**SUMMER – 2022 EXAMINATION**

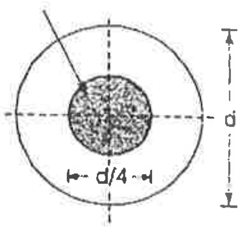
**Subject Name: Strength of Materials** **Model Answer** **Subject Code: 22306**

**Important Instructions to examiners:**

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

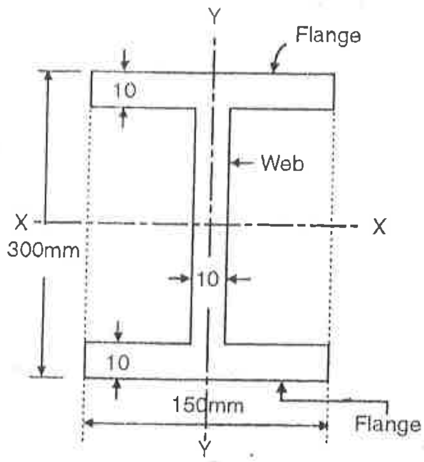
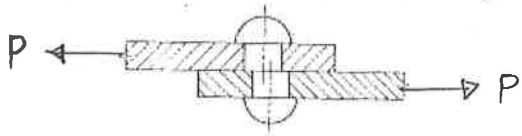
| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 1 | | **Attempt any <u>Five</u> of the following:** | **10** |
| | a | ***Define : Polar Moment of Inertia, Radius of gyration.*** | |
| | | <u>Polar Moment of Inertia</u>: | |
| | | If $I_{XX}$ and $I_{YY}$ are the moment of inertia of a plane section about the two mutually perpendicular axes, then the moment of inertia $I_{ZZ}$ about the third axis ZZ perpendicular to the plane and passing through the intersection of X-X and Y-Y is called as polar moment of inertia. | 01 |
| | | <u>Radius of gyration :</u> | |
| | | Radius of gyration is defined as the distance from the given axis at which the entire area of the given figure is supposed to be concentrated without changing the moment of inertia about the same axis. | 01 |
| | b | ***Define: Temperature stress and give one field example where temp. stress produced.*** | |
| | | <u>Temperature stress:</u> When deformation caused due to temperature change is wholly or partly prevented, some stresses are produced in the body. Such stresses are called temperature stresses. | 01 |

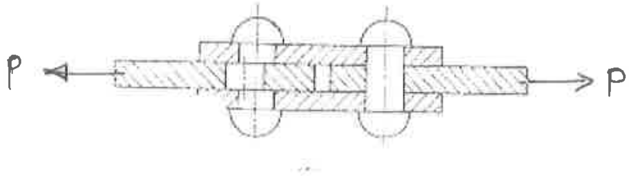
| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | | Field Example: | |
| | | When gap is not provided at the joint between the rails, temperature stresses are produced in rails when they are subjected to rise in temperature. | 01 |
| | | ( 01 mark shall be given for other appropriate example) | |
| | c | ***Define : Creep , Toughness*** | |
| | | Creep : | |
| | | The slow and progressive deformation of a material with time under sustained load is called as creep. | 01 |
| | | Toughness: | |
| | | The capacity of the material to absorb the impact energy before actual fracture or failure takes place is called as toughness. | 01 |
| | d | ***State relation between shear force and bending moment*** | |
| | | $$\frac{dM}{dx} = F$$ | |
| | | The rate of change of bending moment at any section is equal to the shear force at that section | 02 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | e | ***State flexural formula with meaning of each term used.*** | |
| | | **Bending equation or Flexural formula.** | |
| | | $$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$ | 01 |
| | | *Where.* | |
| | | $M$ = Maximum bending moment $(N.mm)$ | |
| | | $I$ = Moment of inertia about N.A. $(mm^4)$ | |
| | | $\sigma$ = Maximum bending stress $(N/mm^2)$ | |
| | | $y$ = Distance of extreme fiber from N.A. $(mm)$ | 01 |
| | | $E$ = Modulus of elasticity $(N/mm^2)$ | |
| | | $R$ = Radius of curvature $(mm)$ | |
| | f | ***Define: Axial load and Eccentric load*** | |
| | | **Axial Load:** When line of action of load coincides with the axis of the member, it is called as axial load. | 01 |
| | | **Eccentric Load:** When line of action of load does not coincide with the axis of the member, but acts away from the axis of the member, it is called as an eccentric load. | 01 |
| | g | ***Define core of section and show it for solid circular section of dia. 'd'*** | |
| | | **Core of section:** A centrally located portion of the cross section of the member, within which if load line acts, there will be either compressive or tensile stresses across the entire cross section of the member, is called as core of the section. | 01 |
| | | Core of the section for solid circular section | |
| | |   | 01 |

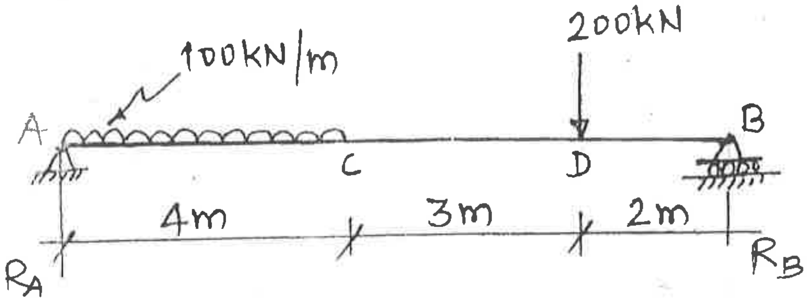
**SUMMER – 2022 EXAMINATION**

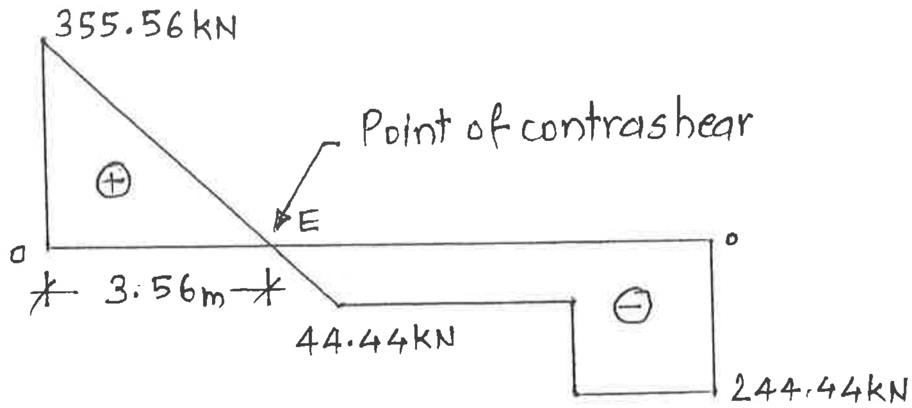
**Subject Name: Strength of Materials** | **Model Answer** | **Subject Code: 22306**

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 2 | | **Attempt any THREE of the following:** | (12) |
| | a) | A symmetrical I-section of overall depth of 300 mm has its flanges 150 mm × 10 mm and web 10 mm thick. Calculate moment of inertia @ XX and YY centroidal axes. | |
| | |  | |
| | | $I_{xx} = \frac{BD^3 - bd^3}{12}$ <br> $= \frac{150 \times 300^3 - 140 \times 280^3}{12}$ <br> $I_{xx} = 81.393 \times 10^6\ mm^4$ | 02 |
| | | $I_{yy} = 2 \times I_{yy}$ due to flange + $I_{yy}$ due to web <br> $= 2 \times \left(\frac{10 \times 150^3}{12}\right) + \frac{280 \times 10^3}{12}$ <br> $= 5.625 \times 10^6 + 0.023 \times 10^6$ <br> $I_{yy} = 5.648 \times 10^6\ mm^4$ | 02 |
| | b) | With neat sketches show the failure of rivet in single shear and double shear. Also write the formulae to calculate shear stress for each case. Assume diameter of rivet = d. | |
| | |  <br> Single shear Failure <br> Shear stress ($\tau$) <br> $\tau = \frac{P}{\left(\frac{\pi}{4} \times d^2\right)}$ | 01+01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | | <br>Double shear failure<br>Shear stress ($\tau$)<br>$\tau = \dfrac{P}{2\times(\frac{\pi}{4}d^2)}$ | 01+01 |
| 2 | c) | A steel tube of external diameter 20 mm and internal diameter 15 mm was subjected to a tensile load of 1.5 kN. It produced an elongation of 0.004 mm in a length of 80 mm while the outer diameter suffered a compression of 0.00028 mm. Calculate the value of Poissons ratio, Modulus of Elasticity and Modulus of rigidity. | |
| | | Given:- For steel tube, $D = 20 mm$, $d = 15 mm$, $P = 1.5\times10^3 N$<br>$L = 80 mm$, $\delta L = 0.004 mm$, $\delta d = 0.00028 mm$.<br>To find :- $\mu$, E and G<br>Solution :- $A = \frac{\pi}{4}[D^2-d^2] = \frac{\pi}{4}[20^2-15^2] = 137.45 mm^2$<br>$Stress = \sigma = \frac{P}{A} = \frac{1.5\times10^3}{137.45} = 10.91 N/mm^2$ | |
| | | Linear strain $= e = \frac{\delta L}{L} = \frac{0.004}{80} = 5\times10^{-5}$ | 01 |
| | | Lateral strain $= e_{Lat} = \frac{\delta d}{d} = \frac{0.00028}{20} = 1.4\times10^{-5}$<br>Poisson's Ratio $= \mu = \frac{e_{Lat}}{e} = \frac{1.4\times10^{-5}}{5\times10^{-5}} = 0.28$ | 01 |
| | | Modulus of Elasticity $= E = \frac{\sigma}{e} = 10.91/5\times10^{-5}$<br>$\therefore E = 2.18\times10^5 N/mm^2$ | 01 |
| | | $E = 2G(1+\mu)$ $\therefore G = \frac{E}{2(1+\mu)} = \frac{2.18\times10^5}{2(1+0.28)} = 0.85\times10^5 \frac{N}{mm^2}$ | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 2 | d) | A simply supported beam is loaded as shown in Fig. No. 1. Draw shear force diagram and locate the position from support 'A' where B.M. is maximum. Also calculate value of Maximum B.M. | |




Shear Force Diagram 01

To find Reactions :- Applying conditions of equilibrium

$\Sigma M_A = 0$ | ↻ +ve.

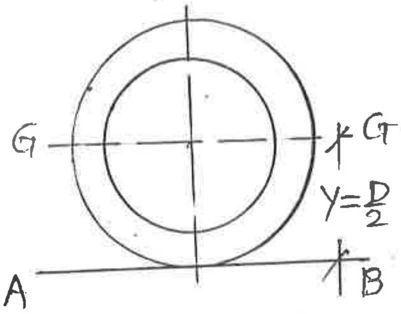
$+(100 \times 4 \times 2) + (200 \times 7) - R_B \times 9 = 0$

$\therefore R_B = 244.44 \text{ kN}.$

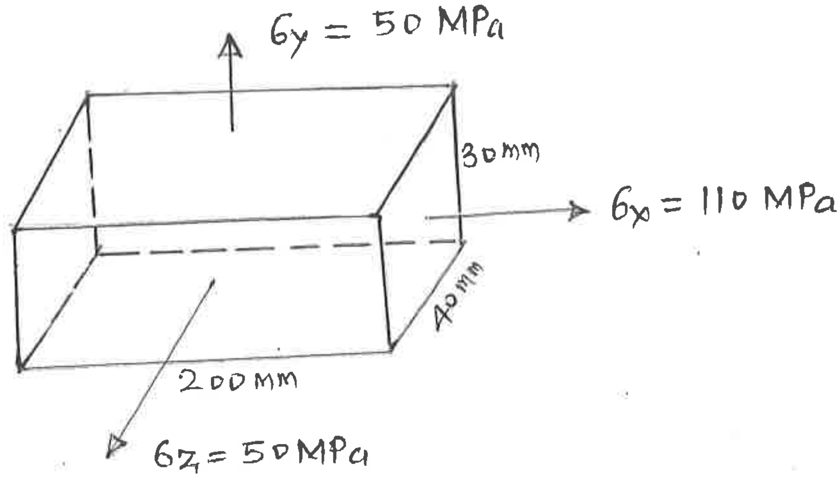
$\Sigma F_y = 0$ | ↑ +ve $\quad R_A + R_B - (100 \times 4) - 200 = 0$

$\therefore R_A = 600 - 244.44 = 355.56 \text{kN}$ 01

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | | B.M. is maximum at the point of contrashear.<br>from shear force diagram –<br>$\frac{x}{355.56} = \frac{4-x}{44.44}$<br>$\therefore 44.44x = 1422.24 - 355.56x$<br>Solving $x = 3.56$ m from support 'A' | 01 |
| | | $\therefore B.M._{max} = B.M_E = 355.56 \times 3.56 - 100 \times \frac{3.56^2}{2}$<br>$B.M_{max} = 632.11$ kN-m | 01 |
| | | | |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 3 | | Attempt any **THREE** of the following | (12) |
| | a) | A hollow circular section has external diameter 50 mm and wall thickness of 10 mm. Calculate moment of inertia about the tangent to the exernal diameter. | |
| | | Given :- for hollow circular section — $D = 50mm$, $t = 10mm$, $d = D - 2t = 50 - 2\times10 = 30mm$ | |
| | | To find :- M.I. @ tangent to the external diameter i.e. $I_{AB}$ | |
| | | Solution :- | |
| | |  | |
| | | $I_G = \frac{\pi}{64}(D^4 - d^4)$ | |
| | | $= \frac{\pi}{64}(50^4 - 30^4)$ | |
| | | $I_G = 2.67\times10^5 mm^4$ | 01 |
| | | To find $I_{AB}$, using parallel axis theorem. | |
| | | $I_{AB} = I_G + Ay^2$ | 01 |
| | | $= 2.67\times10^5 + \frac{\pi}{4}(50^2 - 30^2)\times(50/2)^2$ | |
| | | $= 2.67\times10^5 + 1256.64\times25^2$ | |
| | | $I_{AB} = 10.524\times10^5 mm^4$ | 02 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 3 | b) | A metal bar 200 mm long, 40 mm × 30 mm in cross section is subjected to stress of 110 MPa along the length and 50 MPa on other two faces. All stresses are tensile. Calculate strains along the three direction and also the volumetric strain. Assume E = 120 MPa and μ = 0.30. | |




$E = 120\ N/mm^2$, $\mu = 0.3$

Strain along X-direction

$e_x = \frac{1}{E}(\sigma_x - \mu\sigma_y - \mu\sigma_z) = \frac{1}{120}(110 - 0.3\times50 - 0.3\times50)$

$= +0.667$ — 01

Strain along Y-direction

$e_y = \frac{1}{E}(\sigma_y - \mu\cdot\sigma_z - \mu\sigma_x) = \frac{1}{120}(50 - 0.3\times50 - 0.3\times110)$

$= +0.017$ — 01

Strain along Z-direction

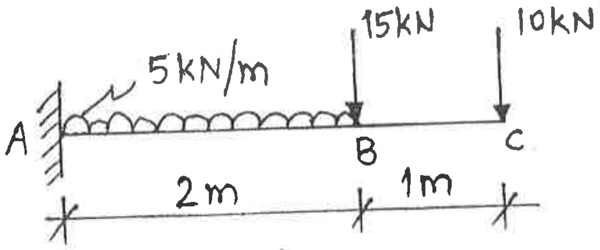
$e_z = \frac{1}{E}(\sigma_z - \mu\sigma_x - \mu\sigma_y) = \frac{1}{120}(50 - 0.3\times110 - 0.3\times50)$

$= +0.017$ — 01

Volumetric strain $= e_v = \sigma_x + \sigma_y + \sigma_z = 0.667 + 0.017 + 0.017$

$e_v = +0.701$ — 01

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 3 | c) | Draw S.F. and B.M. diagrams with all important values for the beam loaded as shown in Fig. No. 2. | |




* S.F. Calculations ↑|↓ +ve

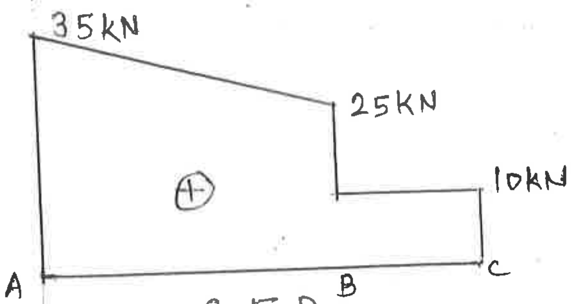
$S.F_C = +10\,kN$

$SF_B(right) = 10\,kN$

$S.F_B(left) = 10+15 = 25\,kN$

$S.F_A = 25 + 5\times 2$

$= 35\,kN.$




S.F.D.

01+01

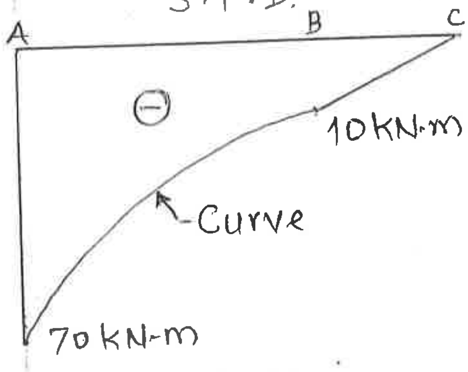
* B.M. Calculations ↻|↺ +ve

$BM_C = 0$

$BM_B = -10\times 1 = -10\,kN.m.$

$B.M_A = -10\times 3 - 15\times 2 - (5\times 2\times 1)$

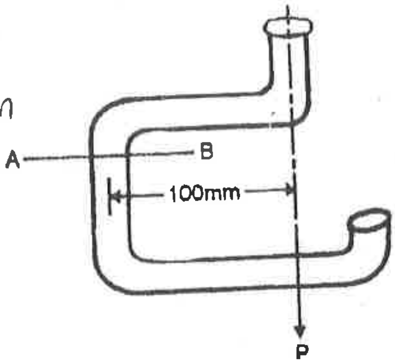
$BM_A = -70\,kN.m.$




B.M.D.

01+01

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 3 | d) | A mild steel tube 50 mm external dia and 10 mm thickness is bent in the form of hook as shown in Fig. No. 3. What maximum load 'P' the hook can lift, if the stresses on the cross section 'AB' shall not exceed 90 MPa in tension and 40 MPa in compression? | |




Given :- For steel tube :-

$D = 50\,mm,\ t = 10\,mm,\ d = 50 - 2\times10 = 30\,mm$

$\sigma_t = 90\,N/mm^2,\ \sigma_c = 40\,N/mm^2,\ e = 100\,mm$

To find :- 'P'

Answer :- $A = \frac{\pi}{4}(50^2 - 30^2) = 1256.64\,mm^2$

$\sigma_0 = \frac{P}{A} = \frac{P}{1256.64} = 7.96\times10^{-4}P$ — 01

$I = \frac{\pi}{64}(50^4 - 30^4) = 2.67\times10^5\,mm^4,\quad Y_{max} = \frac{D}{2} = \frac{50}{2} = 25\,mm$

$\sigma_b = \frac{P\cdot e}{I}\times Y_{max} = \frac{P\times100\times25}{2.67\times10^5} = 9.36\times10^{-3}P$ — 01

* $\sigma_{max} = \sigma_0 + \sigma_b = 7.96\times10^{-4}P + 9.36\times10^{-3}P$

$90 = 7.96\times10^{-4}P + 9.36\times10^{-3}P$

$\therefore$ $P = 8861.76\,N$ —— (A) — 1/2

* $\sigma_{min} = \sigma_0 - \sigma_b$

$-40 = 7.96\times10^{-4}P - 9.36\times10^{-3}P$

$\therefore$ $P = 4670.72\,N$ —— (B) — 1/2

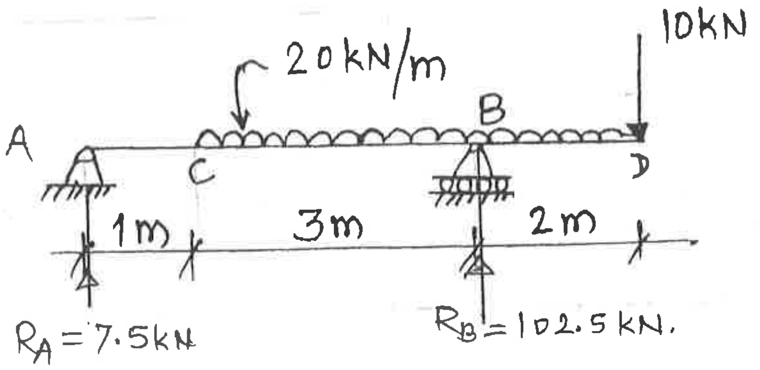
Maximum allowable load = Minimum of (A) & (B)

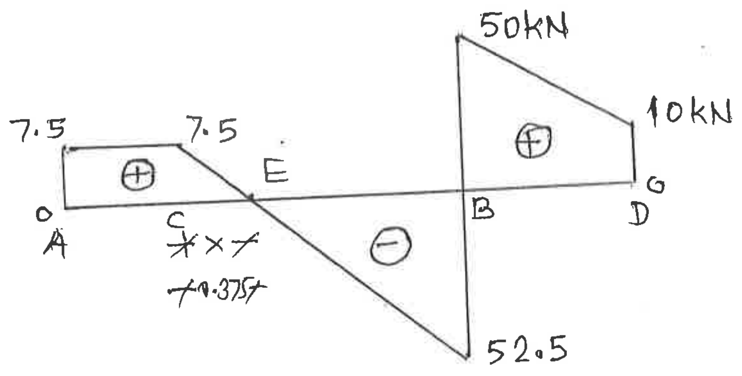
$P = 4670.72\,N$ — 01

**SUMMER – 2022 EXAMINATION**

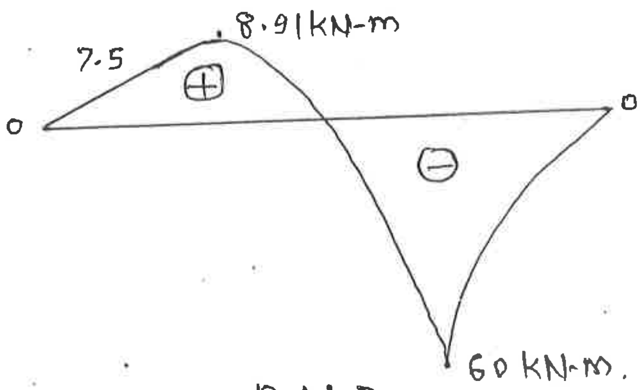
**Subject Name:** Strength of Materials **Model Answer** **Subject Code:** 22306

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 4 | | **Attempt any THREE of the following:** | (12) |
| | a) | Draw S.F. and B.M. diagrams for the beam as shown in Fig. No. 4. | |




S.F.D — 01




B.M.D. — 01

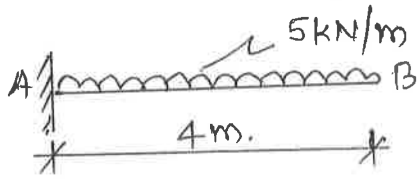
| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | | To find reactions -<br>$\Sigma M_A = 0$ ↻+ve $\quad 20 \times 5 \times 3.5 + 10 \times 6 - R_B \times 4 = 0$<br>$\therefore R_B = 102.5$ kN.<br>$\Sigma F_y = 0$ ↑+ve $\quad R_A + R_B - (20 \times 5) - 10 = 0$<br>$\therefore R_A = 110 - 102.5 = 7.5$ kN<br>* S.F. Calculations ↑\|↓+ve.<br>$S.F_A = 7.5$ kN<br>$S.F_C = 7.5$ kN<br>$S.F_B (left) = 7.5 - (20 \times 3) = -52.5$ kN<br>$S.F_B (right) = -52.5 + 102.5 = 50$ kN.<br>$S.F_D (left) = 50 - (20 \times 2) = 10$ kN.<br>$S.F_D (right) = 10 - 10 = 0$ | 01 |
| | | * B.M. Calculations ↻\|↺ +ve.<br>$B.M._A = 0$<br>$BM_C = 7.5 \times 1 = 7.5$ kN·m.<br>$BM_B = 7.5 \times 4 - 20 \times 3 \times 1.5 = -60$ kN·m<br>$BM_D = 0$<br>* Position of point of contrashear<br>$\frac{x}{7.5} = \frac{3-x}{52.5}$ Solving $x = 0.375$ m from C | 01 |
| | | * Maximum B.M. @ E<br>$B.M._{max} = 7.5 \times 1.375 - 20 \times \frac{0.375^2}{2}$<br>$= 8.91$ kN·m. | |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 4 | b) | A cantilever rectangular metal section is 4 m in length. It is subjected to all inclussive UDL of 5 kN/m. If permissible bending stress in the material is 5 N/mm², determine the size of the section. Assume depth to width ratio = 2. | |

Given : $\sigma_{b,max} = 5\ N/mm^2$, $\frac{d}{b} = 2$, Span = L = 4 m.

To find : b and d

Solution :-




* $B.M_{max} = \frac{wL^2}{2} = \frac{5\times4^2}{2}$

$= 40\ kN\cdot m = 40\times10^6\ N\cdot mm.$ — 01

* M.I. of section = $I = \frac{bd^3}{12} = \frac{b\times(2b)^3}{12} = \frac{2}{3}b^4\ mm^4$

* $y_{max} = \frac{d}{2} = \frac{2b}{2} = b.$

Using the relation

$$\frac{M}{I} = \frac{\sigma_{b,max}}{y_{max}}$$

$$\therefore M = \sigma_{b,max} \times \frac{I}{y_{max}}$$

$$40\times10^6 = 5 \times \frac{2}{3}\frac{b^4}{b}$$

$$\therefore b^3 = \frac{3\times40\times10^6}{2\times5}$$

$\therefore b = 228.94\ mm$ Say $230\ mm$ — 02

$d = 2\times b = 2\times230 = 460\ mm$

Provide Section of 230 mm × 460 mm. — 01

## SUMMER – 2022 EXAMINATION

**Subject Name:** Strength of Materials **Model Answer** **Subject Code:** 22306

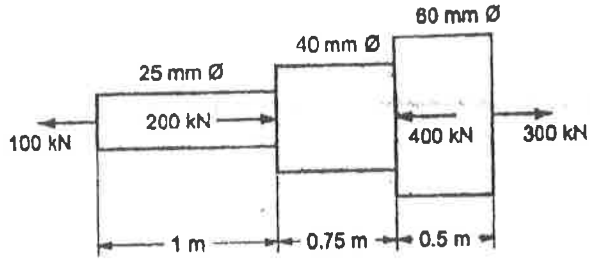
| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 4 | c | Calculate the power transmitted by a solid shaft of 60 mm diameter running at 240 RPM. Permissible shear stress is 70 N/mm$^2$ and the maximum torque is likely to exceed the mean torque by 30%. | |
| | | **Given :-** for solid circular shaft<br>$d = 60mm$, $N = 240$ rpm, $\tau = 70\ N/mm^2$<br>$T_{max} = 1.3\ T_{mean}$. | |
| | | **To find :-** Power transmitted. | |
| | | **Solution :-** from the torsional equation<br>$\frac{T}{J} = \frac{\tau}{R}$ $\therefore T = \frac{J}{R} \times \tau$<br>$= \frac{\pi}{16} d^3 \times \tau$ | 01 |
| | | $\therefore T = \frac{\pi}{16} \times 60^3 \times 70 = 2.968 \times 10^6$ N-mm.<br>$\therefore T = T_{max} = 2.968 \times 10^3$ N-m | 01 |
| | | $\therefore T_{mean} = \frac{T_{max}}{1.3} = \frac{2.968 \times 10^3}{1.3} = 2.283 \times 10^3$ N·m | |
| | | $\therefore$ Power $= \frac{2\pi N T_{mean}}{60} = \frac{2\pi \times 240 \times 2.283 \times 10^3}{60}$ | 01 |
| | | $= 57378$ Watts<br>$P = 57.38$ kW | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 4 | d) | Calculate the strain energy stored in a bar 4m long and 5cm in diameter when it is subjected to suddenly applied tensile load of 200 kN. Also determine the instantaneous elongation produced. Assume E = 210 GPa. | |
| | | Given: $l = 4m = 4000\ mm$, $d = 5cm = 50\ mm$ <br> $P = 200\times10^3\ N$ (suddenly applied), $E = 2.1\times10^5\ N/mm^2$ | |
| | | To find: $U$ and $\delta L$ | |
| | | Solution: $A = \frac{\pi}{4}(d^2) = \frac{\pi}{4}\times(50^2) = 1963.5\ mm^2$ | |
| | | $\text{Stress} = \sigma = \frac{2P}{A} = \frac{2\times200\times10^3}{1963.5} = 203.72\ N/mm^2$ | 01 |
| | | $\text{Strain Energy} = U = \frac{\sigma^2}{2E}\times A\times L$ | 01 |
| | | $\therefore U = \frac{203.72^2}{2\times2.1\times10^5}\times1963.5\times4000$ <br> $= 775886.75\ N\text{-}mm$ <br> $U = 775.89\ N\text{-}m.$ | 01 |
| | | * Instantaneous elongation $= \delta L = \frac{\sigma\cdot L}{E}$ <br> $\therefore \delta L = \frac{203.72\times4000}{2.1\times10^5}$ <br> $\therefore \delta L = 3.88\ mm$ | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 4 | e) | A solid aluminium shaft 1 m long and 50 mm diameter is to be replaced by hollow steel shaft of same length and outside diameter. Determine the inner diameter of hollow steel shaft for the same torque. <br> Take, For aluminium Shaft, $G_A = 2.8 \times 10^4$ N/mm$^2$ <br> for steel shaft, $G_s = 8.5 \times 10^4$ N/mm$^2$ | |
| | | Given: • For Aluminium solid shaft <br> $l = 1000$ mm, $d = 50$ mm, $G_A = 2.8 \times 10^4$ N/mm$^2$ <br> • For hollow steel shaft <br> $l = 1000$ mm, $D = 50$ mm, $G_s = 8.5 \times 10^4$ N/mm$^2$ | |
| | | To find: Inner dia of hollow steel shaft. | |
| | | Polar M.I. of aluminium shaf = $I_p = \frac{\pi}{32} d^4 = \frac{\pi}{32} \times 50^4$ <br> $\therefore I_p = 6.14 \times 10^5$ mm$^4$ | 01 |
| | | Torsional equation is – $\frac{T}{I_p} = \frac{G\theta}{L}$ <br> $\therefore T = \frac{G\theta}{L} \times I_p$ —— ① <br> Applying eq$^n$ ① to both shafts – | |
| | | $\frac{G_A \cdot \theta_A}{L_A} \times (I_p)_A = \frac{G_s \cdot \theta_s}{L_s} \times (I_p)_s$ | 01 |
| | | But $\theta_A = \theta_s$ and $L_A = L_s$ | |
| | | $\therefore G_A \cdot (I_p)_A = G_s \times (I_p)_s$ | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | | $\therefore 2.8\times10^4 \times 6.14\times10^5 = 8.5\times10^4 \times \frac{\pi}{32}(50^4 - d^4)$ | |
| | | $= 8.5\times10^4 \times 0.098(50^4 - d^4)$ | |
| | | $\therefore (50^4 - d^4) = \frac{2.8\times10^4 \times 6.14\times10^5}{8.5\times10^4 \times 0.098}$ | |
| | | $= 2.06\times10^6$ | |
| | | $\therefore d^4 = 4.19\times10^6$ | |
| | | $\therefore d = 45.24\ mm$ | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 5 | | Attempt any TWO of the following. | (12) |
| | a) | A steel bar is subjected to axial loads as shown in Fig. No. 5. Calculate deformation of the bar. Take E = 210 GPa. | |




Force in AB = + 100 kN
Force in BC = +100 − 200 = − 100 kN
Force in CD = +100 − 200 + 400 = +300 kN. — 01

$A_{AB} = \frac{\pi}{4} \times 25^2 = 490.87\ mm^2$, $A_{BC} = \frac{\pi}{4} \times 40^2 = 1256.64\ mm^2$
$A_{CD} = \frac{\pi}{4} \times 60^2 = 2827.43\ mm^2$ — 01

$\delta L = PL/AE$.

$\therefore \delta_{AB} = \frac{+100 \times 10^3 \times 1000}{1256.64 \times 210 \times 10^3} = +0.970\ mm.$ — 01

$\delta_{BC} = \frac{-100 \times 10^3 \times 750}{1256.64 \times 210 \times 10^3} = -0.284\ mm$ — 01

$\delta_{CD} = \frac{+300 \times 10^3 \times 500}{2827.43 \times 210 \times 10^3} = +0.252\ mm.$ — 01

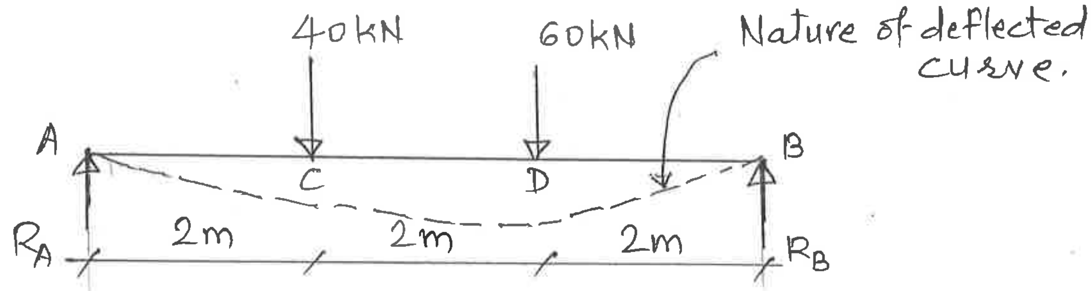
$\delta_{Total} = +0.970 - 0.284 + 0.252\ mm$

$\therefore \delta_{Total} = +0.938\ mm$ (Elongation). — 01

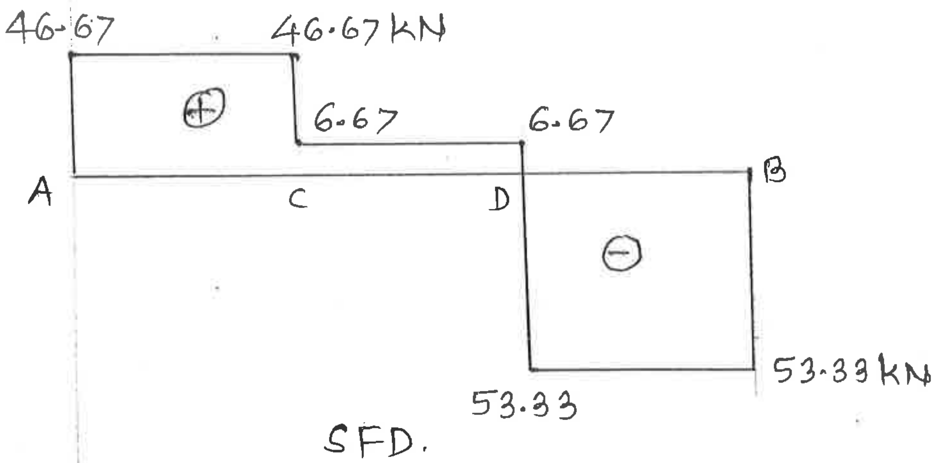
**SUMMER – 2022 EXAMINATION**

**Subject Name:** Strength of Materials **Model Answer** **Subject Code:** 22306

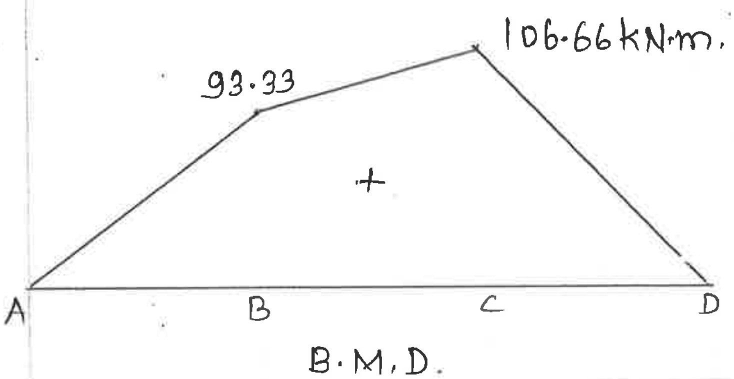
| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 5 | b) | A simply supported beam of 6 m span is subjected to two point loads of 40 kN and 60 kN at 2 m and 4 m from left had support respectively. Draw S.F., B.M. diagrams. Also draw the nature of deflected curve of the beam. | |




deflected curve 01

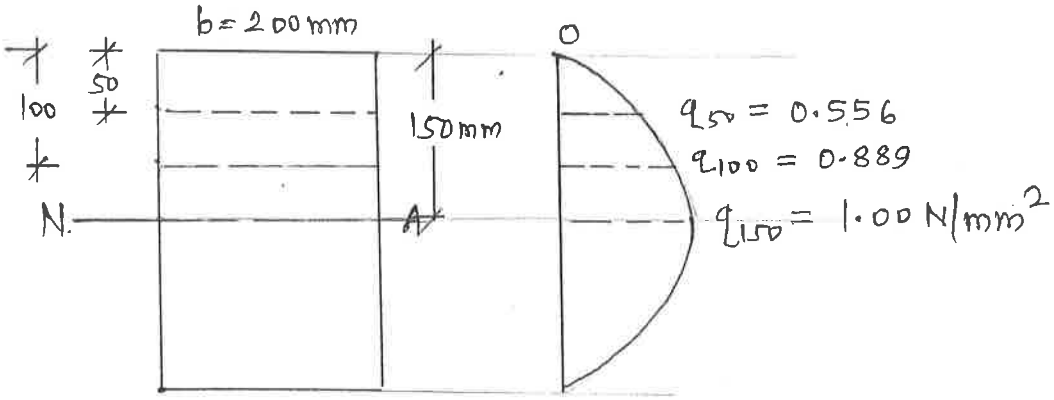



01




01

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | | To find reactions – | |
| | | $\Sigma M_A = 0$ ↻+ve. $40 \times 2 + 60 \times 4 - R_B \times 6 = 0$ | |
| | | $\therefore R_B = \frac{320}{6} = 53.33$ kN. | 01 |
| | | $\Sigma f_y = 0$ ↑+ve. $R_A + R_B - 40 - 60 = 0$ | |
| | | $\therefore R_A = 100 - 53.33 = 46.67$ kN. | |
| | | * **S.F. Calculations** ↑\|↓ +ve. | |
| | | $S.F_A = +46.67$ kN | |
| | | $S.F_C (left) = +46.67$ kN | |
| | | $S.F_C (right) = +46.67 - 40 = 6.67$ kN | |
| | | $S.F_D (left) = 6.67$ kN | |
| | | $S.F_D (right) = 6.67 - 60 = -53.33$ kN | |
| | | $S.F_B (left) = -53.33$ kN | |
| | | $S.F_B (right) = -53.33 + 53.33 = 0$ | 01 |
| | | * **B.M. Calculations** ↻\|↺ +ve | |
| | | $BM_A = BM_B = 0$ ∵ simple support | |
| | | $BM_C = 46.67 \times 2 = 93.33$ kN·m. | |
| | | $BM_D = 53.33 \times 2 = 106.66$ kN·m. | 01 |

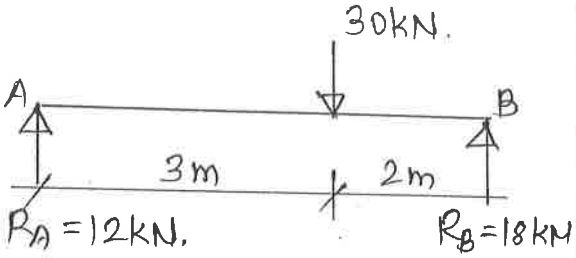
| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 5 | c. | A rectangular beam 200 mm wide × 300 mm deep is subjected to shear force of 40 kN. Calculate the shear stresses at top layer and at distances of 50 mm, 100 mm and 150 mm from the top layer. Sketch the shear stress distribution. | |
| | | Given, for rectangular beam, $b = 200$ mm, $d = 300$ mm<br>$S = V = 40 \times 10^3$ N | |
| | | To find: $q$ at top, at 50 mm, at 100 mm & at 150 mm from top layer. & shear stress distribution. | |
| | | <br><br>C/s of beam          Shear stress distribution. | Diagram 01 |
| | | $I_{xx} = \frac{bd^3}{12} = \frac{200 \times 300^3}{12} = 450 \times 10^6 \text{ mm}^4$<br>$b = 200$ mm. | 01 |
| | | $q$ at top $= 0$.<br>Shear stress at any layer is given by<br>$q = \frac{Sa\bar{y}}{bI}$ | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| | | * q at 50 mm below the top layer. | |
| | | $q_{50} = \frac{S a\bar{y}}{bI} = \frac{40\times10^3 \times (200\times50)\times(100+50/2)}{200\times450\times10^6}$ | |
| | | $q_{50} = 0.556\ N/mm^2$ | 01 |
| | | * q at 100 mm below the top layer | |
| | | $q_{100} = \frac{S a\bar{y}}{bI} = \frac{40\times10^3 \times (200\times100)\times(50+100/2)}{200\times450\times10^6}$ | |
| | | $q_{100} = 0.889\ N/mm^2$ | 01 |
| | | * q at 150 mm below the top layer. | |
| | | $q_{150} = \frac{S a\bar{y}}{bI} = \frac{40\times10^3 \times (200\times150) * 75}{200\times450\times10^6}$ | |
| | | $q_{150} = q_{N.A.} = 1.00\ N/mm^2$ | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 6 | | Attempt any TWO of the following: | (12) |
| | a) | A circular beam has simply supported span of 5 m and subjected to a point load of 30 kN at a distance 3 m from left hand support. The shear stress across the beam is limited to 2 N/mm$^2$. Design the minimum section for the beam and hence determine the magnitude of average shear stress. | |

Given:

$q_{max} = 2\ N/mm^2$




To find:

i) dia. of circular beam

ii) $q_{avg}$.

Solution :- Max. S.F = Max reaction.

$\Sigma M_A = 0 = 30 \times 3 - R_B \times 5 = 0 \quad \therefore R_B = \frac{90}{5} = 18\ kN.$

$\Sigma F_y = 0, \quad R_A + R_B - 30 = 0 \quad \therefore R_A = 30 - 18 = 12\ kN$ — 01

$\therefore$ Max. Shear force $= R_B = 18\ kN$ — 01

for circular section, $q_{avg} = \frac{q_{max}}{1.33} = \frac{2}{1.33} = 1.5\ \frac{N}{mm^2}$ — 01+01

$q_{avg} = \frac{P}{A} \quad \therefore A = \frac{P}{q_{avg}} = \frac{18 \times 10^3}{1.50}$

$A = 12000\ mm^2$

$A = \frac{\pi}{4} \times d^2 = 12000$

$\therefore d^2 = 12000 \times 4/\pi = 15.28 \times 10^3$

$\therefore d = 123.61\ mm$ Say $125\ mm.$ — 01

$q_{avg} = \frac{P}{A_{provided}} = \frac{18 \times 10^3}{\left(\frac{\pi}{4} \times 125^2\right)} = 1.467\ N/mm^2$ — 01

**SUMMER – 2022 EXAMINATION**

**Subject Name:** Strength of Materials **Model Answer** **Subject Code:** 22306

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 6 | b) | A propeller shaft, 400 mm external and 200 mm internal diameters is subjected to twisting moment of 4650 N.m. Calculate maximum shear stress developed in shaft. Also calculate angle of twist in degrees in a length 20 times the external diameter. Take G = 82 GPa. | |
| | | Given:- for shaft, $D = 400\,mm$, $d = 200\,mm$, $T = 4650\ N\cdot m = 4650\times10^3\ N\cdot mm$, $l = 20\times D = 20\times400\ mm$, $G = 82\times10^3\ N/mm^2$ | |
| | | To find: $q_{max}$ and $\theta$ in degrees. | |
| | | Solution:- $R = D/2 = \frac{400}{2} = 200\ mm.$ | |
| | | * Polar M.I $= I_p = \frac{\pi}{32}(D^4 - d^4) = \frac{\pi}{32}(400^4 - 200^4)$ <br> $I_p = 2.36\times10^9\ mm^4$ | 01 |
| | | * Using torsional equation, $\frac{T}{I_p} = \frac{G\theta}{L} = \frac{q_{max}}{R}$ | |
| | | $\therefore q_{max} = \frac{T}{I_p}\times R = \frac{4650\times10^3}{2.36\times10^9}\times200 = 0.39\ N/mm^2$ | 01+01 |
| | | and $\theta = \frac{T\times L}{G\times I_p} = \frac{4650\times10^3\times8000}{82\times10^3\times2.36\times10^9}$ <br> $\theta = 1.92\times10^{-4}$ radians. | 01+01 |
| | | $\theta = 1.92\times10^{-4}\times180/\pi$ degrees <br> $\theta = 0.011^\circ$ | 01 |

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 6 | C | A short mild steel column of external diameter 200 mm and internal diameter 150 mm carries an deccentric load. Determine the gretest eccentricity which the load can have so as to avoid reversal of stresses in the section of column. | |
| | | For steel column, D = 200mm, d = 150 mm | |
| | | To find: $e_{max}$ | |
| | | Solution: | |
| | | $e_{max} \leq Z/A$ | |
| | | * $A = \frac{\pi}{4}(D^2 - d^2) = \frac{\pi}{4}(200^2 - 150^2) = 13.75 \times 10^3 \text{ mm}^2$ | 01 |
| | | * $Z = \frac{\pi (D^4 - d^4)}{32 D} = \frac{\pi (200^4 - 150^4)}{32 \times 200}$ | 01+01 |
| | | $Z = 5.37 \times 10^5 \text{ mm}^3$ | |
| | | $\therefore e_{max} \leq \frac{Z}{A}$ | 01 |
| | | $e_{max} = \frac{Z}{A} = \frac{5.37 \times 10^5}{13.75 \times 10^3}$ | |
| | | $e_{max} = 39.06 \text{ mm}$ | 02 |