, above or below.
5. The value of E is the same in both compression and tension.

30.Comment on Load Carrying capacity of beams?

The strength of the section or the load carrying capacity of a beam does not depend upon the sectional area provided but upon the disposition of that area in relation to its neutral axis. In other words, the strength of beam directly depends on the section-modulus ‘Z’ of the beam.

31. What do you mean by shear flow?

Shear flow is defined as the longitudinal force per unit length transmitted across the
section at level ‘y1’ from the neutral axis.
If the shear stress is multiplied by the corresponding width of the section, the quantity obtained is known as shear flow. It is denoted

by ‘q’ and is given by q = τ. z (here ‘z’ denotes the width of the section corresponding to that layer)

32. How will you calculate the value of shear stress at a particular distance from the neutral axis?

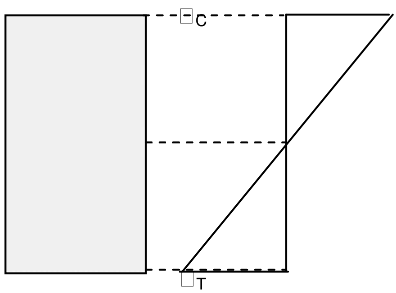
$$\frac{V.A'.y}{I.Z}$$

Here, ‘V’ is the corresponding shear force at a particular distance from the neutral axis, A’ is the partial area of the section, ‘$\bar{y}$ ’is the moment arm of this partial area with respect to neutral axis, ‘I’ is the moment of inertia of the section and ‘Z’ is the corresponding width of the layer or fiber and ‘ □ ’ is the shear stress at a particular distance from the neutral axis.

33.Draw the bending stress variation of a simply supported beam.

The value of bending stress ($N/mm^2$) is zero at the level of neutral axis and maximum at the extreme fiber of the cross-section of the beam. The bending stress is always proportional to the distance of the fiber from the neutral axis. The value of bending stress increases as the distance of the fiber increases.

Above the neutral axis, the beam experiences compressive stress and at the same time it is subjected to tensile stress below the neutral axis. The bending stresses always cause the member to bend in the transverse direction.



# UNIT 3

## TORSION OF CIRCULAR SHAFT & SPRINGS

1. What is power?

Power can be defined as the rate of transferring energy. It is calculated as

$$P = T \times 'n'$$

where, P is the power, T is the torque and ‘n’ is the rotational speed.

2. What do you mean by Torsion?

Torsion refers to the loading of a circular or non-circular member that tends to cause it to rotate or twist. Such a load is called torque, torsional moment, rotational moment, twisting moment or simply couple.

3. What are the assumptions made in Torsion equation

- The material of the shaft is homogeneous, perfectly elastic and obeys Hooke’s law.
- Twist is uniform along the length of the shaft
- The stress does not exceed the limit of proportionality
- The shaft circular in section remains circular after loading
- Strain and deformations are small.

4. Write the governing equation for torsion of circular shaft?

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$

where, T-Torque; J- Polar moment of inertia; G-Modulus of rigidity; L- Length of the shaft; $\tau$- Shear stress; R- Radius of the shaft.

5. What is the type of stress induced in a structural member subjected to torsional loading?

Shear Stress. The variation of shear stress is linear and it vary from zero at the neutral axis and reaches the maximum value at the extreme fiber of the shaft.

i.e. shear stress $\propto$ radius

6. Define polar moment of inertia and establish the equations for a solid and hollow circular shaft.

Polar moment of inertia can be defined as

$$J = \frac{\pi D^4}{32} \text{ (solidcircularshaft)}$$

$$J = \frac{\pi (D^4 - d^4)}{32} \text{ (hollowcircularshaft)}$$

7. Define polar modulus?

Polar modulus can be defined as

$$Z_p = \frac{\pi D^3}{16} \text{ (solidcircularshaft)}$$

$$Z_p = \frac{\pi (D^4 - d^4)}{16D} \text{ (hollowcircularshaft)}$$

8. Why the shear stress is maximum at the outer surface of the shaft than the inner core?

When the circular shaft is subjected to torsional loading, the shear stress is maximum at the extreme fiber of the shaft. This is due to the reason that, the extreme fibers are much strained than the inner surface near centroidal axis of the member. This is the reason why the shear stress is maximum at the extreme fiber of the shaft. Also the materials inside the shaft are not that much utilized at the time of torsional loading. Also it this is the reason why hollow circular shafts are preferred rather than the solid one for practical use.

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

- The torque transmitted by the hollow shaft is greater than the solid shaft.
- For same material, length and given torque, the weight of the hollow shaft will be less compared to solid shaft.

10. What is torsional stiffness?

The measure of torsional stiffness is the angle of twist of one part of a shaft relative to another part when a certain torque is applied.

11. What are various types of rigidity modulus?

- Flexural rigidity (EI)
- Torsional rigidity (GJ)
- Plate rigidity

12. Define spring?

A spring is an elastic member, which deflects under the action of load and regains its original shape after the removal load.

13. What are the various types of springs?

- Disc spring (or) Belleville spring
- Leaf spring
- Spiral spring
- Helical spring

Helical springs can be again classified into

- Open coil helical spring
- Closed coil helical spring

14. State any two major functions of a spring.

- To absorb the shock energy
- To measure forces in spring balance and engine indicators

15. Define pitch?

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

Pitch = (length/ (n-1)) where, n

is the number of turns available in the coil.

16. What is spring index (C)?

The ratio of pitch or mean diameter to the diameter of wire for the spring is called the spring index.

17. What is solid length?

The length of a spring under its maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire. It is usually denoted by the symbol $L_s$.

18. Define free length.

Free length of the spring is the length of the spring when it is free or unloaded condition. It is equal to the solid length plus the maximum deflection or compression plus clash allowance.

$L_f$ = solid length + $Y_{max}$ + 0.15 $Y_{max}$

19. Define stiffness of spring or spring rate.

The spring stiffness or spring constant is defined as the load required per unit deflection of the spring

20. Define helical springs.

The helical springs are made up of a wire coiled in the form of a helix and are primarily intended for compressive or tensile load. Closed coil springs are meant for taking tensile load (springs balance) and the other one is for taking compressive load (Shock observer).

21. What are the differences between closed coil & open coil helical springs?

| Closed coil helical spring | Open coil helical spring |
|---|---|
| Meant for tensile load | Meant for compressive load |
| 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 $10^o$ | Helix angle is large ($>10^o$) |

22. What are the various stresses induced in the open coil helical spring?

- Torsional shear stress
- Direct shear stress
- Stress arises due to curvature

23. What is buckling of springs?

The helical compression spring behaves like a column and buckles at a comparative small load when the length of the spring is more than 4 times the mean coil diameter

24. What is buckling of springs?

The helical compression spring behaves like a column and buckles at a comparative small load when the length of the spring is more than 4 times the mean coil diameter.

25. What is surge in springs?

The material is subjected to higher stresses, which may cause early fatigue failure. This effect is called as spring surge.

26. Define active turns.

Active turns of the spring are defined as the number of turns, which impart spring action while loaded. As load increases the no of active coils decreases.

27. Define inactive turns.

An inactive turn of the spring is defined as the number of turns which does not contribute to the spring action while loaded. As load increases number of inactive coils increases from 0.5 to 1 turn

## UNIT – IV Deflection of Beams

1. What are the important methods used to find slope and deflection?

   - Double integration method
   - Macaulay's method
   - Moment – area method
   - Conjugate beam method

2. What is the disadvantage of double integration method?

   In double integration method, if there are more loads at different sections, then functions will be needed to represent the bending moment and hence additional constants, and a corresponding number of equations will be required resulting in rather lengthy computations.

3. What is the use of moment area method?

   Moment area method is very much useful to find the deflection and slope of a beam at any particular point on the beam. This method can be applied all types of loads or beams of variable cross section.

4. Where does the maximum deflection occur on cantilever beam?

   For cantilever beam having any load or any cross section along the length of the beam, the maximum deflection occurs only at the free end of the beam.

5. Where does the maximum deflection occur for the simply supported beam loaded symmetrically about mid point and having same cross – section through their length?

   The maximum deflection occurs at the centre.

6. State first moment – area theorem (or) Mohr's I theorem (or) One moment area theorem?

   The change of slope between any two parts on the beam is equal to the net area of the M / EI diagram between these two points.

7. State second moment – area (or) Mohr's II theorem?

The tangential deviation between two points on the elastic curve is equal to the areas of the M / EI diagram between that two points about any vertical line.

8. State Castigliano's theorem?

In any beam subjected to any load system the deflection at any point r is given by the partial differential of the total strain energy stored with respect to a force $P_r$ acting at a point r.

9. State conjugate theorem I?

The slope at any section of a loaded beam is equal to the shear force at the corresponding section of the conjugate beam.

10. State conjugate theorem II?

The deflection at any section of a loaded beam is equal to the bending moment at the corresponding section of the conjugate beam.

11. Write the flexural equation?

The flexural equation for the beam is $\frac{d^2y}{dx^2} = \frac{M}{EI}$

12. Write the maximum slope and deflection when simply supported beam of length of l has only one central load W?

Maximum slope $\theta_{max} = \frac{Wl^2}{16EI}$

Maximum Deflection $y_{max} = \frac{Wl^3}{48EI}$

13. What is flexural rigidity?

The product of modulus of elasticity and moment of inertia is called as flexural rigidity.

14. Why deflection of beams is needed for engineering applications like mechanical engineering?

The spindle of a lathe or drill press and the arbor of a milling machine carry cutting tools for machining metals. Therefore the deflection of the spindle would have an adverse effect on the accuracy of the machine output. The manner of loading and support of these machine elements behave like that of a real beam. This is the reason why deflection of beams is necessary for engineering applications like mechanical engineering.

15. Describe the boundary conditions that can be used for finding out the values of the constants of integration in case of common type of beams.

| Support | Deflection | Slope | Moment |
|---|---|---|---|
| Fixed end | Zero | Zero | Yes |
| Free end | Yes | Yes | Zero |
| Roller (i.e. pinned or hinged) | Zero | Zero | Zero |

16.Define the term slope.

Slope is defined as the rotation of the beam axis from its original position.

17.Define deflection.

The displacement of a particular point located in the longitudinal axis of the beam in the vertical direction is called deflection. Deflection may be either upward or downward depending upon the direction of the load which is acting on the beam

18.Write down the moment – curvature relationship?

$$EI \frac{d^2 y}{dx^2} = M$$

where M is the bending moment, EI is the flexural rigidity and ‘y’ is the deflection of the beam.

19.Explain the procedure of finding the slope and deflection of a beam using Macaulay’s method?

- Find the reaction at the supports
- Take a section at a distance ‘x’ from the left support such that it covers all the loads in the beam.
- Form the moment – curvature expression that relates the bending moment
- Integrate the moment curvature expression twice to obtain the expressions for slope and deflection.
- Apply the boundary conditions and the find the constants involved in the moment – curvature expression.
- Find the slope and deflection at various points by substituting the value for ‘x’.

20.List out the relationship exists between slope, deflection, bending moment and the load.

$$\text{Slope} = \frac{dy}{dx}$$

$$\text{Bending Moment} = EI \frac{d^2 y}{dx^2}$$

$$\text{Shear Force} = d^3 y$$

$dx^3$

Load □ $\frac{d^4 y}{dx^4}$

21 Write down the two Moment – Area theorems?

The angle between the tangents at two points A and B of a deflection curve is equal to the area of the M/EI diagram between A and B.

The displacement of B from the tangent at A is equal to the moment of the M/EI diagram between A and B about the point B.

22.State the principle involved in finding the slope and deflection of beams using Moment-Area theorem.

Moment – Area method uses the elastic curve equation or moment curvature expression, but the integration is carried out by doing so, the kinematic boundary conditions are not considered.

23.What is conjugate beam?

Conjugate beam is a fictitious beam which has the same length as the real beam, but supported in such a manner that when it is loaded with M/EI diagram of the real beam, the shear and bending moment at a section in the conjugate beam give the slope and deflection at the corresponding section of a real beam.

24.Explain, how the load is applied in Conjugate beam method and its applicability to different types of beam?

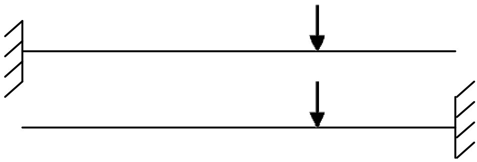
In conjugate beam method, the beam is loaded with elastic weight M/EI corresponding to the actual load.

For cantilever beams, fixed beams and continuous beams, if this method is applied, the fixed ends behave like that it is subjected to rotations and translations. Hence for this type of beams some artificial restraints have to be applied to the conjugate beam, so that it is supported in a manner consistent with the constraints of the real beam.

25.Why deflection of beams is needed for engineering applications like mechanical engineering?

The spindle of a lathe or drill press and the arbor of a milling machine carry cutting tools for machining metals. Therefore the deflection of the spindle would have an adverse effect on the accuracy of the machine output. The manner of loading and support of these machine elements behave like that of a real beam. This is the reason why deflection of beams is necessary for engineering applications like mechanical engineering.

26.Give the conjugate beam for the cantilever shown below.



UNIT – V

Thin Cylinders, Spheres and Thick Cylinders

1. Define thin cylinder?

Cylindrical vessels are used to store liquids and gases under pressure. The diameter to thickness ratio is greater than 20 is called as thin cylinder.

2. What is mean by thick cylinder?

The diameter to thickness ratio is less than 20 called as thick cylinder. Here circumference stress varies from inner to outer wall thickness.

3. What are the stresses induced in thin cylindrical shell subjected to internal pressure?

1. Circumferential stress or Hoop stress
2. Longitudinal stress

4. What is Hoop stress (or) Circumferential stress?

The stress is acting along the circumference of the cylinder is called as Hoop stress (or) Circumferential stress. It is denoted by $\sigma_c$.

$$\sigma_C = \frac{p.d}{2.t}$$

5. What is longitudinal stress?

The stress is acting along the axis of the cylinder is called as longitudinal stress. It is denoted by $\sigma_l$.

$$\sigma_l = \frac{p.d}{4.t}$$

6. Give the expression for hoop stress for thin spherical shell?

Hoop stress on the spherical shell = pd / 4t.

Where, p = Internal pressure of the spherical shell in N / $m^2$

d = diameter of the spherical shell in m

t = thickness of the spherical shell in m.

7. What is minor principal stress?

The principal stress having minimum value is called as minor principal stress.

8. What is circumferential strain?

Circumferential strain is the ratio of increase in diameter to the original diameter.

9. What is longitudinal strain?

Longitudinal strain is the ratio of increase in length to the original length.

10. How will you calculate maximum shear stress using Mohr's circle?

The Maximum shear stress is calculated from the radius of the Mohr's circle.

11. What is wire wound thin cylinder?

In order to increase the tensile strength of a thin cylinder to withstand high internal pressure without excessive increase in wall thickness, they are sometimes pre-stressed by winding with a steel wire under tensions.

12. What are the differences between cylindrical shell and spherical shell?

1. Circumferential stress is twice the longitudinal stress in cylindrical shell. Only hoop stress is present in spherical shell.
2. Cylindrical shell can withstand only low pressure than spherical shell for same diameter.

13.What do you mean a pressure vessel?

Pressure vessel is usually a spherical or cylindrical container intended for the storage of liquids and gases under high internal pressure.

14.What are the types of stresses induced in a pressure vessel due to its internal pressure?

- Longitudinal stress i.e. stress acting in the direction of longitudinal axis of the pressure vessel
- Hoop stress (Circumferential stress or tangential stress) i.e. the stress developed in the circumferential or radial direction

15.What are major classifications of a pressure vessel?

Pressure vessels are classified into

- Thin walled pressure vessels
- Thick walled pressure vessels

If the mean radius (average of outer and inner radius) to the thickness of the pressure vessel is greater than or equal to 10, it is called thin walled pressure vessels otherwise it is called thick walled pressure vessels.

16.Explain the variation of stress over the thickness of wall of a thin walled pressure vessel.

In case of thin walled pressure vessel, the thickness of the wall is very small compared to the radius of the vessel. Also there is no variation of stress and it is only a constant.

17.What are the general shapes of pressure vessels in practice?

- Cylindrical
- Spherical

18.Distinguish between cylindrical shell and spherical shell.

Cylindrical Shells

- Circumferential stress is twice the longitudinal stress.
- It withstands low pressure than spherical shell for the same diameter. Spherical Shells
- Only hoop stress presents.
- It withstands more pressure than cylindrical shell for the same diameter.

Reg. No. | | | | | | | | | | | | |



**Question Paper Code : 57150**

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2016

Third Semester

Mechanical Engineering

CE 6306 – STRENGTH OF MATERIALS

(Common to MecHatronics Engineering, Industrial Engineering and Management, Industrial Engineering, Manufacturing Engineering, Mechanical Engineering (Sandwich), Material Science and Engineering and also Common to Fourth Semester Automobile Engineering, Mechanical and Automation Engineering and Production Engineering)

(Regulations 2013)

Time : Three Hours  Maximum : 100 Marks

Answer ALL questions.

PART – A (10 × 2 = 20 Marks)

1. Define principal planes.
2. Obtain the relation between E and K.
3. Discuss the fixed and hinged support.
4. What are the advantages of flitched beams ?
5. Draw and discuss the shafts in series and parallel.
6. List out the stresses induced in the helical and carriage springs.
7. How the deflection and slope is calculated for the cantilever beam by conjugate beam method ?
8. State the Maxwell's reciprocal theorem.
9. Differentiate between thin and thick cylinders.
10. Describe the Lame's theorem.

**PART – B (5 × 16 = 80 Marks)**

11. (a) (i) A steel bar 20mm in diameter, 2m long is subjected to an axial pull of 50 kN. If $E = 2 \times 10^5$ N/mm$^2$ and m = 3. Calculate the change in the (1) length, (2) diameter and (3) volume. (8)

(ii) A mild steel bar 20mm in diameter and 40 cm long is encased in a brass tube whose external diameter is 30mm and internal diameter is 25mm. The composite bar is heated through 80 °C. Calculate the stresses induced in each metal. $\alpha$ for steel = $11.2 \times 10^{-6}$; $\alpha$ for brass = $16.5 \times 10^{-6}$ per °C. E for steel = $2 \times 10^5$ N/mm$^2$ and E for brass = $1 \times 10^5$ N/mm$^2$. (8)

**OR**

(b) (i) Two steel rods and one copper rod, each of 20 mm diameter, together support a load of 20kN as shown in Fig. Q. 11 (b) (i). Find the stresses in the rods. Take E for steel = 210kN/mm$^2$ and E for copper = 110 kN/mm$^2$. (8)

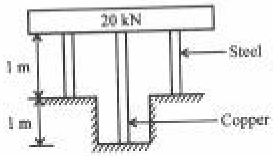



**Fig. Q. 11 (b) (i)**

(ii) Direct stresses of 140N/mm$^2$ tensile and 100N/mm$^2$ compression exist on two perpendicular planes at a certain point in a body. They are also accompanied by shear stress on the planes. The greatest principal stress at the point due to these is 160 N/mm$^2$ (8)

(1) What must be the magnitude of the shear stresses on the two planes ?

(2) What will be the maximum shear stress at the point ?

12. (a) Draw SFD and BMD and indicates the salient features of beam loaded Fig. Q. 12. (a) **(16)**


**Fig. Q. 12. (a)**

**OR**

(b) (i) Find the dimensions of a timber joist, span 4 m to carry a brick wall 230 mm thick and 3m high if the unit weight of brickwork is 20 $kN/m^3$. Permissible bending stress in timber is 10 $N/mm^2$. The depth of the joist is twice the width. **(8)**

(ii) A flitched beam shown in Fig. Q. 12. (b) (ii) is used as a load carrying member. Find the moment of resistance of the combined section and bending stress in steel, if $E_s = 2 \times 10^5$ $N/mm^2$, $E_w = 1.25 \times 10^5$ $N/mm^2$. **(8)**

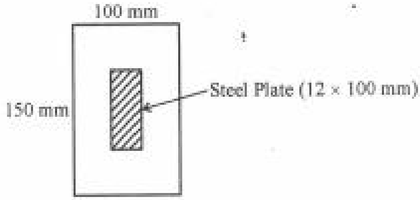



**Fig. Q. 12. (b) (ii)**



13. (a) A solid circular shaft 200mm in diameter is to be replaced by a hollow shaft the ratio of external diameter to internal diameter being 5:3. Determine the size of the hollow shaft if maximum shear stress is to be the same as that of a solid shaft. Also find the percentage savings in mass. **(16)**

**OR**

(b) (i) A closely coiled helical spring made from round steel rod is required to carry a load of 1000 Newton for a stress of 400 $MN/m^2$, the spring stiffness being 20 N/mm. The diameter of the helix is 100mm and G for the material is 80 $GN/m^2$. Calculate (1) the diameter of the wire and (2) the number of turns required for the spring. **(8)**

(ii) A spiral spring is made of 10 mm diameter wire has 20 close coils, each 100 mm mean diameter. Find the axial load the spring will carry if the stress is not to exceed 200 $N/mm^2$. Also determine the extension of the spring. Take $G = 0.8 \times 10^5 N/mm^2$. **(8)**

14. (a) A simply supported beam subjected to uniformly distributed load of w kN/m for the entire span. Calculate the maximum deflection by double integration method. **(16)**

**OR**

(b) A simply supported beam AB of span 5m carries a point of 40 kN at its centre. The value of moment of inertia for the left half is $2 \times 10^8 mm^4$ and for the right half portion is $4 \times 10^8 mm^4$. Find the slopes at the two supports and deflection under the load. Take $E = 200 GN/m^2$. **(16)**

15. (a) (i) A cylindrical vessel is 2 m diameter and 5 m long is closed at ends by rigid plates. It is subjected to an internal pressure of 4 $N/mm^2$. If the maximum principal stress is not to exceed 210 $N/mm^2$, find the thickness of the shell. Assume $E = 2 \times 10^5 N/mm^2$ and Poisson's ratio = 0.3. Find the changes in diameter, length and volume of the shell. **(12)**

(ii) A spherical shell of 1.50 m internal diameter and 12 mm shell thickness is subjected to pressure of 2 $N/mm^2$. Determine the stress induced in the material of the shell. **(4)**

**OR**

(b) (i) A spherical shell of internal diameter 1.2 m and of thickness 12 mm is subjected to an internal pressure of 4 $N/mm^2$. Determine the increase in diameter and increase in volume. Take $E = 2 \times 10^5 N/mm^2$ and $\mu = 0.33$. **(8)**

(ii) A steel cylinder of 300 mm external diameter is to be shrunk to another steel cylinder of 150 mm internal diameter. After shrinking the diameter at the junction is 250 mm and radial pressure at the common junction is 40 $N/mm^2$. Find the original difference in radii at the junction.

Take $E = 2 \times 10^5 N/mm^2$. **(8)**

(ii) A spiral spring is made of 10 mm diameter wire has 20 close coils, each 100 mm mean diameter. Find the axial load the spring will carry if the stress is not to exceed 200 $N/mm^2$. Also determine the extension of the spring. Take $G = 0.8 \times 10^5 N/mm^2$. **(8)**

14. (a) A simply supported beam subjected to uniformly distributed load of w kN/m for the entire span. Calculate the maximum deflection by double integration method. **(16)**

**OR**

(b) A simply supported beam AB of span 5m carries a point of 40 kN at its centre. The value of moment of inertia for the left half is $2 \times 10^8$ $mm^4$ and for the right half portion is $4 \times 10^8$ $mm^4$. Find the slopes at the two supports and deflection under the load. Take $E = 200$ $GN/m^2$. **(16)**

15. (a) (i) A cylindrical vessel is 2 m diameter and 5 m long is closed at ends by rigid plates. It is subjected to an internal pressure of 4 $N/mm^2$. If the maximum principal stress is not to exceed 210 $N/mm^2$, find the thickness of the shell. Assume $E = 2 \times 10^5$ $N/mm^2$ and Poisson's ratio = 0.3. Find the changes in diameter, length and volume of the shell. **(12)**

(ii) A spherical shell of 1.50 m internal diameter and 12 mm shell thickness is subjected to pressure of 2 $N/mm^2$. Determine the stress induced in the material of the shell. **(4)**

**OR**

(b) (i) A spherical shell of internal diameter 1.2 m and of thickness 12 mm is subjected to an internal pressure of 4 $N/mm^2$. Determine the increase in diameter and increase in volume. Take $E = 2 \times 10^5$ $N/mm^2$ and $\mu = 0.33$. **(8)**

(ii) A steel cylinder of 300 mm external diameter is to be shrunk to another steel cylinder of 150 mm internal diameter. After shrinking the diameter at the junction is 250 mm and radial pressure at the common junction is 40 $N/mm^2$. Find the original difference in radii at the junction.

Take $E = 2 \times 10^5$ $N/mm^2$. **(8)**

Reg. No. : 

## Question Paper Code : 27099

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2015.

Third Semester

Mechanical Engineering

CE 6306 — STRENGTH OF MATERIALS

(Common to Mechatronics Engineering, Industrial Engineering and Management, Industrial Engineering, Manufacturing Engineering, Mechanical Engineering (Sandwich) Material Science and Engineering and also Common to Fourth Semester Automobile Engineering, Mechanical and Automation Engineering and Production Engineering)

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Differentiate Elasticity and Elastic Limit.
2. What is principle of super position?
3. Write the assumption in the theory of simple bending?
4. What are the types of beams?
5. The shearing stress is a solid shaft is not to exceed 40 N/mm$^2$ when the torque transmitted is 20000 N-m. Determine the minimum diameter of the shaft.
6. What are the various types of springs?
7. What are the methods of determining slope and deflection at a section in a loaded beam?
8. What is the equation used in the case of double integration method?
9. State the expression for maximum shear stress in a cylindrical shell.
10. Define — hoop stress and longitudinal stress.

PART B — (5 × 16 = 80 marks)

11. (a) A metallic bar 300 mm × 100 mm × 40 mm is subjected to a force of 50 kN (tensile), 6 kN (tensile) and 4 kN (tensile) along x, y and z directions respectively. Determine the change in the volume of the block. Take $E = 2 \times 10^5$ N / mm² and Poisson's ratio = 0.25.

Or

(b) A steel rod of 3 cm diameter is enclosed centrally in a hollow copper tube of external diameter 5 cm and internal diameter of 4 cm as shown in Fig-1. The composite bar is then subjected to axial pull of 45000 N. If the length of each bar is equal to 15 cm, determine: (i) The stresses in the rod and tube, and (ii) Load carried by each bar. Take E for steel = $2.1 \times 10^5$ N/mm² and for copper = $1.1 \times 10^5$ N/mm².

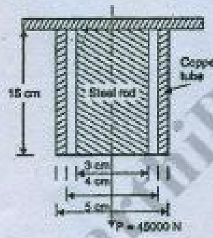



Fig. 1

12. (a) Draw the shear force and B.M diagrams for a simply supported beam of length 8 m and carrying a uniformly distributed load of 10 kN/m for a distance of 4m as shown in fig-2.

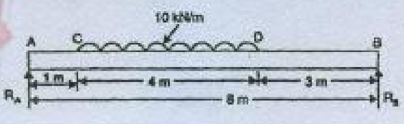



Fig. 2

Or

(b) A steel plate of width 120 mm and of thickness 20 mm is bent into a circular arc of radius 10 m. Determine the maximum stress induced and the bending moment which will produce the maximum stress. Take $E = 2 \times 10^5$ N/mm².

13. (a) A hollow shaft of external diameter 120 mm transmits 300 kW power at 200 r.p.m. Determine the maximum internal diameter if the maximum stress in the shaft is not to exceed 60 N/ mm$^2$.

Or

(b) A closely coiled helical spring of mean diameter 20 cm is made of 3 cm diameter rod and has 16 turns. A weight of 3 kN is dropped on this spring. Find the height by which the weight should be dropped before striking the spring so that the spring may be compressed by 18 cm. Take $C = 8 \times 10^4$ N/mm$^2$.

14. (a) A beam 6m long, simply supported at its ends, is carrying a point load of 50 kN at its centre. The moment of inertia of the beam is given as equal to $78 \times 10^6$ mm$^4$. If E for the material of the beam = $2.1 \times 10^5$ N/mm$^2$, calculate : (i) deflection at the centre of the beam and (ii) slope at the supports.

Or

(b) A beam of length 6 m is simply supported at its ends and carries two point loads of 48 kN and 40 kN at a distance of 1 m and 3 respectively from the left support as shown Fig-3.

Using Macaulay's method find:

(i) deflection under each load,

(ii) maximum deflection, and

(iii) the point at which maximum deflection occurs,

Given $E = 2 \times 10^5$ N/mm$^2$ and $I = 85 \times 10^6$ mm$^4$.

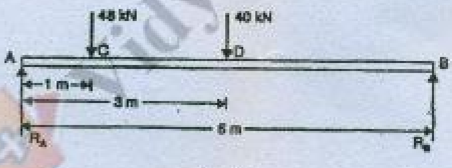



Fig. 3

15. (a) A boiler is subjected to an internal steam pressure of 2N/mm$^2$. The thickness of boiler plate is 2.6 cm and permissible tensile stress is 120 N/mm$^2$. Find the maximum diameter, when efficiency of longitudinal joint is 90% and that of circumference point is 40%.

Or

(b) Calculate: (i) the change in diameter, (ii) change in length and (iii) change in volume of a thin cylindrical shell 100 cm diameter, 1 cm thick and 5 m long when subjected to internal pressure of 3 N/mm$^2$. Take the value of $E = 2 \times 10^5$ N/mm$^2$ and Poisson's ratio, $\mu = 0.3$.

**Question Paper Code : 80197**

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2016.

Third Semester

Mechanical Engineering

CE 6306 — STRENGTH OF MATERIALS

(Common to Mechatronics Engineering, Industrial Engineering and Management, Agriculture Engineering, Industrial Engineering, Manufacturing Engineering, Mechanical Engineering (Sandwich), Materials Science and Engineering and also Common to Fourth Semester Automobile Engineering, Mechanical and Automation Engineering and Production Engineering)

(Regulations 2013)

Time : Three hours  Maximum : 100 marks

PART A — (10 × 2 = 20 marks)

1. Define Young's Modulus.

2. What do you mean by principal planes and principal stresses?

3. Draw the shear force diagram and bending moment diagram for the cantilever beam carries uniformly varying load of zero intensity at the free end and w kN/m at the fixed end.

4. List out the assumptions used to derive the simple bending equation.

5. Define torsional rigidity.

6. What is a spring? Name the two important types of springs.

7. List out the methods available to find the deflection of a beam.

8. State Maxwell's reciprocal theorem.

9. Name the stresses develop in the cylinder.

10. Define radial pressure in thin cylinder.

PART B — (5 × 13 = 65 marks)

11. (a) (i) A compound tube consists of a steel tube 140 mm internal diameter and 160 mm external diameter and an outer brass tube 160 mm internal diameter and 180 mm external diameter. The two tubes are of same length. The compound tube carries an axial compression load of 900 kN. Find the stresses and the load carried by each tube and the amount of its shortens. Length of each tube is 140 mm. Take E for steel as $2 \times 10^5$ N/mm$^2$ and for brass $1 \times 10^5$ N/mm$^2$. (10)

(ii) Two members are connected to carry a tensile force of 80 kN by a lap joint with two number of 20 mm diameter bolt. Find the shear stress induced in the bolt. (3)

Or

(b) (i) A point in a strained material is subjected to the stress as shown in fig. Q.11(b)(i). Locate the principle plane and find the principle stresses. (7)

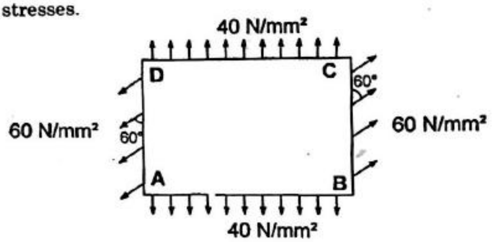



Fig. Q. 11(b)(i)

(ii) A steel rod of 20 mm diameter passes centrally through a copper tube of 50 mm external diameter and 40 mm internal diameter. The tube is closed at the end by rigid plates of negligible thickness. The nuts are tightened lightly on the projecting parts of the rod. If the temperature of the assembly is raised by 50°C, calculate the stresses developed in copper and steel. Take E for steel as $2 \times 10^5$ N/mm² and copper as $1 \times 10^5$ N/mm² and $\alpha$ for steel and copper as $12 \times 10^{-6}$ per °C and $18 \times 10^{-6}$ per °C. (6)

12. (a) (i) A simply supported beam AB of length 5 m carries point loads of 8 kN, 10 kN and 15 kN at 1.50 m, 2.50, and 4.0 m respectively from left hand support. Draw shear force diagram and bending moment diagram. (8)

(ii) A cantilever beam AB of length 2 m carries a uniformly distributed load of 12 kN/m over entire length. Find the shear stress and bending stress, if the size of the beam is 230 mm × 300 mm. (5)

Or

(b) (i) Construct the SFD and BMD for the beam shown in fig. Q. 12(b)(i). (6)

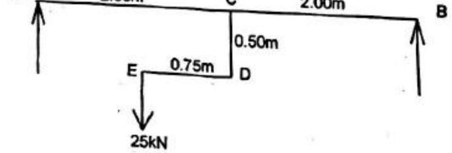



Fig. Q. 12(b)(i)

(ii) Two members are connected to carry a tensile force of 80 kN by a lap joint with two number of 20 mm diameter bolt. Find the shear stress induced in the bolt. (3)

Or

(b) (i) A point in a strained material is subjected to the stress as shown in fig. Q.11(b)(i). Locate the principle plane and find the principle stresses. (7)

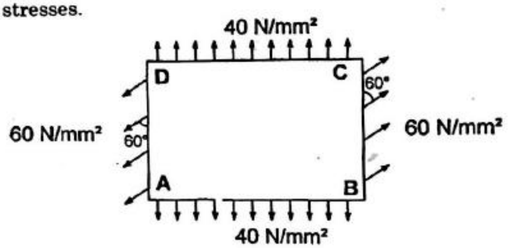



Fig. Q. 11(b)(i)

(ii) A steel rod of 20 mm diameter passes centrally through a copper tube of 50 mm external diameter and 40 mm internal diameter. The tube is closed at the end by rigid plates of negligible thickness. The nuts are tightened lightly on the projecting parts of the rod. If the temperature of the assembly is raised by 50°C, calculate the stresses developed in copper and steel. Take E for steel as $2 \times 10^5$ N/mm² and copper as $1 \times 10^5$ N/mm² and $\alpha$ for steel and copper as $12 \times 10^{-6}$ per °C and $18 \times 10^{-6}$ per °C. (6)

12. (a) (i) A simply supported beam AB of length 5 m carries point loads of 8 kN, 10 kN and 15 kN at 1.50 m, 2.50, and 4.0 m respectively from left hand support. Draw shear force diagram and bending moment diagram. (8)

(ii) A cantilever beam AB of length 2 m carries a uniformly distributed load of 12 kN/m over entire length. Find the shear stress and bending stress, if the size of the beam is 230 mm × 300 mm. (5)

Or

(b) (i) Construct the SFD and BMD for the beam shown in fig. Q. 12(b)(i). (6)

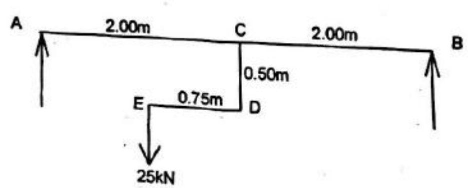
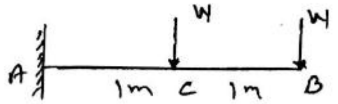



Fig. Q. 12(b)(i)

(ii) Two timber joist are connected by a steel plate, are used as beam as shown in fig. Q. 12(b)(ii). Find the load W if, the permissible stresses in steel and timber are 165 N/mm² and 8.5 N/mm² respectively. (7)





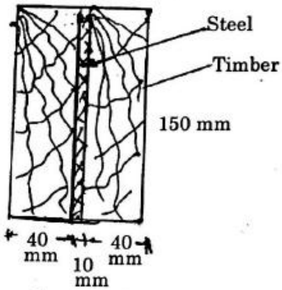




Fig. Q. 12(b)(ii) Cross section

13. (a) (i) A solid shaft has to transmit the Power 105 kW at 2000 r.p.m. The maximum torque transmitted in each revaluation exceeds the mean by 36%. Find the suitable diameter of the shaft, if the shear stress is not to exceed 75 N/mm² and maximum angle of twist is 1.5° in a length of 3.30 m and $G = 0.80 \times 10^5$ N/mm². (8)

(ii) A laminated spring carries a central load of 5200 N and it is made of 'n' number of plates, 80 mm wide. 7 mm thick and length 500 mm. Find the numbers of plates, if the maximum deflection is 10 mm. Let $E = 2.0 \times 10^5$ N/mm². (5)

Or

(b) (i) A stepped solid circular shaft is built in at its ends and subject to an externally applied torque T at the shoulder as shown in fig. Q.13(b)(i). Determine the angle of rotation $\theta$ of the shoulder section when T is applied. (7)

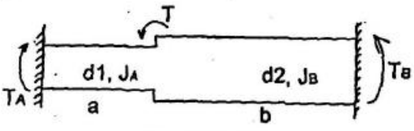



Fig. Q.13(b)(i)

(ii) A closed coiled helical spring is to be made out of 5 mm diameter wire 2 m long so that it deflects by 20 mm under an axial load of 50 N. Determine the mean diameter of the coil. Take $C = 8.1 \times 10^4$ N/mm². (6)

14. (a) Cantilever of length l carrying uniformly distributed load w kN per unit run over whole length. Derive the formula to find the slope and deflection at the free end by double integration method. Calculate the deflection if, w = 20 kN /m, l = 2.30 m and EI = 12000 kN m². (13)

Or

(b) (i) Derive the formula to find the deflection of a simply supported beam with point load W at the centre by moment area method. (8)

(ii) A simply supported beam of span 5.80 m carries a central point load of 37.50 kN, find the maximum slope and deflection, let EI = 40000 kN $m^2$. Use conjugate beam method. (5)

15. (a) Calculate Change in diameter, Change in length and Change in volume of a thin cylindrical shell 100 cm diameter, 1 cm thick and 5 m long when subjected to internal pressure of 3 N/$mm^2$. Take the value of $E = 2 \times 10^5$ N/$mm^2$ and Poisson's ratio = 0.30. (13)

Or

(b) Calculate the thickness of metal necessary for a cylindrical shell of internal diameter 160 mm to with stand an internal pressure of 25 MN/$m^2$, if maximum permissible shear stress is 125 MN/$m^2$. (13)

PART C — (1 × 15 = 15 marks)

16. (a) The intensity of resultant stress on a plane AB (Fig.Q.16(a)) at appoint in a materials under stress is 8 N/$mm^2$ and it is inclined at 30° to the normal to that plane. The normal component of stress on another plane BC at right angles to plane AB is 6 N/$mm^2$. Determine the following :

(i) The resultant stress on the plane BC

(ii) The principal stresses and their directions

(iii) The maximum shear stresses. (15)

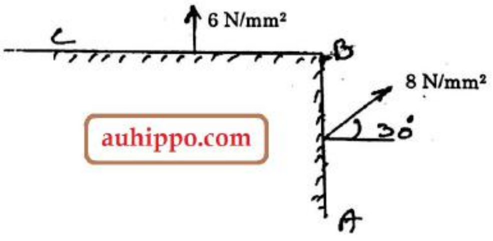





Fig. Q. 16(a)

Or

(b) A water tank vertical wall is stiffened by vertical beam, and the height of the tank is 8 m. The beams are spaced at 1.5 m centre to centre. If the water reaches the top of the tank, calculate the maximum bending moment on a vertical beam. Sketch the shear force and bending moment diagrams. Unit weight weight of water = 9.8 kN/$m^3$. (15)

**Question Paper Code : 71551**

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Third Semester

Mechanical Engineering

CE 6306 — STRENGTH OF MATERIALS

(Common to Mechatronics Engineering, Industrial Engineering and Management, Agriculture Engineering, Industrial Engineering, Manufacturing Engineering, Mechanical Engineering (Sandwich), Materials Science and Engineering and also Common to Fourth Semester Automobile Engineering, Mechanical and Automation Engineering and Production Engineering)

(Regulations 2013)

Time : Three hours  Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Derive a relation for change in length of a bar hanging freely under its own weight.
2. What does the radius of Mohr's circle refer to?
3. Draw shear force diagram for a simply supported beam of length 4 m carrying a central point load of 4 kN.
4. Prove that the shear stress distribution over a rectangular section due to shear force is parabolic.
5. Draw shear stress distribution of a circular section due to torque.
6. What is meant by spring constant?
7. Write down the equation for the maximum deflection of a cantilever beam carrying a central point load 'W'.
8. Draw conjugate beam for a double side over hanging beam.
9. How does a thin cylinder fail due to internal fluid pressure?
10. State Lame's equations.

PART B — (5 × 13 = 65 marks)

11. (a) The bar shown in fig.Q.11(a) is subjected to a tensile load of 160 kN. If the stress in middle portion is limited to 150 N/mm², determine the diameter of the middle portion. Find also the length of the middle portion if the total elongation of the bar is to be 0.2 mm. Young's modulus is $2.1 \times 10^5$ N/mm².

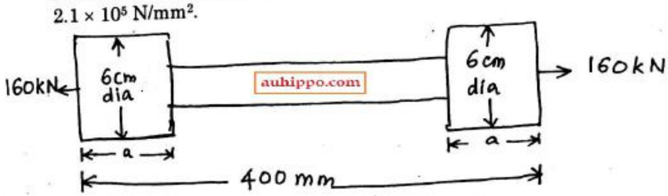



fig.Q.11(a)

Or

(b) A bar of 30 mm diameter is subjected to a pull of 60 kN. The measured extension on gauge length of 200 mm is 0.1 mm and change in diameter is 0.004 mm. Calculate :

(i) Young's modulus

(ii) Poisson's ratio and

(iii) Bulk modulus.

12. (a) Draw shear force diagram and bending moment diagram for the beam given in fig.Q.12(a)

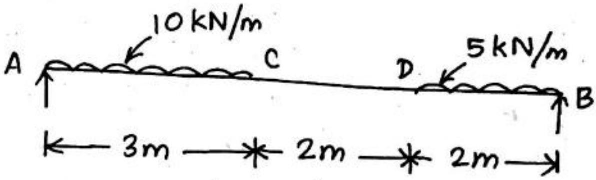



fig.Q.12(a)

Or

(b) A beam of square section is used as a beam with one diagonal horizontal. The beam is subjected to a shear force F, at a section. Find the maximum shear in the cross section of the beam and draw shear stress distribution diagram for the section.

13. (a) A hollow shaft, having an inside diameter 60% of its outer diameter, is to replace a solid shaft transmitting in the same power at the same speed. Calculate percentage saving in material, if the material to be is also the same.

Or

(b) Derive a relation for deflection of a closely coiled helical spring subjected to an axial compressive load 'W'.

14. (a) Determine the deflection at its mid point and maximum deflection for the beam given in fig.Q.14(a). Use Macaulay's method.
$E = 2 \times 10^5$ N/mm$^2$, $I = 4.3 \times 10^8$ mm$^4$.

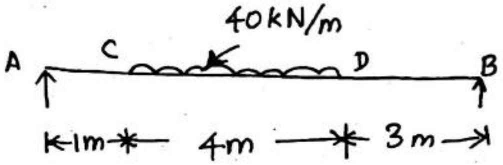



fig.Q.14(a)

Or

(b) Determine the slope at the two supports and deflection under the loads. Use conjugate beam method. $E = 200\,GN/m^2$, I for right half is $2 \times 10^8\,mm^4$, I for left half is $1 \times 10^8\,mm^4$ the beam is given in fig.Q.14(b).

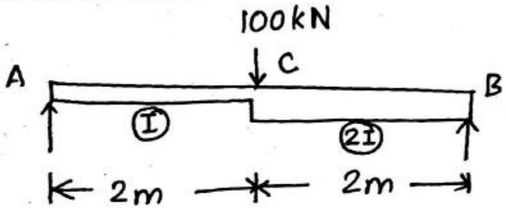



fig.Q.14(b)

15. (a) Derive a relation for change in volume of a thin cylinder subjected to internal fluid pressure.

Or

(b) Determine the maximum and minimum hoop stress across the section of a pipe of 400 mm internal diameter and 100 mm thick, when the pipe contains a fluid at a pressure of $8\,N/mm^2$. Also sketch the radial pressure distribution and hoop stress distribution across the section.

PART C — (1 × 15 = 15 marks)

16. (a) (i) Draw stress strain curve for mild steel and explain the salient points on it. (7)

(ii) Derive a relation for change in length of a circular bar with uniformly varying diameter, subjected to an axial tensile load 'W'. (8)

Or

(b) A water main of 500 mm internal diameter and 20 mm thick is full. The water main is of cast iron and is supported at two points 10 m apart. Find the maximum stress in the metal. The cast iron and water weigh $72000\ N/m^3$ and $10000\ N/m^3$ respectively.

## Question Paper Code : 77058

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2015.

Third Semester

Mechanical Engineering

CE 6306 — STRENGTH OF MATERIALS

(Common to Mechatronics Engineering, Industrial Engineering and Management, Industrial Engineering, Manufacturing Engineering, Mechanical Engineering (Sandwich) Material Science and Engineering and also Common to Fourth Semester Automobile Engineering, Mechanical and Automation Engineering and Production Engineering)

(Regulation 2013)

Time : Three hours  Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What do you mean by thermal stresses?

2. Draw the Mohr's circle for the state of pure shear in a strained body and mark all salient points in it.

3. Define :

   (a) Shearing force and

   (b) Bending moment.

4. What is neutral axis of a beam section? How do you locate it when a beam is under simple bending?

5. What is meant by torsional stiffness?

6. What are the uses of helical springs?

7. What are the advantages of Macaulay's method over other methods for the calculation of slope and deflection?

8. In a cantilever beam, the measured deflection at free end was 8 mm when a concentrated load of 12 kN was applied at its mid-span. What will be the deflection at mid-span when the same beam carries a concentrated load of 7 kN at the free end?

9. Distinguish between thin and thick shells.

10. State the assumptions made in Lame'e theorem for thick cylinder analysis.

PART B — ($5 \times 16 = 80$ marks)

11. (a) A steel rod of diameter 32 mm and length 500 mm is placed inside an aluminium tube of internal diameter 35 mm and external diameter 45 mm which is 1 mm longer than the steel rod. A load of 300 kN is placed on the assembly through the rigid collar. Find the stress induced in steel rod and aluminium tube. Take the modulus of elasticity of steel as 200 GPa and that of aluminium as 80 GPa.

Or

(b) At a point in a strained material the resultant intensity of stress across a vertical plane is 100 MPa tensile inclined at 35° clockwise to its normal. The normal component of intensity of stress across the horizontal plane is 50 MPa compressive. Determine graphically using Mohr's circle method :

(i) The position of principal planes and stresses across them and

(ii) The normal and tangential stress across a plane which is 60° clockwise to the vertical plane.

12. (a) An overhanging beam ABC of length 7 m is simply supported at A and B over a span of 5 m and the portion BC overhangs by 2 m. Draw the shearing force and bending moment diagrams and determine the point of contra-flexure if it is subjected to uniformly distributed loads of 3 kN/m over the portion AB and a concentrated load of 8 kN at C.

Or

(b) Three beams have the same length, the same allowable stress and the same bending moment. The cross-section of the beams are a square, a rectangle with depth twice the width and a circle. Find the ratios of weights of the circular and the rectangular beams with respect to the square beam.

13. (a) A brass tube of external diameter 80 mm and internal diameter 50 mm is closely fitted to a steel rod of 50 mm diameter to form a composite shaft. If a torque of 10 kNm is to be resisted by this shaft, find the maximum stresses developed in each material and the angle of twist in 2 m length. Take modulus of rigidity of brass and steel as $40 \times 10^3$ N/mm$^2$ and $80 \times 10^3$ N/mm$^2$ respectively.

(b) A close-coiled helical spring is to have a stiffness of 900 N/m in compression, with a maximum load of 45 N and a maximum shearing stress of 120 $N/mm^2$. The solid length of the spring (i.e., coils touching) is 45 mm. Find :

(i) The wire diameter,

(ii) The mean coil radius, and

(iii) The number of coils. Take modulus of rigidity of the material of the spring as $0.4 \times 10^5$ $N/mm^2$.

14. (a) A horizontal beam of uniform section and 7 m long is simply supported at its ends. The beam is subjected to a uniformly distributed load of 6 kN/m over a length of 3 m from the left end and a concentrated load of 12 kN at 5 m from the left end. Find the maximum deflection in the beam using Macaulay's method.

Or

(b) A cantilever of span 4 m carries a uniformly distributed load of 4 kN/m over a length of 2 m from the fixed end and a concentrated load of 10 kN at the free end. Determine the slope and deflection of the cantilever at the free end using conjugate beam method. Assume El is uniform throughout.

15. (a) A thin cylindrical shell, 2.5 m long has 700 mm internal diameter and 8 mm thickness. if the shell is subjected to an internal pressure of 1 MPa, find

(i) The hoop and longitudinal stresses developed

(ii) Maximum shear stress induced and

(iii) The changes in diameter length and volume. Take modulus of elasticity of the wall material as 200 GPa and Poisson's ratio as 0.3.

Or

(b) A thick cylinder with external diameter 320 mm and internal diameter 160 mm is subjected to an internal pressure of 8 $N/mm^2$. Draw the variation of radial and hoop stresses in the cylinder wall. Also determine the maximum shear stress in the cylinder wall.