# CE8395 STRENGTH OF MATERIALS FOR MECHANICAL ENGINEERSL T P C

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# 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](#_TOC_250003)

Beams – types of 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](#_TOC_250002)

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](#_TOC_250001)

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](#_TOC_250000)

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.

# TOTAL (L: 45+T: 15): 60 PERIODS

# OUTCOMES:

* Upon completion of this course, the students can able to apply mathematical knowledge to calculate the deformation behavior of simple structures.
* Critically analyze problem and solve the problems related to mechanical elements and analyze the deformation behavior for different types of loads.

# TEXT BOOKS:

1. Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2007
2. Jindal U.C., "Strength of Materials", Asian Books Pvt. Ltd., New Delhi, 2007

# REFERENCES:

1. Egor. P.Popov “Engineering Mechanics of Solids” Prentice Hall of India, New Delhi, 2001
2. Subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2007.
3. Hibbeler, R.C., "Mechanics of Materials", Pearson Education, Low Price Edition, 2007
4. Ferdinand P. Been, Russell Johnson, J.r. and John J. Dewole "Mechanics of Materials", Tata McGraw Hill Publishing „co. Ltd., New Delhi, 2005.

# COURSE OUTCOMES

On completion of this course, the student will be able:

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| C214.1 | Understand the concepts of stress and strain in simple and compound bars, the importance of principal stresses and principal planes. |
| C214.2 | Understand the load transferring mechanism in beams and stress distribution due to shearing force and bending moment. |
| C214.3 | Apply basic equation of simple torsion in designing of shafts and helical spring. |
| C214.4 | Calculate the slope and deflection in beams using different methods. |
| C214.5 | Analyze and design thin and thick shells for the applied internal and external pressures. |

# MAPPING BETWEEN CO, PO AND PSO WITH CORRELATION LEVEL 1/2/3

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| **CE8395** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
| C214.1 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 2 | 2 | 1 | 2 | 1 | 2 | 2 |
| C214.2 | - | 3 | 3 | - | 2 | - | 1 | 3 | - | 2 | 1 | - | 1 | 2 | 1 |
| C214.3 | - | - | - | 2 | - | 2 | 1 | 3 | 2 | - | 1 | 2 | 2 | 2 | 2 |
| C214.4 | 3 | 2 | 3 | 2 | 2 | - | 1 | - | 2 | 2 | - | 2 | 2 | 2 | 1 |
| C214.5 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |

# RELATION BETWEEN COURSE CONTENT WITH Cos UNIT I - STRESS, STRAIN AND DEFORMATION OF SOLIDS

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| **S.No** | **Knowledge**  **Level** | **Topics** | **Course**  **Outcomes** |
| 1 | U, An | Tensile, compressive and shear stresses | C214.1 |
| 2 | U, An | Compound bars |
| 3 | U, An | Thermal Stresses |
| 4 | U, An | Stress strain relationships and Elastic constants |
| 5 | U, An | Principal stresses and Principal planes |
| 6 | U, An | Mohr‟s Circle |

# UNIT II - TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAM

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| **S.No** | **Knowledge**  **Level** | **Topics** | **Course**  **Outcomes** |
| 1 | U, An | Types of beams | C214.2 |
| 2 | U, An | Shear force and bending moment diagram |
| 3 | U, An | Theory of simple bending |
| 4 | U, An | Shear stress distribution in beams |
| 5 | U, An | Proportioning of sections |
| 6 | U, An | Flitched beams |

# UNIT III –TORSION

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| **S.No** | **Knowledge Level** | **Topic** | **Course**  **Outcomes** |
| 1 | U | Theory of Torsion | C214.3 |
| 2 | U, An | Torsional formulation stresses |
| 3 | U, An | Shafts connected in series |
| 4 | U, An | Shafts connected in Parallel |
| 5 | U, An | Stresses in helical springs |
| 6 | U, An | Deflection of helical springs and carriage springs |

# UNIT IV –DEFLECTION OF BEAMS

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| **S.No** | **Knowledge**  **Level** | **Topic** | **Course**  **Outcomes** |
| 1 | U, An | Slope and Deflection of beams- Flextural rigidity | C214.4 |
| 2 | U, An, Ap | Double integration method |
| 3 | U, An, Ap | Macaulay‟s method |
| 4 | U, An,Ap | Area Moment method |
| 5 | U, An,Ap | Conjugate beam method |
| 6 | U, An | Maxwell‟s reciprocal theorems |

# UNIT V - THIN CYLINDERS, SPHERES AND THICK CYLINDERS

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| **S.No** | **Knowledge**  **Level** | **Topic** | **Course**  **Outcomes** |
| 1 | U, An | Thin and Thick cylinders their application | C214.5 |
| 2 | U, An | Stresses developed in cylinders |
| 3 | U,An | Circumferential stress and longitudinal stress calculations |
| 4 | U, An,Ap | Distribution of stresses in thick cylinders and Lame‟s  theorem |
| 5 | U, An | Deformation in spherical shells |

Ap – Apply; An – Analyze; U – Understand, E- Evaluate,C-Create

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|  | **UNIT I STRESS,STRAIN AND DEFORMATION** |
|  | **PART-A – C214.1** |
| **1.** | **Derive a relation for change in length of a bar hanging freely under its own**  **weight. (APR 17) (APR 19)** |
|  | Consider a bar hanging freely under its own weight,  Let, l=Length of the bar; A =Cross-sectional area of the bar; E= young‟s modulus ;  w=Specific weight of the bar material  𝑃(𝑤𝑒i𝑔ℎ𝑡) = 𝑤𝐴𝑥  𝑃𝑙 𝑤𝐴𝑥. 𝑑𝑥 𝑤𝑥. 𝑑𝑥  𝐸𝑙𝑜𝑛𝑔𝑎𝑡i𝑜𝑛 𝑜ƒ 𝑡ℎ𝑒 𝑏𝑎𝑟 𝑑𝑢𝑒 𝑡𝑜 𝑥 𝑙𝑒𝑛𝑔𝑡ℎ, 𝛿𝑥 = = =  𝐴𝐸 𝐴𝐸 𝐸  𝑇𝑜𝑡𝑎𝑙 𝐸𝑙𝑜𝑛𝑔𝑎𝑡i𝑜𝑛 𝑜ƒ 𝑡ℎ𝑒 𝑏𝑎𝑟,  𝑙 𝑙  𝑤𝑥. 𝑑𝑥 𝑤 𝑤 𝑥2 𝑙 𝑤𝑙2 W𝑙  𝛿𝑙 = ∫ = ∫ 𝑥. 𝑑𝑥 = [ ] = = (∴ 𝑤𝑙 = W)  𝐸 𝐸 𝐸 2 2𝐸 2𝐸  0 0 0 |
| **2.** | **What is the radius of Mohr's circle? (Nov10) (APR 17) (APR 19)** |
|  | Radius of Mohr's circle is equal to the maximum shear stress. |
| **3.** | **What is bulk modulus? (NOV 17)** |
|  | Bulk Modulus is the ratio of linear stress to volumetric strain, with in the elastic limit. |
| **4.** | **Define principal stresses and principal plane.(MAY 13)(DEC 15)(DEC 16)(NOV**  **17)(APR 18)(APR 19)** |
|  | Principal stress: The magnitude of normal stress, acting on a principal plane is known as principal stresses. Principal plane: The planes which have no shear stress are known  as principal planes. |
| **5.** | **Give the relation between modulus of elasticity and bulk modulus (APR 18)** |
|  | E=3K(1−2μ)  K is the Bulk modulus,  E is **Young's modulus** or modulus of Elasticity. μ – Poisson‟s Ratio |

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| **6.** | **Define Poisson‟s Ratio (MAY 12)(DEC 15) (NOV 18)** |
|  | 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 Poisson‟s ratio.  It is dimensionless and is denoted by µ or 1/m. Note: The Poisson‟s ratio for a  material cannot be more than 0.5. |
| **7.** | **Write an expression of volumetric strain for a rectangular bar subjected to an**  **axial load P. (NOV 18)** |
|  | ∂𝑉  𝑉𝑜𝑙𝑢𝑚𝑒𝑡𝑟i𝑐 𝑆𝑡𝑟𝑎i𝑛, =  𝑉 |
| **8.** | **What you mean by thermal stresses?(MAY 2015) (APR 19) (Nov/Dec 2020)** |
|  | If the body is allowed to expand or contract freely, with the rise or fall of temperature no stress is developed but if free expansion is prevented the stress developed is called  temperature or thermal stress and the corresponding strain is temperature strain. |
| **9.** | **Differentiate between a rigid body and a deformable body.** |
|  | When a body is subjected to external forces, if it undergoes deformation, it is called as  deformable body. If it does not undergo any deformation, it is called rigid body. |
| **10.** | **What does equilibrium signify? What are the conditions for equilibrium to exist?** |
|  | Word equilibrium signifies the body does not undergo any displacement under the application of external force. The conditions are   * Sum of all forces in x direction must be zero and also in y & z direction. * Moment about any point is zero. |
| **11.** | **Define stress and explain tensile and compressive stress. (April/May 2021)** |
|  | Stress is defined as the external force applied per unit area. When body is subjected to equal and opposite pulls, it elongates. The resistance offered to this elongation is tensile stress. If body is subjected to equal and opposite pushes, it contracts and the resistance offered to this contraction is compressive stress.  Tensile Stress means Pull & Compressive Stress means Pull. |

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| **12.** | **Define strain and explain tensile and compressive strain.** |
|  | It is the ratio of change in dimension to the original dimension. The strain corresponding to the tensile stress is called tensile strain and it is defined as the ratio of the increase in the length to the original length. The strain corresponding to the compressive stress is called as compressive strain. It is defined as the ratio of decrease  in length to the original length. |
| **13.** | **Define shear stress and shear strain. (NOV 2014)** |
|  | The two equal and opposite force act tangentially on any cross sectional plane of the body tending to slide one part of the body over the other part. The stress induced is called shear stress and the corresponding strain is known as shear strain. Or Shear stress is the resistance offered to the force applied. It is the ratio of shear force to shear  area. The corresponding strain is called as shear strain. |
| **14.** | **State Hook‟s law and explain elastic limit.(MAY/JUNE 2013)** |
|  | It states that within elastic limit, the ratio of the stress and strain is a constant. Elastic  limit is a point on the stress strain diagram below which the body regains its original shape when deformed, not necessarily obeying the hook‟s law. |
| **15.** | **Draw the stress-strain diagram for a ductile material**. |
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| **16.** | **Explain Ultimate stress.** |
|  | There is a particular maximum load, which any material can withstand, above which it  starts creeping and breaks. The stress corresponding to this load is called ultimate stress. |
| **17.** | **Define modulus of elasticity. (DEC 2016)** |
|  | According to Hook‟s law, the ratio of stress to strain is a constant. This constant is  modulus of elasticity, E and its unit is N/mm2. |

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| **18.** | **Write the significance of Mohr‟s circle?(MAY 2015) (Nov/Dec 2020)** |
|  | a.) Stresses on different planes passing through a point in strained material can be represented by the points on the Mohr‟s circle.  b.) Problems with more analytical complications can be solved by Mohr‟s circle  method. |
| **19.** | **What is the principle of super position?(NOV 2012) (April/May 2021)** |
|  | The resultant deformation of the body is equal to the algebraic sum of the deformation  of the individual section. Such principle is called as principle of super position. |
| **20.** | **Define factor of safety and state reason for its necessity. (NOV 2014)** |
|  | The term factor of safety is applied to the factor used to evaluate the safeness of a structure.  Factor of safety (Ductile) = Yield stress/allowable stress; FOS (Brittle)=Ultimate stress/Allowable.  Allowable stress is also known as Design stress or Working stress or permissible  stress. |
| **21.** | **What is modular ratio?(NOV 2012)** |
|  | It is the ratio of the Young‟s modulus of two different materials. |
| **22.** | **Define the three elastic moduli and give a relationship between Young‟s modulus**  **and shear modulus.** |
|  | * Young‟s modulus: The ratio of tensile stress (or compressive stress) to the corresponding strain within the elastic limit. It is denoted by E and its unit is N/mm2. * Modulus of rigidity or shear modulus: The ratio of shear stress to the corresponding shear strain within the elastic limit. It is denoted by G or C or N and its unit is N/mm2. * Bulk Modulus is the ratio of linear stress to volumetric strain, with in the elastic limit. |

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| **23.** | **Define Strain Energy (DEC 2014)** |
|  | When a material undergoes deformation, under the action of external load work is  done on the material. The work done on the material is stored as „Strain energy „. Strain energy = (σ2A ℓ) / 2E. |
| **24.** | **Define Resilience.(MAY 2011)** |
|  | Strain energy stored per unit volume is called Resilience. ( σ2 / 2E ) |
| **25.** | **Define major principal stress & minor principal stress. (Dec 2014)** |
|  | The plane carrying maximum normal stress is called major principal plane and the stress across the plane is called major principal stress. The plane carrying minimum normal stress is called minor principal plane and the stress across the plane is called  minor principal stress. |
| **26.** | **What is the pole of a Mohr‟s circle? (Nov/Dec 2020)** |
|  | The pole of a Mohr‟s diagram, for the two-dimensional case, is a unique point on the Mohr circle which permits any point on the Mohr‟s circle to be related to the direction  in the physical plane associated with that point. |
| **27.** | **A rod 150 cm long and of diameter 2 cm is subjected to an axial pull of 20 kN. If**  **the modulus of elasticity of the material of the rod is 2x105 N/mm2; determine: (i) the stress; (ii) the strain and (iii) the elongation of the rod.** |
|  | i) Stress, 𝜎 = 𝑃 = 20000 = 63.662 𝑁/𝑚𝑚2  𝐴 100𝜋  ii) 𝐸 = 𝜎 ; 𝑒 = 𝜎 = 63.662 = 0.000318  𝑒 𝐸 2×105  iii) Elongation: 𝑒 = 𝑑𝐿; 𝑑𝐿 = 𝑒 × 𝐿 = 0.000318 × 150 = 0.477𝑚𝑚  𝐿 |

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|  | **PART B – C214.1** |
| **1.** | A load of 50kN is suspended by a steel pipe of 50mm external diameter. If the ultimate tensile strength of steel is 500 N/mm2 and the factor of safety is 4, determine  (i) the thickness of the pipe. (ii) Elongation of the pipe over a length of 200 mm if it is  stressed to its maximum permissible value. Take E = 200 kN/mm2. **(Nov 2015)** |
| **2.** | A member ABCD is subjected to loads as shown in fig.below. Find the value of P and  determine the total change in length of the bar. Take E = 210 kN/mm2. **(MAY 2017)** |

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| **3.** | A bar of 30mm diameter is subjected to a pull of 60 KN. The measured extension on gauge length is 200mm is 0.1mm and change in diameter is 0.004mm calculate (i)  Young‟s Modulus (ii) Poisson‟s ratio (iii) bulk modulus. **(MAY 17).** |
| **4.** | A compound tube consist of a steel tube 140mm internal diameter and 160mm external diameter and an outer brass tube 160mm internal diameter and 180mm external diameter. The two tubes are the same length. The compound tube carries an axial load of 900KN. Find the stresses and load carried by each tube and the amount it shortens. Length of each tube is 140mm. Take E for steel 2x105N/mm2and for brass  1x105N/mm2**(NOV 17)** |
| **5.** | At a point in a strained material the principal stresses are 100 N/mm2(tensile) and 60 N/mm2(compressive). Determine the normal stress, shear stress and resultant stress on a plane inclined at 50 degree to the axis of major principal stress. Also determine the  maximum shear stress at the point. **(NOV 17)** |
| **6.** | A solid steel bar, 40mm diameter, 2m long passes centrally through a copper tube of internal diameter 40mm, thickness of metal 5mm and length of 2m. the ends of the bar and tube are brazed together and tensile load of 150KN is applied axially to the  compound bar. E for copper 100GN/m2 E for steel 200 GN/m2 **(APR 18).** |
| **7.** | At a point within a body subjected to two mutually perpendicular directions, the tensile stresses are 80 N/mm2and 40 N/mm2respectively. Each stress is accompanied by a shear stress of 60 N/mm2.Determine normal stress, shear stress, and resultant stress on an oblique plane incline at an angle of 45 degree with the axis of minor  tensile stress. (**APR 18**) |
| **8.** | A reinforced short concrete column 250 mm x 250 mm in section is reinforced with 8  steel bars. Total area of steel bar is 2500 mm2. The column carries a load of 390 kN. |

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|  | (i) If the modulus of elasticity for steel is 15 times that of concrete, find the stresses in  concrete and steel. (**NOV 18**) |
| **9.** | The stresses at a point in a bar are 200 N/mm2tensile and 100 N/mm2compressive. Determine the resultant stress in magnitude and direction on a plane inclined at 60 degree to the axis of the major stress. Also determine the maximum intensity of shear  stress in the material at the point. (**NOV 18**) |
| **10.** | A steel rod 3cm diameter, 5m long and connected to two grips is maintained at a temperature of 95°C. Find the stress and force exerted when the temperature falls to 30°C if (i) the ends do not yield, and (ii) the ends yield by 0.12cm. Take E = 2 x  105MN/mm2 and α = 12 x 10-6/ °C. (**APR 2019**) |
| **11.** | An elemental cube is subjected to tensile stresses of 30N/mm2and 10N/mm2acting on two mutually perpendicular planes and a shear stress of 10N/mm2on these planes. Draw the mohr‟s circle of stresses and Determine the magnitude and directions of  principle stresses and also the greatest shear stress. (**APR 19**). |
| **12.** | A steel rod of 25 mm diameter is enclosed centrally in a hollow copper tube of external diameter 50 mm and internal diameter of 40 mm. The composite bar is then subjected to an axial pull of 50 kN. If the length of each bar is equal to 0.25m, determine: (i) the stress in the rod and tube and (ii) load carried by each bar. Take E  for steel = 2 x 105 N/mm2 and for copper = 1 x 105 N/mm2. **(MAY 2012)(DEC 2016)** |
| **13.** | A compound bar is made up of a central plate 60mm wide and 10 mm thick, to which copper plates 60 mm wide and 5 mm thick are rigidly connected one on either side. The length of the bar at normal temperature is 1m. If the temperature is raised by 70°C, determine the stress in each metal and its nature. Also find the change in length. Young‟s modulus for steel and copper are 2 x 105MPa and 1 x 105MPa respectively,  while the thermal coefficients are 12 x 10-6 /°C and17 x 10-6 / °C**. (DEC2016)** |
| **14.** | Two vertical rods of steel and copper are rigidly fixed with the ceiling at their upper ends at 100cm apart. Each rod is 3m long and 25mm in diameter. A horizontal cross piece connects the lower ends of the rods. Where should a load of 3.5 tonnes be placed on the cross piece, so that it remains horizontal after loaded? Assume Es = 2 x  105 N/mm2 and EC =1 x 105 N/mm2. **(DEC 2015)** |

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| **15.** | The normal stresses at a point on two mutually perpendicular planes are 140 MPa (tensile) and 100 MPa (compression). Determine the shear stress on these planes if the maximum principal stress is limited to 150 MPa (tensile). Determine also the following: (i) Min principal stress. (ii) Max shear stress and its plane. (iii) Normal, shear & resultant stresses on a plane inclined at 30° anticlockwise to X plane. **(MAY**  **2015)** |
| **16.** | A tensile test was conducted on a mild steel bar. The following data was obtained from the test.   1. Diameter of the steel bar = 3 cm 2. Gauge length of the bar = 20 cm iii)Load at elastic limit = 250 kN   iv)Extension at a load of 150 kN = 0.21 mm v)M maximum load = 380 kN  vi)Total extension = 60 mm vii)Diameter of rod at failure = 2.25 cm  Determine : 1) The Young‟s modulus (2) The stress at elastic limit (3) The percentage  of elongation (4) The percentage decreases in area.**(April/May 2021)** |
| **17.** | At certain point in a strained material, the intensities of stresses on two planes at right angles to each other are 20 N/mm2 and 10 N/mm2 both tensile. They are accompanied by a shear stress of magnitude 10 N/mm2. Find the location of principal plane and  evaluate the principal stresses.**(April/May 2021)** |
| **18.** | 1. A hollow steel tube of external diameter 100 mm, is used to carry a compressive load of 456 kN. Find the internal diameter if the permissible stress is 150 Nmm2. 2. A 25 mm diameter rod is subjected to an axial load P, and the strain in the rod is   0.00075. Find the tensile force P, if E = 2 × 105 N/mm2.**(Nov/Dec 2020)** |
| **19.** | A steel cylinder is enclosed in a copper tube. The cylinder and tube are compressed between rigid parallel plates. Find the stresses in the steel and copper and also the compressive strain. P = 450 kN, d = 100 mm and D = 200 mm. For steel E = 210  kN/mm2 and for copper E = 110 kN/mm2.**(Nov/Dec 2020)** |

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|  | **PART C – C214.1** |
| **1.** | 1. Draw stress strain curve for mild steel and explain the salient points on it. 2. Drive an relation for change n length of circular bar with uniformly varying diameter, subjected to an axial tensile load W. **(MAY 17)** |
| **2.** | A load of 2 MN is applied on a short concrete column 500mm x 500mm. the column is reinforced with four steel bars of 10mm dia, one in each corner. Find the stress in  concrete and steel bar. Es = 2.1 x 105 N/mm2 and EC =1.4 x 105 N/mm2 **(NOV 17)** |
| **3.** | A bar 250mm long, cross sectional area 100mm x 50mm carries a tensile load of 500kN along lengthwise, a compressive load of 5000KN on its 100mm x 250mm face and tensile load of 2500KN on its 50mm x 250mm face. Calculate change in volume. What change must be made in the 5000KN load so that no change in the volume of bar  occurs. Take E = 1.8 x 105 N/mm2 and Poison ratio= 0.25. **(APR 18)** |
| **4.** | A member is subjected to like Direct stresses in two mutually perpendicular directions.  Derive express for normal and shear stress using principal plane method. |
| **5.** | At certain point in a strained material, the stresses on the two planes at right angles to each other are 40N/mm2 and 20N/mm2 both tensile. They are accompanied by shear stress of magnitude 20N/mm2. Find graphically location of principal plane and  evaluate principal stresses. |
| **6.** | A compound strut consists of a brass portion AB of diameter 75 mm and a steel portion BC of 40 mm diameter. The supports at A and C are rigid. If the temperature is raised through 140°C, find (a) the force exerted on the supports and (b) the relative  movement of the junction B.**(Nov/Dec 2020)** |
| **7.** | At a point in a strained material, there are two planes at right angles to each other on which the normal stresses are 75 MN/m2, tensile on one plane and 45 MN/m2 compressive on the other plane accompanied by a shear stress. If the major principal stress is 105 MN/m2 tensile, evaluate the shear on the two planes. Calculate the minor principal stress and also the maximum shear stress at a point.  **(Nov/Dec 2020)** |

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| **8.** | The bar shown in fig. is subjected to a tensile load of 160 kN. If the stress in the 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 given as equal to 2.1 × 105 N/mm2.**(April/May 2021)** |
| **9.** | Two brass rods each of diameter 35 mm and a steel rod of diameter 45 mm together support a load of 50 kN as shown in Fig. Find the stresses in the rods. Take Es=2x105N/mm2 and Eb=1 x 105 N/mm2. All dimensions are in mm. |

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| **UNIT II TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAM** | |
|  | **PART A-C214.2** |
| **1.** | **Draw shear force diagram for a simply supported beam of length 4m carrying a central point load of 4KN. (APR 17)** |
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| **2.** | **Prove that the shear stress distribution over a rectangular section due to shear force is parabolic (APR 17)** |
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| **3.** | **Draw the SF & BM diagrams for a cantilever of length L carrying a point load W**  **at the free end (NOV 17)** |
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| **4.** | **What is meant by flitched beam? (NOV 17) (NOV 13) (MAY 18) (April/May 2021)**  **(Nov/Dec 2020)** |
|  | It is defined as a section, made up of two or more different materials, joined together, in  such a manner that they behave like a single piece and each material bends to same radius of curvature. |
| **5.** | **What do you mean by point of contraflexture? (APR 18) (NOV 18) (APR 19) (MAY**  **13) (MAY 15)** |
|  | The point where B.M changes its sign or the point where the value of BM is Zero |
| **6.** | **What is meant by shear stress in beam? (APR 18)** |
|  | Generally, the beam subjected to the transverse load exerts the longitudinal shear  stress in the beam. The shearing stress in beam is defined as the stress that occurs due to the internal shearing of the beam that results from shear force subjected to the beam. |
| **7.** | **Enlist the assumption in theory of simple bending. (NOV 18) (DEC 15) (DEC 16)** |
|  | Assumptions made in the simple bending theory are: 1.The material of the beam is perfectly homogeneous throughout.2.The stress induced is directly proportional to strain.  3. The value of modulus of elasticity is the same, for the fibers of the beam under  compression or tension.4.The transverse of the beam, remains plane before and after bending. 5. There is no resultant pull or push on the cross section of the beam. |
| **8.** | **What is ratio of maximum shear stress to the average shear stress in the case of solid**  **circular section? (APR 19)** |
|  | Ratio of maximum shear stress to average  shear stress is 4/3 |

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| **9.** | **What is known as shear force?** |
|  | The algebraic sum of the vertical forces at any section of a beam to the right or to the left  of the section is known as shear force. |
| **10.** | **What is bending moment?** |
|  | The algebraic sum of the bending moment due to all the individual forces to the right or  to the right of the section. |
| **11.** | **What are the types of the beam? (Nov/Dec 2020)** |
|  | The different types of the beam are  a. Fixed beam b. Cantilever beam c. Simply supported beam  d. Over hanging beam e. Continuous beam |
| **12.** | **What is neutral axis? (May2010) (May 2015)** |
|  | As a result of bending moment, a length of the beam will take up a curved shape. It follows that outer radii of the material will be in tension, the inner radii impression, and  at some radius there will be no stress. This layer of the material is the neutral axis (NA). |
| **13.** | **What is section modulus? (NOV 13)** |
|  | It is the ratio of moment of inertia about the neutral axis to distance of the most distant point of the section from the neutral section, Where  Z = I / Ymax,  Z is the sectional modulus  I is the moment of inertia about neutral axis  Ymax is the distance of the most distant point of the section from the NA  Unit of section Modulus – mm3 |
| **14.** | **In case of triangular section what would be the shear stress distribution? (DEC 2015)** |
|  | The shear stress is not maximum at the Neutral Axis, but it is maximum at a height of h  / 2 in a triangular section. The max. Shear stress at N.A. for a circular section and is given by qmax = 4/3qave |
| **15.** | **Derive the relation between shear force and bending moment, in bending theory. (NOV14)** |
|  | dM = Fdx (The rate of change of bending moment is equal to the shear force at that section),  dF= -w dx  (The rate of change of shear force is equal to the rate of loading) |

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| **16.** | **Write the bending equation.** |
|  | M/I=f/y=E/R; M-Bending moment, E-Young‟s modulus, R-radius of curvature, f-  bending stress, y-Distance of the layer from the neutral axis. |
| **17.** | **Sketch the shear stress distribution diagram across the depth of a T section.** |
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| **18.** | **Draw the shear stress distribution diagram for an I section.** |
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| **19.** | **Draw the shear stress distribution diagram for a rectangular beam with values at**  **important points**.(**DEC 2014)** |
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| **20.** | **What is B.M.D. (bending moment diagram)?** |
|  | The diagram which shows the variation of bending moment along the length of the beam  is known as B.M.D. |
| **21.** | **What is S.F.D(shear force diagram)?** |
|  | The diagram which shows the variation of shear force along the length of the beam is known as S.F.D. |
| **22.** | **How the Shear force varies with load what is the law applied.** |
|  | Shear force varies with UDL when compared to its constancy between two loads, and for UDL it varies with straight line law. |
| **23.** | **When effect does the bending moment face with respect to a couple being**  **experienced in a beam.** |
|  | When a beam is subjected to a couple, the maximum bending moment does not occur at  the point of zero shear force. |
| **24.** | **How the Shear force varies with load what is the law applied.** |
|  | Shear force varies with UDL when compared to its constancy between two loads, and for  UDL it varies with straight line law. |
| **25.** | **What is meant by transverse loading on beam? (April/May 2021)** |
|  | Transverse loading is a load applied vertically to the plane of the longitudinal axis of a configuration, such as a wind load. It causes the material to bend and rebound from its original position, with inner tensile and compressive straining associated with the change in curvature of the material. |
|  | **PART B-C214.2** |
| **1.** | Draw Shear force diagram and bending moment diagram for the simply supported beam of length 7m carrying UDL of 10KN/m from left end A for length of 3m and another  UDL of 5KN/m from right end B for length of 2m. **(MAY 17)** |

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| **2.** | 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 for the section. **(MAY 17)** |
| **3.** | A cantilever of length 2m carries a uniformly distributed load of 2KN/m length over the whole length and a point load of 3KN at the free end. Draw SF and BM for the beam.  **(NOV 17)** |
| **4.** | A beam is simply supported and carries a UDL of 40KN/m runs over the whole span. The section of beam is rectangular and having depth of 500mm. If the maximum stress in the material of the beam is 120N/mm2 and moment of inertia of the section is 7x108 mm4 Find  the span of the beam. **(NOV 17)** |
| **5.** | A simply supported beam of 16m effective span carries the concentrated loads of 4KN, 5KN, and 3 KN at a distance 3m, 7m, 11m respectively from the left support. Calculate  maximum SF and BM. Draw SF and BM diagrams. **(APR 18)** |
| **6.** | A timber beam of rectangular section is support a load of 50 KN uniformly distributed over span of 4.8 wen beam is simply supported. If the depth of section is to be twice the breath, and the stress in the timber is not to exceed 7 N/mm2 . Find the dimension of the  cross section. **(APR 18)** |
| **7.** | Draw SF & BM diagram for simply supported beam of length 9m and carrying UDL of 10KN/m for a distance of 6m from the left end. Also calculate maximum BM on the  section. **(NOV 18)** |
| **8.** | A simply supported wooden beam of 1.3m span having a cross section of 150mm wide by 250mm deep carries a point load of W at the center. The permissible stress are 7 N/mm2  in bending 1 N/mm2 in shearing. Calculate the safe load W. **(NOV 18)** |
| **9.** | Draw SF and BM for the overhanging beam of length 6m supported at two points which is 4m apart from left end and carrying UDL of 2KN/m for the entire length and a point  load of 2KN at it overhanging free end. **(APR 19)** |

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| **10.** | A timber beam of 100mm wide and 200mm deep is to be reinforced by bolting on two steel flitches each of 150mm by 12.5 mm in section. Calculate the moment of resistance when flitches are attached symmetrically at the top and bottom. Allowable stress in timber is 6 N/mm2 take E of steel 2x105N/mm2 and E for timber is 1x104N/mm2  **(APR 19)** |
| **11.** | A 250 mm x 150 mm rectangular beam is subjected to a maximum Bending Moment of 750 kN.m. Determine (a) maximum stress in the beam (b) if E = 200 GPa, find the radius of curvature for that portion of the beam where Bending Moment is maximum.  (**Nov 2015**) |
| **12.** | A beam of rectangular cross section is Simply Supported over a span of 6m. The beam has a depth of 400 mm and width of 300mm. Find (i) uniformly distributed load, the beam can carry if the bending stress is not to exceed 16 MPa and (ii) the central point  load, which the beam may carry for the same bending stress. **(MAY/JUNE 2013)** |
| **13.** | A circular pipe of external diameter 70 mm and thickness 8mm is used as a Simply Supported Beam over an effective span of 2.5m. Find the maximum concentrated load that can be applied at the center of the span, if the permissible stress in the tube is 150  N/mm2. **(NOV 2013)** |
| **14.** | The shear force acting on a section of a beam is 50kN. The section of the beam is of T shaped of dimensions 100 mm x 100 mm x 20 mm (Flange width 100mm; flange thickness 20 mm; thickness of the web 20 mm; depth of the web 80mm) the moment of inertia about the horizontal neutral axis is 314.221 x 104 mm4. Calculate the shear stress  at the neutral axis and at the junction of the web and the flange. **(MAY 2014)** |
| **15.** | A beam of rectangular cross section is of 250 mm wide and 300mm deep, 4m of its length is simply supported and carries a uniformly distributed load of 10 kN/m for the entire span. Calculate (i) the shear force at 2m from the left support and (ii) shear stress distribution at every 100 mm level from the top surface. Sketch the shear stress distribution. Consider the flange thickness=30 mm and web thickness=40mm.  **(MAY 2015)** |

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| **16.** | A cantilever 1.5 m long is loaded with a UDL of 2 kN/m run over a length of 1.25 m from the free end. It also carries a point load of 3 kN at a distance of 0.25m from the free end. Draw the shear force and bending moment diagrams of the cantilever.  **(April/May 2021)** |
| **17.** | Rectangular beam 100 mm wide and 250 mm deep is subjected to a maximum shear force of 50 kN. Determine   1. Average shear stress 2. Maximum shear stress 3. Shear stress at a distance of 25 mm above the neutral axis. **(April/May 2021)** |
| **18.** | A timber joist of rectangular section 150 mm wide × 300 mm deep is freely supported over a span of 4 m and carries a uniformly distributed load 7.5 kN/m. Calculate the skin  stresses at 0.5 m intervals from the left-hand support. **(Nov/Dec 2020)** |
|  | **PART-C (C214.4)** |
| **1.** | Water main of 500mm internal diameter and 200 mm thick is full. The water main is of cast iron and is supported at two points 10m apart. Find the maximum stress in the metal.  Cast iron and water weight 72000N/m3 and 10000N/m3 respectively **(MAY 17)** |
| **2.** | A beam ABCD 10m long is simply supported at B and C which are 4m apart and overhangs the support B by 3m. The overhanging part AB carries UDL of 1KN/m and part CD carries UDL of 0.5KN/m. Calculate the position and magnitude of the least value  of BM between supports. Draw SF and BM diagram**.(APR 18)** |
| **3.** | A beam of length 12m is simply supported at two supports which are 8m apart, which an overhanging of 2m on each side The beam carries a concentrated load of 100N. Draw SF  and BM diagram**.(NOV 18)** |
| **4.** | An I section Beam 350mm x 150mm has a web thickness of 10mm and a flange thickness of 20mm. if the shear force acting on the section is 40KN, Find the maximum shear stress developed in the I-section Also sketch the shear stress distribution across the section.  **(APR 19)** |

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| **5.** | A cast iron bracket subjected to bending has the cross section I form with unequal flanges. The dimensions are as follow  Width of top flange 200mm Depth of top flange 50mm Width of bottom flange 130mm Depth of bottom flange 50mm Width of web 50mm  Depth of web 200mm  Find the position of neutral axis and moment of inertial of the section about the neutral axis. If the maximum bending moment on the section is 40MN-mm, determine maximum  bending stress. What is the nature of the stress. |

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| **UNIT III TORSION** | |
|  | **PART A-C214.3** |
| **1.** | **Draw shear stress distribution of a circular section due to torque (MAY 17)** |
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| **2.** | **What is meant by spring constant? (MAY 17)** |
|  | The quantity that specifies the stiffness of a spring is called the spring constant. Every spring has its own natural value of spring constant. The letter *k* is used to denote the  quantity. Its SI unit is Newton per meter (N/m). |

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| **3.** | **Write the expression for polar modulus for solid shaft and hollow shaft.(NOV 17)** |
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| **4.** | **What is a spring? Name the two important types of spring. (NOV 17) (April/May**  **2021)** |
|  | A spring is an [elastic](https://en.wikipedia.org/wiki/Elasticity_(physics)) object that stores [mechanical energy](https://en.wikipedia.org/wiki/Mechanical_energy_storage). Springs are typically made of [spring steel](https://en.wikipedia.org/wiki/Spring_steel). There are many spring designs. In everyday use, the term often refers to [coil springs](https://en.wikipedia.org/wiki/Coil_spring).  Tension/extension spring Compression spring  [Coil spring](https://en.wikipedia.org/wiki/Coil_spring) or [helical](https://en.wikipedia.org/wiki/Helix) spring |
| **5.** | **What is polar moment of inertia for solid shaft? (APR 18)** |
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| **6.** | **Differentiate Open coil helical spring from closed coil helical spring. State the type**  **of stress induced in each spring due to axial load. (APR 18)(MAY 15)** |
|  | Closed coil helical springs: (i) The spring wires are coiled very closely, each turn is nearly at right angles to the axis of helix. (ii)Helix angle is less than 10°.  Open coil helical springs: (i) The wires are coiled such that there is a gap between the  two consecutive turns. (ii) Helix angle is large (>10°) |

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| **7.** | **What is called twisting moment? (NOV 18)** |
|  | A special case of a Bending Moment is Twisting moment. A straight beam when loaded sags due to the Bending moment. But if the ends of the beam are held and one end is twisted, clockwise and the other anti-clockwise, then this bending moment is called twisting Moment (or Torsional moment or Torque) |
| **8.** | **Give any two function of spring(NOV 18) (DEC16)** |
|  | To measure forces in spring balance, meters and engine indicators. 2. To store energy. |
| **9.** | **Write down the expression for power transmitted by a**  **shaft (APR 19)** |
|  | Power transmitted P=2πNT/60 |
| **10.** | **Define helical spring(APR 19)** |
|  | A coil spring, also known as a helical spring, is a mechanical device which is typically used to store energy and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an [elastic](https://en.wikipedia.org/wiki/Elasticity_(physics)) material formed into the shape  of a [helix](https://en.wikipedia.org/wiki/Helix) which returns to its natural length when unloaded. |
| **11.** | **What are the assumptions made in the theory of torsion? (MAY 2014)** |
|  | 1. The material of the shaft is uniform throughout. 2. The twist along the shaft is uniform 3. Normal cross sections of the shaft which were plane and circular before twist must remain plane and circular after twist.   The diameter of the cross sections which were straight before twist must remain straight  without any change in the magnitude. |
| **12.** | **Define Torsional rigidity**. **(MAY 2014) (DEC 2016)** |
|  | We know, θ= T ℓ / GJ, The quantity GJ is called torsional rigidity. Product of rigidity  modulus and polar moment of inertia is called torsional rigidity. |
| **13.** | **Define polar modulus. (DEC 2014)** |
|  | Polar modulus is defined as the ratio of polar moment of inertia (J) to the radius of the shaft. It is also called torsional section modulus and is denoted by Zp |

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| **14.** | **Why hollow circular shafts are preferred than solid circular shafts. (DEC 2015)**  **(Nov/Dec 2020)** |
|  | a. The torque transmitted by the hollow shaft is greater than the solid shafts. Hence the solid shafts are stronger. b. The weight of the hollow shaft is less when compared with  the solid shaft of same material, length and torque. So the solid shafts are economical. |
| **15.** | **What is a spring? (DEC 2016) (MAY 18)** |
|  | A spring is an elastic member, which deflects, or distorts under the action of load and regains its original shape after the load is removed. |
| **16.** | **Define Stiffness of spring. (MAY/JUNE2013)(MAY 2015)** |
|  | Stiffness of spring (K) is the force per unit deflection. Its unit is N / mm in SI units. |
| **17.** | **What is solid length?(DEC 2015)** |
|  | The length of a spring under the maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire.Ls = nt x d,Where, nt = total  number of coils. |
| **18.** | **Write the expression for the Strain energy stored in a solid circular shaft. (MAY**  **2012)** |
|  | Strain energy stored in a solid circular shaft = r2 /4C\*Volume |
| **19.** | **What is toughness? (DEC 2014)** |
|  | It is the ability of the material to resist impact load and propagate fracture. |
| **20.** | **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. Lf = solid length + Ymax -0.15 Ymax |
| **21.** | **What is composite shaft?** |
|  | Sometimes a shaft is made up of composite section i.e. one type of shaft is sleeved over other types of shaft. At the time of sleeving, the two shafts are joined together, that the composite shaft behaves like a single shaft.  Composite Shafts have two different materials. |

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| **22.** | **Write the expression for the Strain energy stored in a hollow circular shaft.** |
|  | Strain energy stored in a hollow circular shaft = r2 /4C x Volume x (R2 +r2)/R2 |
| **23.** | **Write an expression for the angle of twist for a hollow circular shaft with external**  **diameter D, internal diameter d, length l and rigidity modulus G. (April/May 2021)** |
|  | Angle of twist, θ=Tl/GJ, Polar moment of Inertia J= π/32 (D4 –d4); D=External dia,  d=internal dia, l= length of the shaft, T = Torque transmitted and G = Rigidity modulus |
| **24.** | **Define stiffness of a helical spring and write an expression for it.** |
|  | Stiffness of a spring is defined as the load required to produce unit deflection.  K=Gd4/64R3n |
| **25.** | **Define Torsion.** |
|  | When equal and opposite torque are applied at ends, the shaft is said to be in torsion. |
| **26.** | **Distinguish the springs in parallel and series. (Nov/Dec 2020)** |
|  | When two or more springs are connected end-to-end or point-to-point in mechanics, they  are said to be in series, and when they are connected side-by-side, they are said to be in parallel; in both cases, they act as a single spring. |
| **27.** | **Write short notes on shaft. (Nov/Dec 2020)** |
|  | Shafts are mechanical components, usually of circular cross-section, used to transmit power/torque through their rotational motion. In operation they are subjected to: torsional shear stresses within the cross-section of the shaft, with a maximum at the outer surface  of the shaft. |
|  | **PART – B – C214.3** |
| **1.** | A hollow shaft having inside diameter 60% of its outside diameter, is to replace a solid  shaft transmitting in the same power at the same speed. Calculate the percentage saving in material, if the material to be is also the same. **(MAY 17) (April/May 2021)** |
| **2.** | Derive an expression for closely coil helical spring subjected to an axial compressive load  of W**.(MAY 17) (April/May 2021)** |

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| **3.** | A hollow shaft is to transmit 300 kW at 80 rpm. If the shear stress is not to exceed 60 N/mm2 and the internal diameter is 0.6 times the external diameter, find the diameters. Assume maximum torque is 1.4 times mean torque. **(NOV 17) (NOV 18) (Nov/Dec**  **2020)** |
| **4.** | A closely coiled helical spring made out of a 10 mm diameter steel bar has 15 complete coils, each of mean diameter of 100 mm. Calculate the shear stress induced in the section of the rod, the deflection and stiffness if it is subjected to an axial pull of 100 N. Modulus  of rigidity is 8.16x104 N/mm2 **(NOV 17)** |
| **5.** | A closely coiled helical spring made out of a 10 mm diameter steel bar has 12 complete coils, each of mean diameter of 100 mm. Calculate the stress induced in the section of the rod, the deflection under the pull and the amount of energy stored in the spring during the extension if it is subjected to an axial pull of 200 N. Modulus of rigidity is 0.84x105  N/mm2 **(DEC 2015)** |
| **6.** | A solid cylindrical shaft is to transmit 300 kW at 100 rpm. If the shear stress is not to exceed 80 N/mm2, find the diameters. What percentage saving in weight would be obtained if the shaft is replace by hollow if the internal diameter is 0.6 times the external  diameter, the length, material and maximum shear stress being the same. **(APR 18)** |
| **7.** | The close coiled helical spring is to have a stiffness of 1.5N/mm in compression under a maximum load of 60N. The maximum shear stress in the wire of the spring is 125 N/mm2. The solid length of the spring (when the coils are touching) is 50 mm. Find the diameter of coil, diameter of wire and number of coils. G = 45 kN/mm2. **(APR 18)(MAY**  **15)(NOV 18)** |
| **8.** | Two shafts of same materials and same length are subjected to the same torque, if the shaft is of solid circular section and the second shaft is of hollow section whose internal diameter is 2/3 times of the outside diameter and maximum shear stress developed in  each shaft is the same. Compare the weights of thee shafts. **(APR 19)** |
| **9.** | A closely coil helical spring of mean diameter 20cm is made of 3cm diameter rod and has 16 turns. A weight of 3KN 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  18cm take modulus of rigidity 8 x 104 N/mm2 **(APR 19) (Nov/Dec 2020)** |

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| **10.** | A hollow shaft with diameter ratio 3/8 is required to transmit 500kW at 100 rpm, the maximum torque being 20% greater than the mean. The maximum shear stress is not to exceed 60 N/mm2 and the twist in a length of 3m is not to exceed 1.4°. Determine the  minimum diameters required for the shaft. **(DEC 2015, 2016)** |
| **11.** | A shaft 7m long is securely fixed at each end. A torque of100 kN.mm is applied to the shaft at a section 3m from the left end. Find the fixing torque setup at the ends of the shaft. If the shaft is 35mm diameter find the maximum shear stresses in the two portions. Find also the angle of twist for the section where the torque is applied. Assume G = 8.4 x  104 N/mm2. **(MAY/JUNE 2013)** |
| **12.** | A close coiled helical spring is to carry a load of 1kN. Its mean coil diameter is to be times that of wire diameter. Calculate these diameters if the maximum stress in the material of the spring is to be 90N/mm2. Also find the stiffness of spring. Take G =  8.5 x 104 N/mm2. **(Nov 2014)** |
| **13.** | A composite spring has two close coiled helical springs in series. The mean coil diameter of each spring is 8 times the wire diameter. One coil has 20 coils of wire diameter 2.54 mm. Find the diameter of the wire of the other spring, if it has 15 coils and the stiffness of the composite spring is 1.26 N/mm. Find the maximum axial load that can be applied and the corresponding extension if the maximum shear stress is 310 N/mm2. Take G =  80GPa. **(MAY/JUNE 2013) (Nov/Dec 2020)** |
| **14.** | In a compound helical spring the inner spring is arranged inside and concentric with the outer one, but is 9 mm shorter. The outer coil is of mean diameter 24 mm, wire diameter 3 mm and has 10 turns. Find the stiffness of the inner spring if an axial load of 150 N  causes the outer one to compress 18 mm. **(MAY 2015)** |
| **15.** | A laminated spring carries a central load of 5200 N and it is made of „n‟ number of plates, 80mm wide, 7 mm thick and length 500mm. Find the number of plates, if the  maximum deflection is 10mm. Let E=2.0x105 N/mm2 **(Dec 2016)** |
| **16.** | 2250 kW has to be transmitted at 1 Hz. If the permissible shear stress is 80 N/mm2. Determine the necessary diameter for a solid of circular section. If a hollow circular section is used with its internal diameter = 0.75 times  external diameter. **(Nov/Dec 2020)** |

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|  | **PART - C (C214.5)** |
| **1.** | A hollow shaft with diameter ratio 3/5 is required to transmit 450kW at 120rpm. The shearing stress in the shaft must not exceed 60N/mm2 and the twist in a length of 2.5m is  not to exceed 1°. Calculate the maximum external diameter of the shaft. C= 80 kN/mm2. |
| **2.** | A leaf spring of semi elliptical type has 10 plates, each 60mm wide and 5 mm thick. The longest plate is 700 mm long. Find the greatest central load on the spring so that the bending stress shall not exceed 150 N/mm2 and the central deflection shall not exceed 10  mm. take E=2×105 N/mm2. |
| **3.** | A closely coiled helical spring of round steel wire 10 mm in diameter having 10 complete turns with a mean diameter of 12 cm is subjected to an axial load of 250 N. Determine   1. The deflection of the spring 2. Maximum Shear Stress in the wire 3. Stiffness of the spring 4. Frequency of vibration. Take C = 0.8 x 105 N/mm2 |

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| **UNIT-IV DEFLECTION OF BEAMS** | | | | |
|  | **PART – A (C214.4)** | | | |
| **1.** | **Write down the equation for the maximum deflection of a cantilever**  **beam carrying a central point load „W‟ (APR 17).** | | | |
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| **2.** | **Draw conjugate beam for a double side over hanging beam.(APR 17)** | | | |
|  |  | BOTH SIDE OVER HANGING BEAM | CONJUGATE BEAM |  |
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| **3.** | **How will you use conjugate beam method for finding slope and deflection at any**  **section of given beam? (NOV 17) (Nov/Dec 2020)** |
|  | Conjugate beam is defined as the imaginary beam with the same dimensions (length) as that of the original beam but load at any point on the conjugate beam is equal to the bending moment at that point divided by EI. The conjugate-beam method is an engineering method to derive the slope and displacement of a beam. The conjugate-  beam method was developed by H. Müller-Breslau in 1865. |
| **4.** | **State Maxwell‟s reciprocal theorem.(NOV 17) (NOV 18) (APR 19)** |
|  | Clerk-Maxwell's reciprocal theorem state that in a linearly elastic structure, the deflection at  any point. A due to a load applied at some other point B will be equal to the deflection at B when the same load is applied at A. |
| **5.** | **A cantilever beam 3 m long carries point load of 20KN at a distance of 2m from the free end. Determine the slope at the free end of the beam, take EI=8\*1012 N-mm2.** |
|  | Hint: iB=Wl2/2EI=**0.005 rad** |
| **6.** | **State the two theorems of conjugate beam method. (APR 18)** |
|  | The conjugate beam must be supported by a pin or a roller, since this support has zero  moment but has a shear or end reaction. When the real beam is fixed supported, both the slope and displacement are zero. |
| **7.** | **A cantilever beam is subjected to a point load of W at the free end. What is the slope**  **and deflection at the free end? (NOV 18)** |
|  | Slope =Wl2 /2EI;  Deflection y=Wl2/3EI |
| **8.** | **A beam 3m long, simply supported at its ends, is carrying a point load of W at the center. If the slope at the beam should not exceed 1 degree, find the deflection at the**  **center of the beam.** |
|  | Solution:  Deflection at the center y=WL3/48EI = 1.35mm  y – Deflection (mm) |

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| **9.** | **Write down the general Differential equation of a beam**. |
|  | EI [d2y / dx2] = Mx Where , Mx = BM at section at x–x,  EI = Flexural Rigidity. |
| **10.** | **State the theorems of Moment Area Method stated by Mohr.** |
|  | THEOREM I: The change in slope between any two points (Say P and Q ) in a beam is equal to the area of the BMD, under that particular portion of the beam divided by EI. θp- θq=(Area of BMD between P&Q)/E.  THEOREM II: The deflection between any two points in a beam is equal Moment of the area of the bending moment Diagram, under that particular portion of the beam divided  by EI. |
| **11.** | **Define Slope**. **(Nov 2014)** |
|  | Slope at any point is the angle between the tangent (drawn to the elastic curve at that point) and the horizontal. |
| **12.** | **Define Deflection. (Dec 2015)** |
|  | When the beam is loaded with transverse loads the axis of the beam will deviate from the  actual position. The deviation at any cross section is called Deflection. |
| **13.** | **What condition is used for finding maximum deflection? (Nov 2014)** |
|  | The condition used for finding deflection of the beam is dy/dx = 0 (ie.,slope at the point of maximum deflection is equal to zero) |
| **14.** | **What is the advantage of Macaulay‟s method? (MAY 2015) (April/May 2021) (Nov/Dec 2020)** |
|  | In Macaulay‟s method a continuous expression is formed for bending moment and it is integrated in such a way that the constants of integration are valid for all sections of the beam even though law of bending moment varies from section to section. |
| **15.** | **What is the use of moment area method? (DEC 2015)** |
|  | Moment area method is very much useful to find the deflection and a slope of a beam at any particular point on the beam. This method can be applied to all types of beams of variable section. In this method, the area of the bending moment diagrams is utilized for computing the slope and or deflections at particular points along the axis of the beam or  frame. |

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| **16.** | **What is Mohr‟s theorem 1?** |
|  | The change of the slope between any two points, on an elastic curve is equal to the net  area of B.M. diagram between these points divided by EI. |
| **17.** | **What are all the methods to find out the slope and deflection?(DEC 2016)**  **(April/May 2021)** |
|  | Double integration method, Moment area Method, Macaulay‟s Method. |
| **18.** | **Write the significance of conjugate beam.** |
|  | * This method can be directly used for SSB. * Artificial constraints need to be applied to the conjugate beam. |
| **19.** | **What are the advantages of fixed beam?** |
|  | For the same loading, the maximum deflection of a fixed beam is less than that of a simply supported beam. For the same loading, the fixed beam is subjected to a less  maximum bending moment. |
| **20.** | **What is “Elastic curve”** |
|  | When the load is applied within the elastic limit, the deflected shape of the beam is called  Elastic Curve. |
| **21.** | **Calculate area of BDM of a cantilever carrying UDL of w/m for full span L** |
|  | Area = 1/3 \* base \* depth; Area = 1/3 \* AC \* AB; Area= 1/3 \* ½ wL2\*L; Area=wL3/6 |
| **22.** | **What is the disadvantage of double integration method?** |
|  | In double integration method if there are more loads at different sections then more functions will be needed to represent the bending moment and hence additional constants and a corresponding number of equations will be required in rather lengthy calculations. |
| **23.** | **A cantilever beam 120 mm wide and 150 mm deep is 1.8 m long. Determine the**  **deflection at the free end of the beam, when it carries a point load of 20 KN at its free end. Take E for the beam as 200 GPa.** |
|  | Hint: YB=Wl3/3EI=**5.76 mm** |

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| **24.** | **A cantilever beam 120 mm wide and 150 mm deep is 1.8 m long. Determine the slope at the free end of the beam, when it carries a point load of 20 KN at its free end. Take E for the beam as 200 GPa.** |
|  | Hint: I=bd3/12= 33.75\*106, iB=Wl2/2EI=**0.0048 rad** |
|  | **PART-B (C214.4)** |
| **1.** | A simply supported beam of length 8m carries a UDL of 40kN/m for a length of 4m which is placed 1m from left end and 3m from right end. Determine deflection at its mid- point and maximum deflection. Use Macaulay‟s method. E=2 x105 N/mm2 , I= 4.3 x 108  mm4 . **(MAY 17) (Nov/Dec 2020)** |
| **2.** | Determine the slope at the two supports and deflection under the loads. Use conjugate beam method E=GN/m2 I for right half is 2 x 108 mm4 I for left half is 1 x 108 mm4  **(MAY 17)** |
| **3.** | A cantilever length 3m is carrying a point load of 50KN at a distance of 2m from the fixed end. If I=108 mm4 and E=2 x 105 N/mm2 fine slope and deflection at free end. **(NOV**  **17)** |
| **4.** | A simply supported beam of length 5m carries a pint load of 5kN at a distance of 3m  from the left end. If I=108 mm4 and E=2 x 105 N/mm2 Determine the slope at the left support and deflection under the point load using conjugate beam method. **(NOV 17)** |
| **5.** | A cantilever 2m long is of rectangular cross section 120mmwide and 240mm deep. It carries a UDL of 2.5kN/m for a length of 1.25m from the fixed end and a point load of 1  kN at free end. Find the deflection at the free end. Take E=10GN/m2 **(APR 18)** |
| **6.** | A beam AB of 8m span is simply supported at the ends. It carries a point load of 10kN at a distance of 1m from the end A and a UDL of 5kN/m for a length of 2m from the end B. If I=10 x 106 m4 determine deflection at mid span, maximum deflection, slope at end A.  **(APR 18)** |
| **7.** | A beam of length 5m and of uniform rectangular section is supported at its ends and carries UDL over entire length. Calculate the depth of the section if the maximum permissible bending stress is 8N/mm2 and the central deflection is not to exceed 10mm.  **(NOV 18)** |

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| **8.** | Derive the equation for slope and deflection of simply supported beam of length L  carrying point load W at the center by Mohr‟s theorem. **(NOV 18)** |
| **9.** | A beam of length 5m and of uniform rectangular section is supported at its ends and carries UDL of 9 kN/m over entire length. Calculate the depth of the section if the maximum permissible bending stress is 7N/mm2 and the central deflection is not to  exceed 10mm. E for beam material = 1 x 104 N/mm2 **(APR 19)** |
| **10.** | A beam of 5m span is simply supported at the ends. It carries a point load of 5kN at a distance of 3m from the left end. If I=108 mm4 , E=2 x 105 N/mm2determine deflection at  the left support and deflection under point load using conjugate beam **(APR 19)** |
| **11.** | A simply supported beam of span 6 m is acted upon by a point load of 60 kN at 4 m from one support. Taking I = 8000 cm4 and E = 2 X 105 N/mm2 and using area moment method, calculate deflection at the point of loading and the slope at both the supports.  Also, calculate the maximum deflection. **(May 2015)(DEC 2016)** |
| **12.** | A simply supported beam 5m long carries point loads of 10kN each at points 1m from the ends. Using Moment area method or otherwise, Find (a) the maximum slope and deflection (b) the slope and deflection of the beam under each load. Take EI = 1.2 x 104  kNm2. **(NOV 2015)** |
| **13.** | A simply supported beam of length „l‟ carries two point loads „W‟ each at a distance „a‟ from the ends. Using Moment area method or otherwise, calculate (a) the maximum  deflection (b) the deflection of the beam under each load. **(DEC 2016)** |
| **14.** | A 3 m long cantilever of uniform rectangular cross–section 150 mm wide and 300 mm deep is loaded with a point load of 3 kN at the free end and a udl of 2 kN/m over the entire length. Find the maximum deflection. E = 210 kN/mm2. Use Macaulay‟s method.  **(DEC 2015)** |
| **15.** | A simply supported beam of length 4 m carries two point loads 3 kN each at a distance of 1 m from each end. E = 2 x 105 N/mm2. I = 108 mm4. Using conjugate beam method  determine slope at each end and deflection under each load. **(DEC 2015)** |

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| **16.** | A simply supported beam of span „l‟ is carrying concentrated „W‟ at the centre and a  UDL of intensity of „w‟ per unit length. Show that Maxwell‟s reciprocal theorem holds good at the centre of the beam. **(April/May 2021)** |
| **17.** | A cantilever of length 3 m carries a uniformly distributed load of 80 kN/m length over the entire length. If, E = 2 × 108 kN/m2 and I = 108mm4, find the slope and deflection at the  free end using conjugate beam method. **(Nov/Dec 2020)** |
| **18.** | Find the deflection of a simply supported beam of length 4.85 m and carrying a uniformly distributed load of 18 kN/m, by moment area method. Let EI = 9750 kN.m2.  **(Nov/Dec 2020)** |
|  | **PART-C (C214.4)** |
| **1.** | A cantilever of length 3m carries a uniformly distributed load of 80KN/m over the entire length. If Es= 2 x 108 kN/mm2 and I =108 KN/mm2 find slope and deflection at free end  using conjugate beam method**.(NOV 18)** |
| **2.** | Derive and expression for slope and deflection for a simply supported beam subjected to  uniformly distributed load. **(APR 19)** |
| **3.** | Derive a relation between slope, deflection and radius of curvature. |
| **4.** | Using Macaulay‟s method derive slope and deflection expression for simply supported  beam loaded with UDL. |
| **5.** | A simply supported beam of length 4 m carries a point load of 3 kN at a distance of 1 m from each end. If E = 2 × 105 N/mm2 and I = 108 mm4 for the beam, then using conjugate beam method determine :   1. Slope at each end and under each load. 2. Deflection under each load and at the centre. **(April/May 2021)** |

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| **UNIT V- THIN CYLINDERS, SPHERES AND THICK CYLINDERS** | |
|  | **PART-A (C214.5)** |
| **1.** | **How does a thin cylinder fail due to internal pressure?(MAY 17)** |
|  | As a result of circumferential stress a cylinder has a tendency to split up along its diameter. Because of hoop stress, the failure is a longitudinal failure.  Explanation: Longitudinal stress is developed along the walls of the cylinder in the  shell due to internal fluid pressure on the ends. |
| **2.** | **State Lame‟s equations (MAY 17)(MAY 18)(MAY 19) (April/May 2021)** |
|  | The Lame‟s equation are : px=B/x2-A and fx=B/x2+A ; A and B Lame‟s Constants. |
| **3.** | **Define thin cylinders(NOV 17)** |
|  | A cylinder is called as a thin cylinder when the ration of wall thickness to the diameter of the cylinder is less than 1/20. |
| **4.** | **List assumption made in Lame‟s theory (NOV 17)(NOV 18)(MAY 15) (April/May 2021)** |
|  | The material of the shell is homogeneous and isotropic. Plane sections of the cylinder, perpendicular to the longitudinal axis, remain plane under pressure. |
| **5.** | **Write expression for circumferential stress and longitudinal stress when a thin**  **cylinder is subjected to internal fluid pressure of P (MAY 18)** |
|  | Hoop stress=ϭc=pd/2t; Longitudinal stress, ϭl=pd/4t Where, p- internal pressure, d- diameter of the cylinder, t – thickness |
| **6.** | **Distinguish between thick cylinder and thin cylinder.(NOV 18)(MAY 19)(MAY 15)** |
|  | A cylindrical shell whose t\d ratio (thickness/dia.) is lesser than 1/10, then it is called thin cylinder shell & if it is greater than 1/10, then it is called thick cylinder shell. |
| **7.** | **What is hoop stress & longitudinal stress? (MAY 2010)** |
|  | The int. pressure acting on the long sides of a thin cylinder is called as hoop stress. Since the direction of the stress is along the circumference of the shell, it is also called as circumferential stress. Whereas longitudinal Stress is the pressure acting at the ends  transmitted to the walls of the cylinder. |

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| **8.** | **What is the effect of riveting a thin cylindrical shell? (NOV 2012)** |
|  | Riveting reduces the area offering the resistance. Due to this, the circumferential and longitudinal stresses are more. It reduces the pressure carrying capacity of the shell. |
| **9.** | **State Maxwell‟s reciprocal theorem.**  **(DEC 2015) (DEC 2016)** |
|  | It states that the work done by the first system of loads due to displacements caused by a  second system of loads equals the work done by the second system of loads due to displacements caused by the first system of loads. |
| **10.** | **What is Wahl‟s factor?** |
|  | Wahl‟s factor is factor which compensates for the direct shear stress and curvature of wire in to consideration for calculating the shear stress in a spring. Maximum shear stress  τ=K x 8wD/ᴨ d3 |
| **11.** | **Name the stresses induced in a thin walled cylinder subjected to int. fluid pressure?**  **(DEC 2016)** |
|  | a.) Circumferential stress or hoop stress b.) Longitudinal stress. |
| **12.** | **A gas cylinder of internal diameter 40 mm is 5 mm thick. If the tensile stress in the material is not to exceed 30 MPa, find the maximum pressure (p) which can be**  **allowed in the cylinder.** |
|  | Solution: Circumferential stress = pd/ 2t; p=7.5 N/mm2. |
| **13.** | **Distinguish between cylindrical shell and spherical shell.** |
|  | Cylindrical shell: a. Circumferential stress is twice the longitudinal stress. b. It withstands low pressure than spherical shell for the same diameter. Spherical shell a. Only hoop stress presents. b. It withstands more pressure than cylindrical shell for the same  diameter. |
| **14.** | **What is a 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 steel wire under tensions. |

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| **15.** | **Write the expression for circumferential stress induced in the boiler plated.** |
|  | Circumferential stress c = pd/2t |
| **16.** | **Write the expression for change in volume? (Nov 2014)** |
|  | Change in volume δv= ᴨ d4P/8tE x (1-μ); P-Load, μ-Poisson‟s ratio, t-thickness and E-  Young‟s Modulus |
| **17.** | **What are all failure modes of a thin cylindrical shell due to an internal pressure?**  **(Dec 2015) (April/May 2021)** |
|  | Split up into two troughs, split up into two cylinders.  Thin cylinder failure due to internal fluid pressure by the formation of circumferential stress and longitudinal stress |
| **18.** | **A stream boiler of 800 mm diameter is made up of 10 mm thick plates. If the boiler is subjected to an internal pressure of 2.5 MPa, find the circumferential and**  **longitudinal stresses induced in the boiler. (May 2014)** |
|  | Solution: circumferential stress= pd/2t= 100 N/mm2, longitudinal stress=pd/4t=50 N/mm2 |
| **19.** | **Write down the expression for determining the thickness of the thin cylindrical**  **shell.** |
|  | The thickness of the thin cylindrical shell (t)= pd/2c |
| **20.** | **A spherical gas vessel of 1.2 m diameter is subjected to a pressure of 1.8MPa.**  **Determine the stress induced in the vessel plate, if its thickness is 5 mm.** |
|  | Solution: stress in the shell material () = pd/4t= 108 MPa p - Pressure  d - Diameter  t – Thickness Unit - MPa |
| **21.** | **When will you call a cylinder as thin cylinder?** |
|  | The cylinder which has a thickness is less than 1/10 to 1/20 of its Diameter, that cylinder  is called a thin cylinder. The cylinder which has Thickness is more than 1/20 of its diameter, that Cylinder is called a thick Cylinder. |

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| **22.** | **What is the effect of riveting a thin cylinder shell?** |
|  | Riveting reduce the area offering the resistance. Due to this the circumferential and longitudinal stress are more. It reduce the pressure carrying of the smell.  In thin spherical shell, volumetric strain is three times the circumferential strain. |
| **23.** | **In a thin cylinder will the radial stress vary over the thickness of wall?** |
|  | No, In thin cylinders radial stress developed in its wall is assumed to be constant since  the wall thickness is very small as compared to the diameter of cylinder. |
| **24.** | **For thin cylinder, write down the expression for the volumetric strain.** |
|  | Volumetric strain = ev = (p\*d/2tE) ((5/2)-(2/m)) |
| **25.** | **Write short notes on spherical shell and its advantages. (Nov/Dec 2020)** |
|  | In geometry, a spherical shell is a generalization of an annulus to three dimensions. It is the region of a ball between two concentric spheres of differing radii. An advantage of spherical storage vessels is, that they have a smaller surface area per unit volume than any other shape of vessel. This means, that the quantity of heat transferred from warmer surroundings to the liquid in the sphere, will be less than that for cylindrical or  rectangular storage vessels. |
| **28.** | **List out the assumptions used in the Shells. (Nov/Dec 2020)** |
|  | Shell theories are based on the assumption that the strains in the shell are small enough to be discarded in comparison with unity. It is also assumed that the shell is thin enough that  quantities, such as the thickness/radius ratio may be discarded in comparison with unity. |
|  | **PART - B (C214.5)** |
| **1.** | Derive relation for change in volume of a thin cylinder subjected to internal fluid  pressure. **(MAY 17)** |
| **2.** | Determine the maximum and minimum hoops stress across the section of pipe of 400mm internal diameter and 100mm thick, when the pipe contains the fluid at a pressure of 8N/mm2 also check the radial pressure distribution and hoop‟s stress distribution across  the section. **(MAY 17)(NOV 17)** |

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| **3.** | Calculate (i) Change in diameter (ii)Change in length and (iii) Change in volume of thin cylindrical shell of 100cm diameter 1cm thick and 5m long when subjected to internal pressure of 3N/mm2. Take value E=2\*105 N/mm2 and poison ratio=0.3 **(NOV 17) (DEC**  **15)** |
| **4.** | A cylindrical shell 3m long which is closed at the ends has an internal diameter of 1.5m and a wall thick of 20mm. Calculate the circumferential and longitudinal stresses induced and also the changes in the dimensions of the shell, if it is subjected to an internal  pressure of 1.5 N/mm2. Take E = 2 x 105 N/mm2 and µ = 0.3. **(MAY 18)** |
| **5.** | A compound cylinder formed by shrinking one tube to another is subjected to an internal pressure of 90MN/m2. Before the fluid is admitted, the internal and external diameter of the compound cylinder are 180mm and 300mm respectively and the diameter at the junction is 240mm. If after shrinking on the radial pressure at the common surface is  12MN/m2, determine the final stresses developed in the compound cylinder. **(APR 18)** |
| **6.** | A thin cylindrical shell 1200 mm long, 200 mm in external diameter, thickness of metal 8 mm is filled with a fluid at atmospheric pressure. If an additional 25 cm3 of the fluid is pumped in to the cylinder, find the pressure exerted by the fluid on the wall. Take E = 2.1 x 105 N/mm2 and Poisson‟s ratio = 0.33. Find also the hoop stress induced. **(NOV 2014)**  **(NOV 18)** |
| **7.** | A boiler shell is to be made of 15mm thick plate having a limiting tensile stress of 120N/mm2. If the effectiveness of the longitudinal and circumferential joints are 70% and 30% respectively. Determine the maximum permissible diameter of the shell for the  internal pressure of 2N/mm2 **(NOV 18)** |
| **8.** | Calculate (i) Change in diameter (ii)Change in length and (iii) Change in volume of thin  cylindrical shell of 80cm diameter 1cm thick and 3m long when subjected to internal pressure of 2.5N/mm2. Take value E=2\*105 N/mm2 and poison ratio=0.25 **(APR 19)** |
| **9.** | Calculate (i) increase in diameter (ii) increase in volume of spherical shell of 0.9m internal diameter 1cm thick and 3m long when subjected to internal pressure of  1.4N/mm2. Take value E=2\*105 N/mm2 and poison ratio=1/3 **(APR 19)** |

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| **10.** | From the first principles, derive an expression for the change in volume of a thin closed  pressure vessel with cylindrical body of length L and radius R with flat bottom and hemispherical top, subjected to internal fluid pressure „p‟. **(May 2014)** |
| **11.** | A cylindrical shell 3 m long, 1 m internal diameter and 10 mm thick is subjected to an internal pressure of 1.5 N/mm2. Calculate the changes in length, diameter and volume of  the cylinder. E = 200 kN/mm2, Poisson‟s ratio = 0.3. **(MAY 2015)** |
| **12.** | A thin cylindrical shell 1.5m long, internal diameter 300mm and wall thickness 10mm is filled up with a fluid at atmospheric pressure. If the additional fluid of 300 x 103 mm3 is pumped into the shell, find the pressure exerted by the fluid on the shell. Take E = 2 x 105  N/mm2 and 1/m = 0.3. Also find the hoop stress induced. **(NOV 2013)** |
| **13.** | Find the thickness of metal necessary for a thick cylindrical shell of internal diameter 160mm to withstand an internal pressure of 8 N/mm2.The maximum hoop stressin the  sectionis not to exceed 35N/mm2 **(NOV 2014)** |
| **14.** | A cylindrical shell 1m in internal diameter and 15mm wall thickness is 3m long. Calculate the maximum intensity of shear stress induced and also the changes in the dimensions of the shell, if it is subjected to an internal pressure of 1.5 N/mm2. Take E =  2.04 x 105 N/mm2 and 1/m = 0.3. **(DEC 2015)** |
| **15.** | A cylindrical shell of 80 mm internal diameter and 1.2 mm thick is closed at the ends and subjected to internal fluid pressure so that the maximum direct stress in the tube is 120 N/mm2. Determine the percentage increase in the capacity of the tube. Consider E = 2 ×  105 N/mm2 and 1/m = 0.3. **(Nov/Dec 2020)** |
| **16.** | Calculate the thickness of metal required for a C.I. water main 800 mm diameter, for  water under a static head of 100 m, if the permissible tensile stress is 20 N/mm2. Consider unit weight of water w = 10 kN/m3. **(Nov/Dec 2020)** |
| **17.** | A thick cylinder whose external diameter is k times its internal diameter is subjected to an internal pressure. If the ratio of the maximum to minimum hoop stress is η, find the relation between η and k. If the maximum hoop stress 45 N/mm2 and the value of η is 2.5, find the internal radial pressure exerted and the necessary thickness of metal if the  diameter of the bore is 150 mm. **(Nov/Dec 2020)** |

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| **18.** | A cylindrical Shell 3 m long which is closed as the ends an internal diameter of one metre and a wall thickness of 15 mm. Calculate the circumferential and longitudinal stresses induced and also changes in the dimensions of the shell, if it is subjected to an internal  pressure of 1.5 N/mm2 and m = 0.3. **(April/May 2021)** |
| **18.** | Find the thickness of metal necessary for a cylindrical shell of internal diameter 160 mm to withstand an internal pressure of 8 N/mm2. The maximum hoop stress in the section is  not to exceed 35 N/mm2. **(April/May 2021)** |
|  | **PART - C (C214.5)** |
| **1.** | A water main 80cm dia contains water at a pressure head of 100mm. if the weight density of water is 9810N/m3 find the thickness of metal required for the water main. Given the  permissible stress as 20N/mm2 |
| **2.** | Derive Lame‟s equation. |
| **3.** | A compound tube is composed of a tube 25 cm internal diameter and 2.5 cm thick shrunk on a tube of 25 cm external diameter and 2.5 cm thick. The radial pressure at the junction is 80 kg/cm2 . The compound tube is subjected to an internal fluid pressure of 845  kg/cm2. The variation of the hoop stress over the wall of the compound tube. |