# SRM VALLIAMMAI ENGINEERING COLLEG

SRM Nagar,Kattankulathur – 603 203.

**DEPARTMENT OF CIVIL ENGINEERING**

**QUESTION BANK**

**SUBJECT : CE8402 / STRENGTH OF MATERIALS II**

**SEM / YEAR: IV/II**

## UNIT I -ENERGY PRINCIPLES

Strain energy and strain energy density – strain energy due to axial load(gradual ,sudden and impact load) shear, flexure and torsion – Castigliano's theorems – Maxwell's reciprocal theorems - Principle of virtual work – Unit load method-Application of energy theorems for computing deflections in beams, plane frame and plane trusses - Lack of fit and temperature effects - Williot Mohr's Diagram.

## PART A

| Q.No | Questions | BT Level | Competence |
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| 1. | State the various methods for computing the joint deflection of perfect frame | BT-1 | Remembering |
| 2. | Write about strain energy and strain energy density. | BT-1 | Remembering |
| 3. | A mild steel bar of diameter 30 mm and length 2.4 m is subjected to a tensile load of 90kN. Find the strain energy stored in the bar if the loadisappliedgradually.Whatisthemodulusofresilienceifthe proportional limit to 220 MPa. E = 200 GN/m$^2$. | BT-1 | Remembering |
| 4. | State Castigliano's first theorem. | BT-1 | Remembering |
| 5. | State Castigliano's second theorem. | BT-1 | Remembering |
| 6. | Write an expression for strain energy due to shear, torsion, axial load and bending. | BT-1 | Remembering |
| 7. | Predict the maximum strain energy stored in a solid shaft of diameter 100 mm and of length 1.25 m, if the maximum allowable shearstressis 50 N/mm$^2$. Take C = 8 x 10N/mm$^2$. | BT-2 | Understanding |
| 8. | Describe Mohr's correction. | BT-2 | Understanding |
| 9. | Estimate the strain energy per unit volume, the shear stress for a material is given as 50 N/mm$^2$. Take G=80000 N/mm$^2$. | BT-2 | Understanding |
| 10. | Identify the assumptions made in Castigliano's theorem. | BT-2 | Understanding |
| 11. | Solve strain energy due to bending of a cantilever beam of span 6 m Subjected to udlof 10 kN/m over entire length, EI is constant. | BT-3 | Applying |
| 12. | Show the deflections at the free end of the cantilever beam which carries a point load at the free end. | BT-3 | Applying |
| 13. | Illustrate "Maxwell reciprocal theorem". | BT-3 | Applying |
| 14. | A beam of span 4m is cantilever and subjected to a concentrated load of 10 KN at the free end.Find the total strain energy stored | BT-4 | Analyzing |
| 15. | Compare Resilience, proof resilience and modulus of resilience. | BT-4 | Analyzing |
| 16. | Write the application of unit load method | BT-4 | Analyzing |
| 17. | Rewrite complementary strain energy with stress-strain curve. | BT-5 | Evaluating |
| 18. | Write down the formula to calculate strain energy if moment value is given | BT-5 | Evaluating |
| 19. | Write the application of Williot-mohr's diagram. | BT-6 | Creating |

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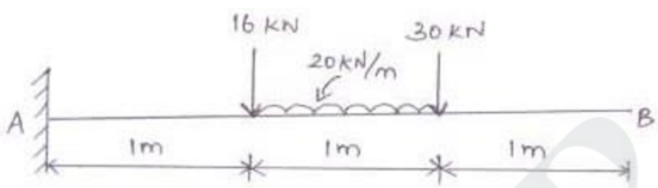
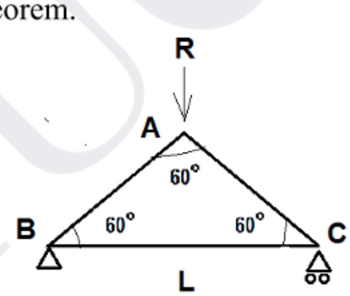
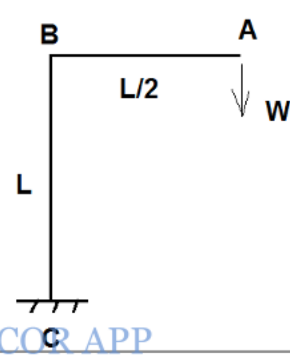
| 20. | Summarize complimentary virtual work. | BT-6 | Creating |
| | **PART B** | | |
| 1. | A beam of 4 m length is simply supported at the ends and carries a uniformly distributed load of 6 kN/m length. Find the strain energy and hence deflection. Take E = 200 GPa and I = 1440 $cm^4$.Use Strain energy method. | BT-1 | Remembering |
| 2. | A beam of simply supported over a span of 3 m carries a uniformly distributed load of 20 KN/m over the entire span. Take EI = 2.25 MN/m2. Use Castigliano's theorem. Find the deflection at the centre<br>of the beam. | BT-1 | Remembering |
| 3. | Using Castigliano's theorem, write the deflection of the free end of the cantilever beam shown in figure. Take EI = 4.9 $MN/m^2$<br> | BT-1 | Remembering |
| 4. | A simply supported beam of 8m carries two concentrated loads of 32 KN and 48 KN at a distance of 3m and 6m from left support.Calculate the deflection at the centre by strain energy principle | BT-1 | Remembering |
| 5. | An axial pull of 40 KN is suddenly applied to steel rod 2m long and 1000 mm2 in cross section .Calculate the strain energy that can be absorbed if E = 200 GN/m2 | BT-2 | Understanding |
| 6. | Outline the vertical and horizontal displacement at the free end D in the frameshown in figure. Take EI = 12 x $10^3$ N-$mm^2$.Use Castigliano's theorem.<br> | BT-2 | Understanding |
| 7. | Identify the vertical and the horizontal deflection at the free end of the bent (linear arch) shown in figure. Assume uniform flexural rigidity EI throughout.<br> | BT-2 | Understanding |

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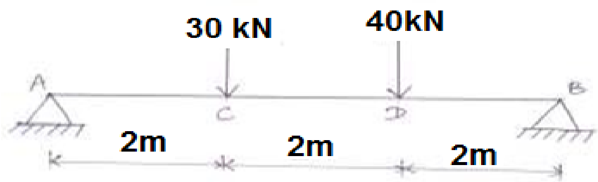
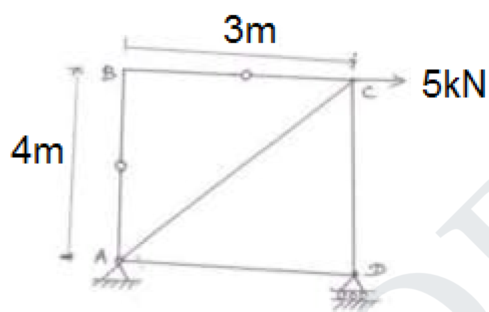
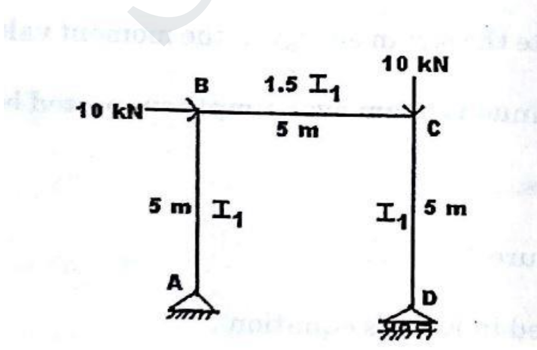
| 8. | Using the method of virtual work, examine the deflection at the freeend of the cantilever beam carrying uniformly distributed load 25 kN/m throughout the length of 12m. Take E = 2 x $10^5$MPa, I = 825 x $10^7$$mm^4$. | BT-3 | Applying |
| 9. | For the beam shown in figure, find the deflection at C. I = 40 X $10^7$ $mm^4$, E = 200 GPa.   | BT-3 | Applying |
| 10. | For the truss shown in figure, Investigate the horizontal movement of the roller at D. AB, BC, CD area = $8cm^2$. E= 2 x $10^5$N/$mm^2$.   | BT-4 | Analyzing |
| 11. | A 1 m long bar of rectangular cross sectiona 50 x 80 mm is subjected to an axial load of 1.2 kN. Write the maximum stress and strain energy developed in the bar if the load applied is (a) gradual (b) sudden (c) falls through a height of 25 mm. Take E = 205 GPa | BT-4 | Analyzing |
| 12. | A simply supported beam of span 6 m is subjected to a concentrated load of 45kN at 2 m from the left support. Identify the deflection under the load point. Take E = 200 x $10^6$kN/$m^2$, I = 14 x $10^{-6}$$m^4$.Useunit load method. | BT-4 | Analyzing |
| 13. | Determine the horizontal displacement at the roller support of the rigid frame shown in figure.Take E=2 x $10^5$MPa and I =30x10$mm^4$   | BT-5 | Evaluating |

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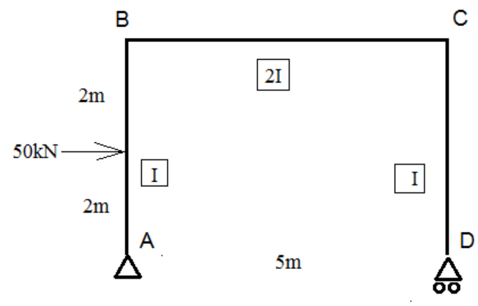
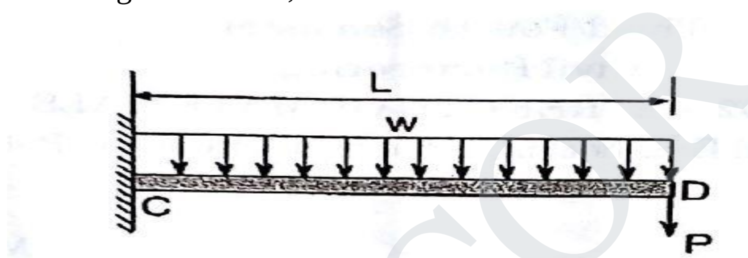
| 14. | Using the principle of virtual work, Write the horizontal displacement of support D of the frame shown in figure. The values of I are indicated along the members. E = 200 x 106 kN/m2 and I = 300 x 10-6 $m^4$.<br><br> | BT-6 | Evaluating |
| | **PART C** | | |
| 1. | Find the deflection at the centre of simply supported beam carrying a uniformly distributed load of W/m throughout the span l. EI is constant. Use unit load method. | BT-1 | Remembering |
| 2. | Determine the deflection at the point D as shown below using following data L =3m,w=6 kn/m P=6 kN and EI= 5MN/$m^2$.<br><br> | BT-1 | Remembering |
| 3. | (i) Create an expression for the strain energy due to bending for a beam of length 'L' simply supported at the ends and carrying UDL of 'w' per unit length and having flexural rigidity EI. (8)<br>(ii) Using Castigliano's theorem, design the central deflection and the slope at ends of asimply supported beam carrying an UDL of intensity 'w' per unit length over the whole span. (7) | BT-6 | Evaluating |
| 4. | A beam of length L simply supported at the ends is loaded with a point load W at a distance „a" from left end. Assume that the beam has constant cross-section with moment of inertia 'I' and Young's modulus of elasticity for the material of the beam 'E'. Predict the strain energy of the beam and hence deflection under the load.Use castigliano"s theorem. | BT-3 | Applying |

| **UNIT II- INDETERMINATE BEAMS** |
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| Concept of Analysis - Propped cantilever and fixed beams-fixed end moments and reactions – Sinking and rotation of supports - Theorem of three moments – analysis of continuous beams – shear force and bending moment diagrams. |

## PART A

| Q.No | Questions | BT Level | Competence |
|---|---|---|---|
| 1. | Define fixed beam. | BT-1 | Remembering |
| 2. | State “Degree of static indeterminacy”. | BT-1 | Remembering |
| 3. | Define prop and explain propped cantilever beam. | BT-1 | Remembering |
| 4. | Define compatibility condition. | BT-1 | Remembering |
| 5. | How compatibility condition is related to degree of static indeterminacy? | BT-1 | Remembering |
| 6. | List the methods of analysis of indeterminate beams. | BT-1 | Remembering |
| 7. | Describe statically determinate and statically indeterminate with an example. | BT-2 | Understanding |
| 8. | Classify structure based on degree of static indeterminacy. | BT-2 | Understanding |
| 9. | Outline the shear force diagram and bending moment diagram for the fixed beam for the following conditions and mark the salient points.<br>(i) Central point load<br>(ii) Eccentric point load | BT-2 | Understanding |
| 10. | Explain the advantages and disadvantages of the fixed beam. | BT-2 | Understanding |
| 11. | What is continuous beam and classify its types? | BT-3 | Applying |
| 12. | Show the BM diagram (qualitative) of a propped cantilever of 1 m long carries an UDL of w/unit run over the entire span and propped at the free end. | BT-3 | Applying |
| 13. | Illustrate the advantages of continuous beam. Also draw its deflected shape. | BT-3 | Applying |
| 14. | Explain about sinking of supports. | BT-4 | Analyzing |
| 15. | Examine fixed end moment when the support sinks by amount of deflection. | BT-4 | Analyzing |
| 16. | Compare statically determinate and statically indeterminate structure. | BT-4 | Analyzing |
| 17. | A fixed beam of length 3 m is having moment of inertia $I=3X10^6$ $mm^4$, the support sinks down by 3 mm. If $E = 2 X 10^5 N/mm^2$, find the fixed end moments. | BT-5 | Evaluating |
| 18. | Asses the degree of indeterminacy for a) propped cantilever b) fixed beam c) continuous beam? | BT-5 | Evaluating |
| 19. | Write the compatibility equation for propped cantilever beam and fixed beam. | BT-6 | Creating |
| 20. | Write the principle by which a continuous beam can be analyzed. | BT-6 | Creating |

## PART B

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| 1. | A propped cantilever of span of 6 m having the prop at the end is subjected to two concentrated loads of 24 kN and 48 kN at one third points respectively from left fixed end support. Describe shear force gram with salient points. | BT-1 | Remembering |

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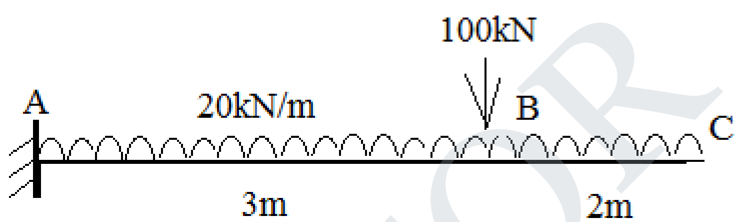
| 2. | A propped cantilever of length 6 m is fixed at one end and supported on a rigid prop at other end. It carries a point load of 20 kN at a distance of 4 m from the fixed end. Find the prop reaction and point of contraflexure and draw the SFD and BMD. Assume prop sinks by 20 mm. $E = 200 \times 10^6 kN/m^2$ and $I=15 \times 10^{-6} m^4$ | BT-1 | Remembering |
| 3. | A propped cantilever of span 6 m is subjected to a UDL of 2 kN/m over a length of 4 m from the fixed end. Write the prop reaction and draw the SFD and BMD. | BT-1 | Remembering |
| 4. | A propped cantilever of span of 6 m having the prop at the end is subjected to two concentrated loads of 24 kN and 48 kN at one third points respectively from left fixed end support. Describe shear force and bending moment diagram with salient points. | BT-1 | Remembering |
| 5 | Analyse the beam shown in fig. EI = constant. Outline the bending moment diagram.   | BT-2 | Understanding |
| 6. | A fixed beam of 6 m span is loaded with point loads of 150 kN at a distance of 2 m From each support. Predict the shear force and bending moment diagram. Also find the maximum deflection. Take E = 200 GPa and $I = 8 \times 108 mm^4$. | BT-2 | Understanding |
| 7. | A fixed beam of AB, length 6 m carries point loads of 160 kN and 120 kN at distance of 2 m and 4 m from the left end. Predict the following.<br>(i) FEM<br>(ii) Support Reactions<br>(iii) Draw SFD and BMD | BT-2 | Understanding |
| 8. | A fixed beam of length 6 m carries a couple of 500 Nm at its centre. Solve the following:<br>(i) Maximum deflection<br>(ii) Draw SFD and BMD | BT-3 | Applying |
| 9. | A fixed beam AB of span 10 m carries point load of 180 kN and clockwise moment of 160 kNm at distances 3 m and 6 m from left end respectively. If the left end support sinks by 15 mm, Examine the fixed end moments and reactions at the supports. Draw also SFD and BMD for the beam. Take $EI = 6000 kNm^2$. | BT-3 | Applying |

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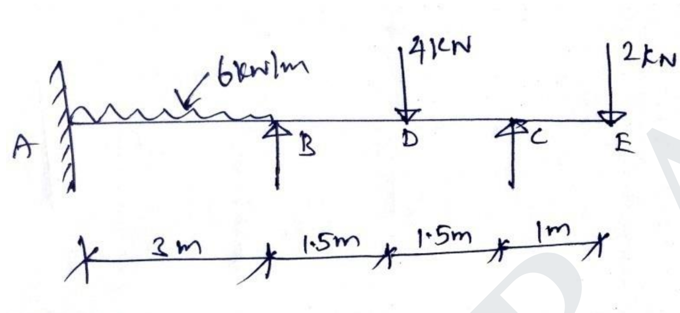
| 10. | A fixed beam AB of span 4.5 m carries a point load of 80 kN at its mid span and a uniformly distributed load of 15 kN/m throughout its length. Investigate (i) Fixed End Moments (ii) Reactions. Also draw the SFD and BMD. | BT-4 | Analyzing |
| 11. | A continuous beam ABCD is simply supported at A, B, C and D, AB = BC = CD = 5 m. Span AB carries a load of 30 kN at 2.5 m from A. Span BC carries an UDL of 20 kN/m. Span CD carries a load of 40 kN at 2 m from C. Examine SFD and BMD. | BT-4 | Analyzing |
| 12. | For the continuous beam shown in figure, draw SFD and BMD. All the supports are at the same level.<br><br> | BT-5 | Evaluating |
| 13 | Construct a continuous beam ABC by three moment equation, fixed at its ends A and C and simply supported at support B. Span AB of length 10 m carries a point load of 115 kN at the left of support B. Span BC of length 10 m carries UDL of 20 kN/m of its full length. Draw its SFD and BMD. | BT-6 | Creating |
| 14. | A continuous beam ABCD simply supported at all its end. Span AB of length 6 m carries a central point load of 40 kN. Span BC of 7 m length carries 50 kN to the right of 3 m from support B. Span CD of length 6 m carries a UDL of 10 kN/m throughout its length. If the support B sinks by 10 mm, Identify the following.<br>(i) Moment at the supports<br>(ii) Reactions at the supports<br>(iii) Draw SFD and BMD. | BT-4 | Analyzing |
| | **PART C** | | |
| 1. | Draw the SFD and BMD of a propped cantilever beam for the following cases.<br>(i) Central point load (7)<br>(ii) UDL throughout its length (8) | BT-1 | Remembering |
| 2. | State an expression for the end moments of a fixed beam of length L for the following conditions.<br>(i) Central point load (7)<br>(ii) UDL throughout its length (8)<br>Also draw the SFD and BMD for the beam. | BT-1 | Remembering |
| 3. | Find the following for the fixed beam, continuous beam and propped cantilever beam.<br>(i) Degree of static indeterminacy (5)<br>(ii) Compatibility condition (5)<br>ctions and moments developed at support.(5) | BT-1 | Remembering |

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| 4. | Outline the shear force and bending moment diagram for a simply supported beam with UDL and propped at the centre. | BT-2 | Understanding |

## UNIT 3-COLUMNS AND CYLINDERS

Euler‟scolumn theory – critical loads for prismatic columns with different end conditions- Effective length-limitations-Rankine-Gordon formula -Eccentrically loaded columns –middle third rule – core of a section – Thin cylindrical and spherical shells- Stresses and change in dimensions- Thick cylinders – Compound cylinders-shrinking on stresses.

### PART A

| Q.No | Questions | BT Level | Competence |
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| 1. | What are the types of column failure? | BT-1 | Remembering |
| 2. | What are the assumptions made in the Euler'sEquations? | BT-1 | Remembering |
| 3. | Write the limitations of Euler's Formula. | BT-1 | Remembering |
| 4. | Define buckling load and safe load | BT-1 | Remembering |
| 5. | Give the parameters influencing buckling load of a long column. | BT-1 | Remembering |
| 6. | Write equivalent length of column. | BT-1 | Remembering |
| 7. | Distinguish between thick and thin cylinder. | BT-2 | Understanding |
| 8. | Write Johnson's Parabolic Formula. | BT-2 | Understanding |
| 9. | Differentiate between eccentrically loaded column and axially loaded column. | BT-2 | Understanding |
| 10. | Explain middle third rule. | BT-2 | Understanding |
| 11. | The actual length of a column is 10 m. Solve its effective length when both endsof the column are (a) Hinged, (b) Fixed. | BT-3 | Applying |
| 12. | What is known as crippling load? | BT-3 | Applying |
| 13. | Illustrate the core (or) kern of a column section. | BT-3 | Applying |
| 14. | What are the advantages of compound cylinders? | BT-4 | Analyzing |
| 15. | Differentiate Rankine method and Euler‟s method. | BT-4 | Analyzing |
| 16. | Distinguish between long column and short column. | BT-4 | Analyzing |
| 17. | How many types of stresses are developed in thick cylinders? | BT-5 | Evaluating |
| 18. | How columns are classified depending upon slenderness ratio. | BT-5 | Evaluating |
| 19. | State Lame's Equation. | BT-6 | Creating |
| 20. | Write Rankine‟s-Gordon formula. | BT-6 | Creating |

| PART B | | | |
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| 1. | (i) A thin cylindrical pressure vessel of 500 mm diameter is subjected to an internal pressure of 2 N/mm$^2$. If the thickness of the vessel is 20mm, find the hoop stress, longitudinal stress and the maximum shear stress.(7)<br>(ii) Find the thickness for a tube of Internal diameter 100mm subjected to an internal pressure which is 5/8 of the value of the maximum permissible circumferential stress, Also find the increase in internal diameter of such a tube when the internal pressure is 90 N/mm$^2$. Take E = 205kN/mm$^2$ and $\mu$=0.29. Neglect longitudinal strain. (6) | BT-1 | Remembering |
| 2. | A hollow cylindrical cast iron column whose external diameter is 200 mm and has a thickness of 20 mm is 4.5 m long and is fixed at the both ends. Calculate the safe loadbyRankine's formula using a factor of safety of 2.5. Take the crushing strength of material as 550 N/mm$^2$ and Rankine's constant as 1/1600. Find also the ratio of Euler's to Rankine's load. Take E=150GPa. | BT-1 | Remembering |
| 3. | A bar of length 4m when used as a SSB and subjected to UDL of 30kN/m over the whole span, deflects 15mm at the centre. Find the EI value for the above beam and hence determine the crippling loads when it is used as a column with the following end conditions<br>i. Bothendspin-jointed (4)<br>ii. One end fixed and the otherendhinged (5)<br>iii. Both ends fixed (4) | BT-1 | Remembering |
| 4. | A load of 75kN is carried by a column made of cast-iron. The external and internal diameters are 20cm and 18cm respectively. If the eccentricity of the load is 3.5cm Find<br>(i) The maximum and minimumstressintensities<br>(ii) Upto what eccentricity, there is no tensile stress incolumn | BT-1 | Remembering |
| 5. | Identify the Euler's critical load for a strut of T-section. The flange width is100mm, over all depth is 80mm, and both the flange & stem are 10mm thick. The strut is 3m longand is built in at both ends.Take E= 2x10$^5$ N/mm$^2$. | BT-2 | Understanding |
| 6. | A 1.5 m long column has a circular cross-section of 5 cm diameter. One of the ends of the column is fixed in direction and position and the other end is free. Taking factor of safety as 3, Report the safe load using.<br>(i) Rankine's formula. Take yield stress $\sigma_C$ = 560 N/mm$^2$and $\alpha$=1/1600 forpinnedends (6)<br>(ii) Euler's formula. Take E= 1.2 x10$^5$N/mm$^2$. (7) | BT-2 | Understanding |
| 7. | A thin walled steel cylindrical shell of internal diameter 150mm and external diameter 500mm is subjected to fluid pressure of 100 MPa. Calculate the principal stress at a point on the inside surface of the cylinder and calculate the increase in inside diameter due to fluid pressure. Assume E=200 kN/mm$^2$. | BT-2 | Understanding |

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| 8. | i) A slender pin ended aluminum column 2m long and of circular Cross-section is to have an outside diameter of 50cm. Solve the necessary internal diameter to prevent failure by buckling ifthe actual load applied is 12kN and the critical load applied is twice the actual load. Take E for aluminum as70GN/$m^2$ (8)<br>ii) An I-section 400 mm X 200 mm X 20 mm and 6m long is used as Strut with both ends fixed. Write the Euler's crippling load for a column. Take E=200GPa. (7) | BT-3 | Applying |
| 9. | A built up column consisting of rolled steel beam ISWB 300 with two plates 200 mm x 10 mm connected at the top and bottom flanges. Calculate the safe load the column can carry, if the length is 3m and both ends are fixed. Take factor of safety 3, fc= 320 N/$mm^2$ and a = 17500. Take properties of joist; A = 6133 $mm^2$ $I_{xx}$=9821.6 x $10^4$ $mm^4$; $I_{yy}$ = 990.1 x $10^4$ $mm^4$. | BT-3 | Applying |
| 10. | Identify the ratio of thickness to internal diameter for a tube subjected to internal pressure when the pressure is 5/8 of the value of the maximum permissible circumferential stress. Find the increase in internal diameter of such a tube 100 mm internal diameter when the internal pressure is 80MN/$mm^2$. Also find the change in wall thickness. Take E=205GN/$m^2$ and 1/m = 0.29 | BT-4 | Analyzing |
| 11. | Explain the Euler's assumption in column theory. And derive a relation for theEuler's crippling load for a column with both ends hinged. | BT-4 | Analyzing |
| 12. | i) Differentiate thick andthincylinders. (3)<br>ii) State the assumptions inthickcylinders (3)<br>iii) Examine the stress acting in thethickcylinders (4)<br>iv) Explain aboutcompoundcylinders (3) | BT-4 | Analyzing |
| 13. | A mild steel tube 4m long, 3cm internal diameter and 4mm thick is used as a strut with both ends hinged. Find the collapsing load, what will be the crippling load?<br>i) Both ends are built in<br>ii) One end is built-in and one end is free. | BT-5 | Evaluating |
| 14. | Evaluate the ratio of the buckling strengths of columns of circular section one with hollow and other solid of the sane material, having the same length, same cross sectional area and same end condition. The internal diameter of the hollow column is half of the external diameter. | BT-6 | Creating |

**PART C**

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| 1. | Find out the kern of a column cross-section for the follwing<br>a) Rectangularsection<br>b) Square section<br>c) Circularsection<br>d) Hollow circularsection | BT-1 | Remembering |
| 2. | State the Euler's assumption in column theory. And derive a relation for theEuler's crippling load for a column with both ends fixed. | BT-1 | Remembering |

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| 3. | Describethe relation for theEuler's crippling load for a column with one end fixed and other end hinged along with the assumptions. | BT-2 | Understanding |
| 4. | Explain the failure of long column and also write the assumptions involved in lame's theory. | BT-2 | Understanding |

## UNIT 4- STATE OF STRESS IN THREE DIMENSIONS

Stress tensor at a point- Stress invariants-Determination of principal stresses and principal planes – Volumetric strain –Theories of failure; Maximum Principal stress theory –Maximum Principal strain theory – Maximum shear stress theory – Total Strain energy theory – Maximum distortion energy theory– application problems.

### PART A

| Q.No | Questions | BT Level | Competence |
|---|---|---|---|
| 1. | What do you mean by principal plane and principal stress? | BT-1 | Remembering |
| 2. | Define principal strain. | BT-1 | Remembering |
| 3. | State "Rankine"s theorem of failures" | BT-1 | Remembering |
| 4. | Define octahedral stress. | BT-1 | Remembering |
| 5. | State Guests Tresca's theories of failure. | BT-1 | Remembering |
| 6. | State maximum strain energy theory or Haigh"s theory. | BT-1 | Remembering |
| 7. | Explain Shear strain energy theory or Von-mises theory. | BT-2 | Understanding |
| 8. | Maximum principal strain theory (or) St. Venant"s theory- Report it. | BT-2 | Understanding |
| 9. | Define Spherical tensor. | BT-2 | Understanding |
| 10. | Describe octahedral shearing stress theory. | BT-2 | Understanding |
| 11. | What are the theories used for ductile failure? | BT-3 | Applying |
| 12. | Define Major and minor principal stress theory. | BT-3 | Applying |
| 13. | Examine stress tensor and Stress deviator. | BT-3 | Applying |
| 14. | What are the assumptions involved in analysis of thin cylindrical Shells? | BT-4 | Analyzing |
| 15. | Define Dilatation. | BT-4 | Analyzing |
| 16. | Define residual stresses. | BT-4 | Analyzing |
| 17. | Generalize the term stress invariants. | BT-5 | Evaluating |
| 18. | State distortion energy theory for failure. | BT-5 | Evaluating |
| 19. | Explain hydrostatic types of stress. | BT-6 | Creating |
| 20. | Summarize strain rosette. | BT-6 | Creating |

**PART B**

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| 1. | The rectangular stress components of a point in three dimensional stress system are defined as $\sigma_x$ = 20 MPa, $\sigma_y$ = -40 MPa,$\sigma_z$ = 20 MPa, $\tau_{xy}$ = 40 MPa, $\tau_{yz}$ = -60 MPa and $\tau_{zx}$ = 20MPa. Examine the principal stresses and principal planes. Also determineassociated direction of the state of stress. | BT-1 | Remembering |
| 2. | In a material, the principal stresses are 60 MN/$m^2$ , 48 MN/$m^2$ and -36 MN/$m^2$, find the following:<br>(i) Total strainenergy<br>(ii) Volumetric strainenergy<br>(iii) Shear strainenergy<br>(iv) Factor of safety on the total strain energy criterion if the material yields at 120 MN/$m^2$. Take E = 200 GN/$m^2$, 1/m =0.3. | BT-1 | Remembering |
| 3. | A cylindrical shell made of mild steel plate and 1.2m in diameter is to be subjected to an internal pressure of 1.5 MN/$m^2$. If the material yields at 200 MN/$m^2$, find the thickness of the plate on the basis of the following three theories. Assuming factor of safety 2 in each case.<br>(i) maximum principalstresstheory (5)<br>(ii) maximum shearstresstheory (4)<br>(iii) maximum shear strainenergytheory (4) | BT-1 | Remembering |
| 4. | At a section of a mild steel shaft, the maximum torque is 8437.5 Nm and maximum bending moment is 5062.5 Nm. The diameter of shaft is 90 mm and the stress at the elastic limit in simple tension for the material of the shaft is 220 N/$mm^2$.Tell whether the failure of the material will occur or not according to maximum shear stress theory. If not then find the factor of safety. | BT-1 | Remembering |
| 5. | The principal tensile stresses at a point across two perpendicular planes are 120 MN/$m^2$ and 60 MN/$m^2$. Predict<br>(i) thenormalandtangentialstressandtheresultantstressandits obliquity on a plane at 20 with the major principal plane.<br>(ii) the intensity of stress which acting alone can produce the same maximum strain. Take poisson's ratio =1/4 | BT-2 | Understanding |
| 6. | The inside and outside diameters of a cast-iron cylinder are 240 mm and 150 mm respectively. If the ultimate strength of a cast iron is 180 MN/$m^2$,Identifyaccording to each of the following theories the internal pressure which would causerupture:<br>(i) maximum principal stresstheory<br>(ii) maximum strain theoryand<br>(iii) maximum strain energytheory.<br>Poison's ratio = 0.25. Assume no longitudinal stress in the cylinder. | BT-2 | Understanding |
| 7. | In a steel member, at a point the major principal stress is 180 MN/$m^2$ and the minor principal stress is compressive. If the tensile yield point of the steel is 225 MN/$m^2$, Find the value of the minor principal stress at which yielding will commence, according to each of the following criteria offailure<br>(i) Maximumshearingstress (5)<br>(ii) Maximum total strainenergyand (4)<br>(iii) Maximum shear strain energy. Take poisson ratio = 0.26(4) | BT-2 | Understanding |

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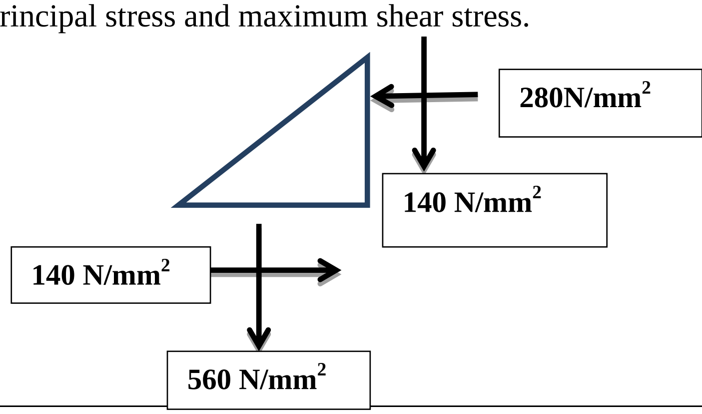
| 8. | (i) Illustrate Maximum shearstresstheory. (3)<br>(ii) A shaft is subjected to a maximum torque of 10 kNm and a maximum of bending moment of 8 kNm at a particular section. If the allowable equivalent stress in simple tension is 160MN/$m^2$, Calculate the diameter of the shaft according to the<br>(a) Maximum shearstresstheory. (5)<br>(b) Octahedral shearstresstheory (5) | BT-3 | Applying |
| 9. | A bolt is subjected to an axial pull of 10 kN together with a transverse shear force of 5kN. Solve the diameter of the bolt by using<br>(i) maximum principalstresstheory (4)<br>(ii) maximumstraintheory (4)<br>(iii)Octahedral shearstresstheory (5) | BT-3 | Applying |
| 10 | (i) In a metallic body the principal stress are 40 MN/$m^2$ and -100 MN/$m^2$, third principal stress being zero. The elastic limit stress in simple tension as well as in simple compression is 80 and 400 MN/$m^2$.Analyze the factor of safety based on the elastic limit if the criterion of failure is the maximum principalstresstheory. (4)<br>(ii) A steel shaft is subjected to an end thrust producing a stress of compression 90MPaand maximum shearing stress on the surface arising from torsion is 60 MPa. The yield point of the material in simple tension was found to be 300MPa.Examine the FOS of the shaft accordingto<br>(i) maximum shearstresstheory (5)<br>(ii) maximum distortionenergytheory. (4) | BT-4 | Analyzing |
| 11 | At a point in a two-dimensional stressed system strains measured with a rectangular rosette as shown below:<br>Take $e_A$= 500 microns, $e_B$= 250 microns and $e_C$= -150 microns, E = 2 x $10^5$ N/$mm^2$ and 1/m = 0.3.Analyze the principal strain and principal stress. | BT-4 | Analyzing |
| 12 | A strain energy rosette has axes of three gauges OA, OB, OC at120°to each other. The observed strains are $e_A$= 600 microns, $e_B$= -450 microns and $e_C$= -100 microns. Calculate the principal stresses. Take E = 2 x $10^5$ N/$mm^2$ and 1/m = 0.3. | BT-4 | Analyzing |
| 13 | A block of material is subjected to a tensile strain of 12 x $10^{-6}$ and a compression strain of 15 x $10^{-6}$ on planes at right angles to each other. There is also a shear strain of 12 x $10^{-6}$ and there is no strain on planes at right angles to the above planes. Rewrite the principalstrain in magnitude and direction. | BT-5 | Evaluating |
| 14 | For the state of stress shown in figure. Find the principal plane, principal stress and maximum shear stress.<br> | BT-6 | Creating |

## PART C

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| 1. | Obtain the principal stresses and the related direction cosines for the following state of stress.<br>$$\begin{vmatrix} 3 & 4 & 6 \\ 4 & 5 & 2 \\ 6 & 5 & 1 \end{vmatrix} \text{MPa}$$ | BT-1 | Remembering |
| 2. | Illustrate in detail about the following.(5x3=15)<br>(i) Rankine"s theories offailure<br>(ii) Guest"sorTresca"stheroy<br>(iii) Haigh"stheory<br>(iv) Von Mises-Henkytheory<br>(v) St. Venanttheory | BT-3 | Applying |
| 3. | A steel flat of 250 mm long and 30 mm x 50 mm uniform section is acted upon by a tensile force of 30 kN along its length. A compressive force of 350 kN along its width, a compressive force of 200 kN along its thickness. Assuming Poisson"s ratio of 0.3 and E = 2 x 10 N/mm$^2$. Find change in dimensions and change in volume. | BT-1 | Remembering |
| 4. | A thick steel cylinder with an internal diameter 200 mm has to withstand an internal fluid pressure of 30 N/mm$^2$, Calculate the thickness of the metal by using,<br>(i) Maximum principal stresstheory<br>(ii) Maximum shear stresstheory<br>The tensile stress at yield point is 250 N/mm$^2$.<br>Use factor of safety of2.5 | BT-3 | Applying |

## UNIT V - ADVANCED TOPICS IN BENDING OF BEAMS

Unsymmetrical bending of beams of symmetrical and unsymmetrical sections – Shear Centre - curved beams – Winkler Bach formula– stresses in hooks.

## PART A

| Q.No | Questions | BT Level | Competence |
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| 1. | Write the shear centre equation for channel section. | BT-3 | Applying |
| 2. | Write the formula for stress using Winkler-Bach theory | BT-1 | Remembering |
| 3. | List the assumptions made in the analysis of curved bars. | BT-1 | Remembering |
| 4. | Tell the concept behind unsymmetrical bending. | BT-1 | Remembering |
| 5. | Name the reasons for unsymmetrical bending | BT-1 | Remembering |
| 6. | Define Unsymmetrical Bending. State two reasons for unsymmetrical bending. | BT-1 | Remembering |
| 7. | How will you calculate the stress due to unsymmetrical bending? | BT-1 | Remembering |
| 8. | How will you calculate the distance of neutral axis from centroidal | BT-1 | Remembering |

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| 9. | How will you predict the angle of inclination of neutral axis with respect to principal axis? | BT-2 | Understanding |
| 10. | Restate the formula for deflection of a beam causing unsymmetrical bending. | BT-2 | Understanding |
| 11. | How will you interpret the resultant stress in a curved bar subjected to direct stress and bending stress? | BT-2 | Understanding |
| 12. | How will you predict resultant stress in a chain link? | BT-2 | Understanding |
| 13. | Show the shape of distribution of bending stress in a curved beam. | BT-3 | Applying |
| 14. | Investigate where the neutral axis lies in a curved beam. | BT-4 | Analyzing |
| 15. | Identify the nature of stress in the inside section of a crane hook. | BT-4 | Analyzing |
| 16. | Analyze where the maximum stress in a ring under tension occur. | BT-4 | Analyzing |
| 17. | Assess the most suitable section for a crane from your knowledge. | BT-5 | Evaluating |
| 18. | Rewrite fatigue strength and list out the causes for fatigue failure? | BT-5 | Evaluating |
| 19. | Generalize stress concentration. | BT-6 | Creating |
| 20. | Compare polar moment of inertia and the product of inertia. | BT-6 | Creating |
| **PART B** | | | |
| 1. | Derive the equation of shear center for channel section | BT-6 | Creating |
| 2. | Determine (i) position of neutral axis, and (ii) maximum and minimum stresses when a curved beam of circular section of diameter 10mm is subjected to pure bending moment of +11.5kNm. The radius of curvature is 100mm. | BT-3 | Analyzing |
| 3. | An 80 x 80 x 10 mm angle is used as a simply supported beam over a span of 2.4 m. It carries a load of 400 kN along the vertical axis passing through the centroid of the section. Find the resulting bending stress on the outer corners of the section along the middle section of the beam. | BT-1 | Remembering |
| 4. | A beam of rectangular cross section is subjected to pure bending with a moment of 20kN.m. The trace of the plane of loading is inclined at $45^0$ to the YY axis of the section. Identify the N.A of the section and calculate the bending stress induced at each corner of the beam section. | BT-1 | Remembering |
| 5. | Estimate principal moment of inertia of angle section 100 mm x 40 mm x 60 mm | BT-2 | Remembering |

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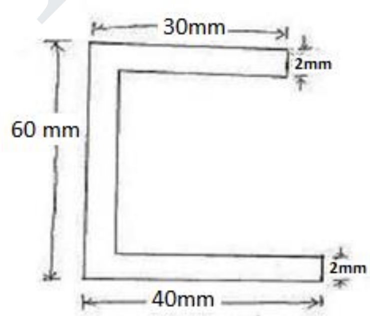
| 6. | Predict the shear flow variation and sketch the same for a channel section of 100mm X 200mm X 5mm carrying a shear force of 2500N. | BT-2 | Understanding |
| 7. | A beam of rectangular section 20 mm X 40 mm has its Centre line curved to a radius of 50mm. the beam is subjected to a bending moment of $45x10^5$ N.mm. Solve the intensity of maximum stresses in the beam. Also plot the bending stress across the section. | BT-3 | Understanding |
| 8. | A curved bar is formed of a tube 120mm outside diameter and 7.5mm thickness. The center line of this beam is a circular arc of radius 225mm. A bending moment of 3kN.m tending to increase curvature of the bar is applied. Calculate the maximum tensile and compressive stresses set up in the bar. | BT-3 | Analyzing |
| 9. | A curved bar of rectangular section, initially unstressed is subjected to bending moment of 2000 N.m tends to straighten the bar. The section is 5 cm wide and 6 cm deep in the plane of bending and the mean radius of curvature is 10 cm. Judge the position of N.A and the stress at the inner and outer face. | BT-4 | Applying |
| 10 | Analyze the shear center of a channel section of 400 mm X 200 mm outside and 5 mm thick. | BT-4 | Analyzing |
| 11 | An I-Section of a beam consists of top flange 140mmX40mm and bottom flange 140mm X 40mm, web 20mm X 220mm. The center line of web is 80mm from the left edge of flange and 60mm from the right edge. Evaluate the shear center of the beam. | BT-4 | Analyzing |
| 12 | Evaluate the principal moment of inertia of channel section shown in fig.   | BT-5 | Evaluating |
| 13 | An equal angle section 150 mm x 150 mm x 10 mm is used as a simply supported beam of 4.2 m length is subjected to a vertical load passing through the centroid. Predict bending stress at any one point in the section. | BT-2 | Understanding |

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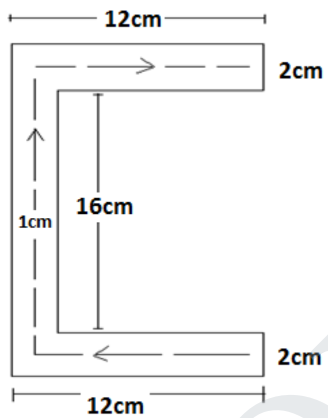
| 14 | A curved bar of rectangular section, initially unstressed is subjected to pure bending moment of 400 N.m tends to straighten the bar. The section is 20 mm wide and 40 mm deep is curved in plane parallel to the depth and the mean radius of curvature is 50 mm. Assess the position of N.A and the ratio of maximum to the minimum stress. | BT-6 | Creating |
| | **PART C** | | |
| 1. | a) Write a detailed note on Shear Centre (5 Marks)<br>b) A channel section has flanges 12cm x 2cm and web 16cm x 1cm as shown. Determine the shear centre of the channel.<br><br><br>(8 Marks) | BT-1 | Remembering |
| 2. | Describe brief technical notes on:<br>a) Unsymmetrical bending on beams (4 Marks)<br>b) Curved beams (4 Marks)<br>c) Stress concentration (3 Marks)<br>d) Significance of shear centre (4 Marks) | BT-2 | Understanding |
| 3. | Show the expression for Winkler Bach formula | BT-3 | Applying |
| 4. | Locate and derive the shear centre of an unequal I-section | BT-2 | Understanding |

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