Modified

CBCS SCHEME

USN | | | | | | | | | | **18ME32**

Third Semester B.E. Degree Examination, Jan./Feb. 2021
Mechanics of Materials

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Module-1

1 a. A mild steel bar of 25mm diameter and 200mm gauge length has an extension of 0.15mm under a load of 75kN. Load at elastic limit is 160kN and maximum load is 250kN. Total extension is 55mm. Diameter at failure is 18.5mm. Find i) Elastic limit ii) Young's modulus iii) Percentage elongation iv) Percentage reduction in area. **(06 Marks)**

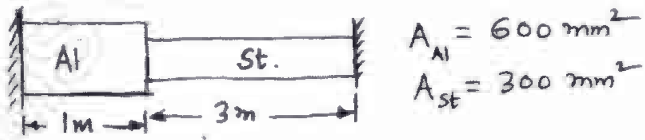
b. A tapered bar of length 'L' having rectangular cross – section of constant thickness 't' is subjected to a tensile force P. Find extension of the bar. **(08 Marks)**

c. Draw typical stress – strain curve for i) Mild steel ii) Aluminum and iii) Brittle material. **(06 Marks)**

OR

2 a. A composite bar is rigidly fitted at the support A and B as shown in Fig. Q2(a). Determine the reactions at the supports when temperature rises by 20^0C. E_{Al} = 70 GPa , E_{St} = 200 GPa $\alpha_{Al} = 11 \times 10^{-6}/^0C$ and $\alpha_{St} = 12 \times 10^{-6}/^0C$. **(08 Marks)**

Fig. Q2(a)



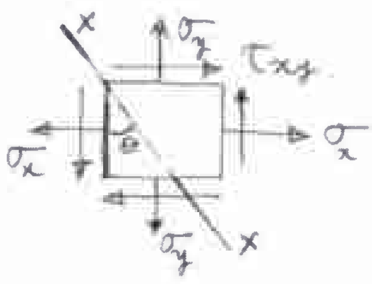
b. Define 'Bulk modulus'. Obtain an expression relating Young's modulus , Bulk modulus and Poisson's ratio. **(06 Marks)**

c. A 500mm long bar has rectangular cross – section 200mm × 40mm. This bar is subjected to
i) 40 kN tensile force on 20mm × 40mm faces
ii) 200 kN compressive force on 20mm × 500mm faces and
iii) 300 kN tensile force on 40mm × 500mm faces.
Find change in volume if E = 200 GPa and μ = 0.3. **(06 Marks)**

Module-2

3 a. Obtain expressions for normal and shear stress acting on a plane XX shown in Fig. Q3(a). **(10 Marks)**

Fig. Q3(a)



b. Draw Mohr's circle and find
i) Maximum shear stress if σ_x = 40 MPa , σ_y = 20 MPa and τ_{xy} = 0.
ii) Principal stresses if σ_x = 0 , σ_y = 0 and τ_{xy} = 25 MPa. **(10 Marks)**

OR

4 a. A thin cylinder of internal radius r_i , thickness t , length 'ℓ' is subjected to internal pressure p_i, find i) expressions for hoop stress and longitudinal stress ii) expression for volumetric strain. **(10 Marks)**

b. A thick cylinder of outside diameter 300mm and thickness 50mm is subjected to an internal pressure of $40N/mm^2$ and an external pressure of $2.5N/mm^2$. Find maximum and minimum values of hoop stress and radial stress, Plot the stress variations across the cylinder section. **(10 Marks)**

Module-3

5 a. Obtain expressions relating load, shear force and bending moment. **(06 Marks)**

b. Draw the bending moment and shear force diagrams for the beam shown in Fig. Q5(b) indicating values at important sections. Also find the positions of i) Maximum bending moment ii) Maximum shear force and iii) Point of contraflexure. **(14 Marks)**

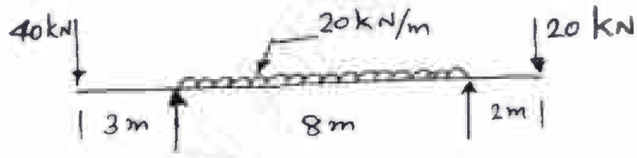


Fig. Q5(b)

OR

6 a. Stating the assumptions of Pure bending theory, derive

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}.$$ **(10 Marks)**

b. A wooden beam 10m long , 360mm deep and 300 mm wide is simply supported and loaded with uniformly distributed load for the entire length. Maximum stress intensity of the material is 60MPa. Find the safe udℓ if factor of safety = 6. **(10 Marks)**

Module-4

7 A solid circular shaft is subjected to a bending moment of 9000 N-m and a twisting moment of 12000N-m. In a tensile test of the same material, it gave the following details :
Stress at yield point = 300Mpa ; Modulus of elasticity = 200GPa ; Poisson's ratio = 0.25.
Assuming factor of safety = 3, find the least diameter required according to i) Maximum Principal stress theory ii) Maximum Shear stress theory. **(20 Marks)**

OR

8 a. State the assumptions of 'Pure torsion' theory and prove

$$\frac{\tau_{max}}{r_0} = \frac{\tau}{r} = \frac{G\theta}{L}.$$ **(08 Marks)**

b. A hollow circular shaft with a 250mm external diameter and thickness of metal 25mm transmits power at 180 rpm. The angle of twist over a length of 3m was found to be 0.72^0. Calculate the power transmitted and the maximum shear stress induced. Modulus of rigidity = 84 GPa. **(12 Marks)**

Module-5

9 a. Obtain an expression for Euler's critical load for a long column with both ends pinned. **(10 Marks)**

b. State the assumptions made in Euler's theory and explain limitations of Euler's estimation of critical load. **(10 Marks)**

OR

10 a. What is Strain Energy? Explain in brief. **(05 Marks)**

b. Obtain an expression for strain energy due to shear stresses. **(05 Marks)**

c. Determine the ratio of strain energy stored in two bars of the same material shown in Fig. Q10 (c), if the gradually applied load is same. **(10 Marks)**

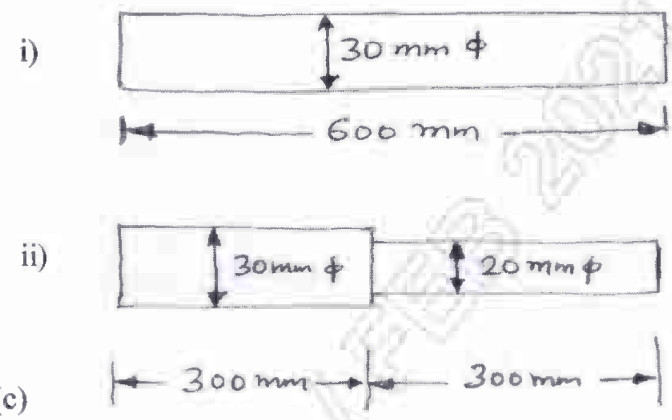


Fig. Q10(c)

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[SPAM] Fw: Sir, regarding Modification of scheme and solutions (18ME32)

"virupaxi bagodi" <virupaxibagodi@yahoo.com>

April 9, 2021 7:47 AM

To: boe@vtu.ac.in, boe@vtu.ac.in

Dear Sir,

18ME32

The scheme and solution are correct

Thanking you with warm regards.

Sincerely,
Dr. Virupaxi Bagodi
Principal
Government Engineering College,
TALAKAL - 583238, India
E-mail: virupaxibagodi@yahoo.com
Cell: +91 94 49 973293

----- Forwarded message -----
From: jhansi lakshmi <jhansibharath@gmail.com>
To: virupaxi bagodi <virupaxibagodi@yahoo.com>
Sent: Thursday, 8 April, 2021, 10:14:10 pm IST
Subject: Re: Fw: Sir, regarding Modification of scheme and solutions (18ME32)

Dear Sir,
All the answers are correct. No corrections required.

On Thu, Apr 8, 2021 at 5:23 PM virupaxi bagodi <virupaxibagodi@yahoo.com> wrote:

Thanking you with warm regards.

Sincerely,
Dr. Virupaxi Bagodi
Principal
Government Engineering College,
TALAKAL - 583238, India
E-mail: virupaxibagodi@yahoo.com
Cell: +91 94 49 973293

----- Forwarded message -----
From: "boe@vtu.ac.in" <boe@vtu.ac.in>
To: "virupaxibagodi@yahoo.com" <virupaxibagodi@yahoo.com>
Sent: Thursday, 8 April, 2021, 05:13:43 pm IST
Subject: Sir, regarding Modification of scheme and solutions (18ME32)

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With regards,
Jhansilakshmi K P
Assistant Professor
Department of Mechanical Engineering

"APPROVED"
Registrar (Evaluation)
Visvesvaraya Technological University
BELAGAVI - 590018

Visvesvaraya Technological University
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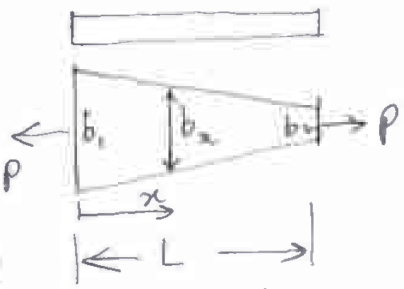
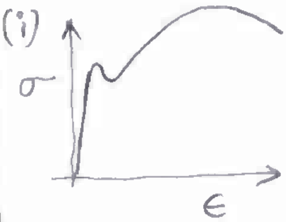
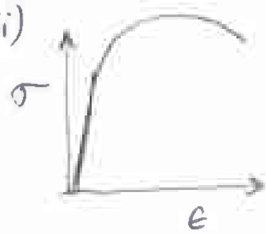
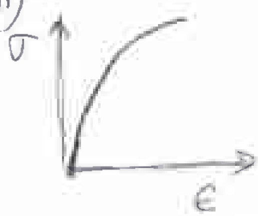
190918ME3215315

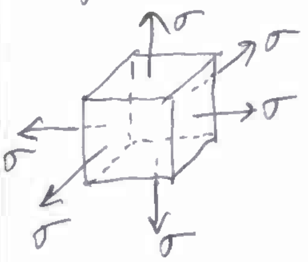
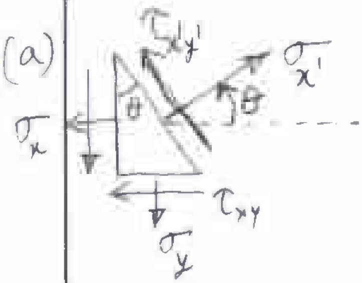
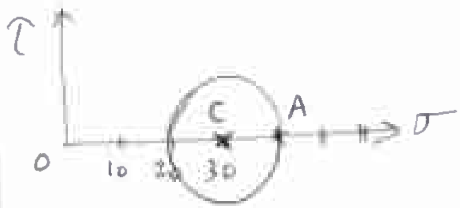
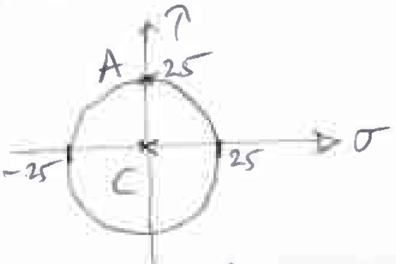
Accepted (signature) 10/8/20 (Dr. S.L. Gombi)
Signature of Scrutinizer

Scheme & Solution

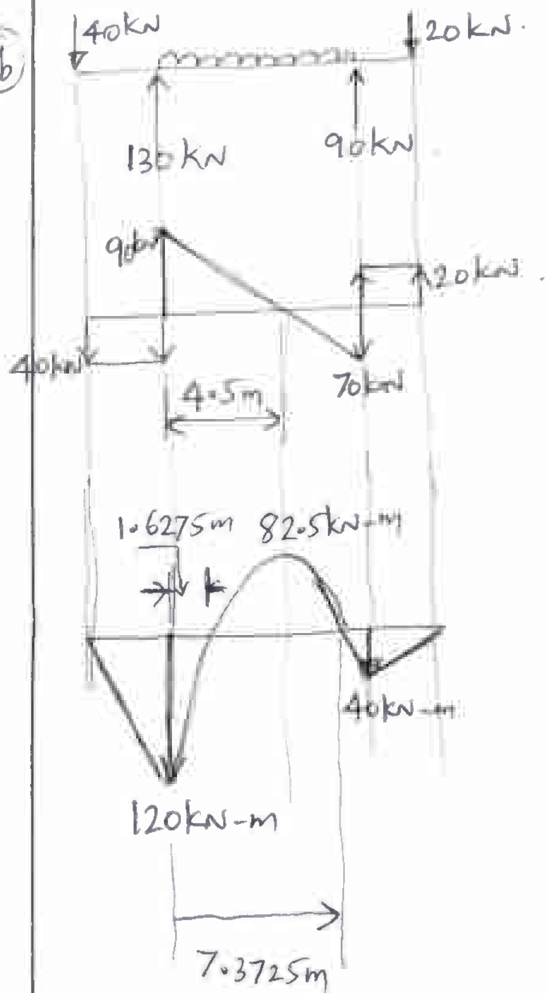
Subject Title : Mechanics of materials **Subject Code :** 18ME32

Question Number	Solution	Marks Allocated
1 (a)	$\sigma_e = \frac{160 \times 10^3}{\frac{\pi}{4} \times 25^2} = 326\ N/mm^2$	1
	$E = \frac{75 \times 10^3 / A}{0.15/200} = 203.8 \times 10^3\ \frac{N}{mm^2}$	2
	% Elongation $= \frac{55}{200} \times 100 = 27.5$	1
	% reduction in area $= \frac{\frac{\pi}{4}(25^2 - 18.5^2)100}{\frac{\pi}{4} \times 25^2} = 45.24$	2
(b)	 $b_x = b_1 - \left(\frac{b_1 - b_2}{L}\right) x$	3
	$A_x = b_x t$; $P_x = P$ $\Delta l = \int_0^L \frac{P\ dx}{b_x t E} = \frac{PL}{Et(a-b)} \ln \frac{a}{b}$	5
(c)	(i)  (ii)  (iii) 	2 + 2 + 2
2 (a)	Free expansion (would have been) $= (\alpha_{Al} L_{Al} + \alpha_{st} L_{st}) \Delta T$ $= 0.94\ mm$	3
	If 'P' is support reactions at each end, $0.94 = \frac{P L_{Al}}{A_{Al} E_{Al}} + \frac{P L_{st}}{A_{st} E_{st}}$ $P = 12735.5\ kN$.	5

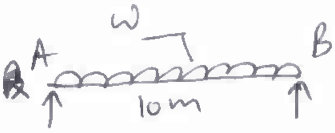
Subject Title : MOM **Subject Code :** 18ME32

Question Number	Solution	Marks Allocated
2(b)	Defn. — (2) $= \frac{\sigma}{\epsilon_v}$	(2)
	 $\epsilon_v = \epsilon_x + \epsilon_y + \epsilon_z$ $\epsilon_x = \epsilon_y = \epsilon_z = \frac{\sigma}{E} - \nu\frac{\sigma}{E} - \nu\frac{\sigma}{E} = \frac{\sigma}{E}(1-2\nu)$ $\epsilon_v = \frac{3\sigma}{E}(1-2\nu)$ $\therefore K = \frac{\sigma E}{3\sigma(1-2\nu)}$ $\therefore$ $E = 3K(1-2\nu)$	(4)
(c)	$\sigma_x = 50\,MPa$; $\sigma_y = 20\,MPa$ & $\sigma_z = 15\,MPa$	(2)
	$\epsilon_x = \frac{51.5}{E}$; $\epsilon_y = -\frac{39.5}{E}$ & $\epsilon_z = \frac{6}{E}$	(2)
	$\epsilon_v = \epsilon_x + \epsilon_y + \epsilon_z = \frac{18}{E}$ $\therefore \Delta V = 36\,mm^3$	(2)
3(a)	 $\sigma_{x'} = \left(\frac{\sigma_x + \sigma_y}{2}\right) + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$	(6)
	$\tau_{x'y'} = -\left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta$	(4)
(b)	(i) $C \equiv (30, 0)$ & $A \equiv (40, 0)$  $\tau_{max} = 10\,MPa$ (ii) $C = (0, 0)$ & $A \equiv (0, 25)$  $\sigma_1 = 25\,MPa$ (tensile) $\sigma_2 = -25\,MPa$ (Compr.)	(5) + (5)
4(a)	$\sigma_{hoop} = \frac{p_i d_i}{2t}$ & $\sigma_l = \frac{p_i d_i}{4t}$ — both tensile	(6)
	$\epsilon_{hoop} = \frac{\delta d_i}{d_i} = \frac{\sigma_{hoop}}{E} - \nu\frac{\sigma_l}{E} = \frac{p_i d_i}{4tE}(2-\nu)$	(1)

Subject Title : MOM **Subject Code :** 18ME32

Question Number	Solution	Marks Allocated
	$\epsilon_l = \frac{\sigma_l}{E} - \nu \frac{\sigma_{hoop}}{E} \Rightarrow \frac{dl}{l} = \frac{p_i d_i}{4tE}(1-2\nu)$	1
	$\therefore \epsilon_v = \epsilon_l + 2\epsilon_{cir} = \frac{p_i d_i}{4tE}(5-4\nu)$	2
(b)	$\sigma_r = -a + \frac{b}{r^2}$ & $\sigma_t = a + \frac{b}{r^2}$; $r_o = 150$ mm ; $r_i = 100$ mm $40 = -a + \frac{b}{100^2}$ & $2.5 = -a + \frac{b}{150^2}$ $\therefore b = 675000$ N & $a = 27.5 \frac{N}{mm^2}$	4
	σ_t max at $r = r_i = 95\ N/mm^2$ (tensile) σ_t min at $r = r_o = 57.5\ N/mm^2$ (tensile)	2
	Variation of σ_r & σ_t	4
5 (a)	$\frac{dF}{dx} = \omega$ and $\frac{dM}{dx} = -F$	3+3
(b)		
	Reactions	2
	SFD	3
	BMD	6
	Positions	3

Subject Title : MOM Subject Code : 18ME32

Question Number	Solution	Marks Allocated
6 (a)	Assumptions (i) $\frac{\sigma}{y} = \frac{E}{R}$ & (ii) $\frac{M}{I} = \frac{E}{R}$	(3)+(3)+(4)
(b)	 $R_A = R_B = \frac{10w}{2} = 5w$	(2)
	$M_{max} = 5w \times 5 - 5w\left(\frac{5}{2}\right) = 12.5w$ N-m	(2)
	$\sigma_{per} = \frac{60}{6} = 10$ MPa ; $w = 5184 \frac{N}{m}$	(6)
7	$\frac{M}{I} = \frac{\sigma}{y} \Rightarrow \sigma_x = \frac{32M}{\pi D^3}$ $\frac{T}{I_p} = \frac{\tau}{r} \Rightarrow \tau = \tau_{xy} = \frac{16T}{\pi D^3}$	(6)
	$\sigma_y = 0$ (a) $\sigma_1 = \frac{16}{\pi D^3}\left[M + \sqrt{M^2 + T^2}\right] = \frac{300}{3}$ $D = 106.9$ mm	(7)
	(b) $\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$ $= \frac{16}{\pi D^3}\sqrt{M^2 + M_t^2} = \frac{1}{2}\left(\frac{300}{3}\right)$ $D = 115.2$ mm	(7)
8 (a)	Assumptions & Derivation	(4)+(4)
(b)	$I_p = \frac{\pi}{32}\left[250^4 - 200^4\right] = 226.4 \times 10^{-6}\ m^4$	(2)
	$\frac{T}{I_p} = \frac{G\theta}{L} \Rightarrow T = 79680$ N-m	(5)
	$\tau_{max} = 43.99 \frac{N}{mm^2}$ & $P = \frac{2\pi NT}{60} = 1502$ kW	(3)+(2)

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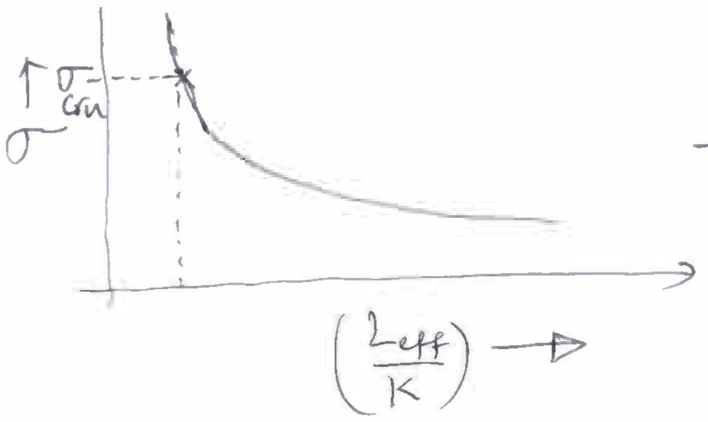
Question Number	Solution	Marks Allocated
9(a)	Derivation of $P = \frac{\pi^2 EI}{l^2}$ — Sketch	1
	Differential Eqn.	2
	Solution of diff. eqn	3
	End conditions & Simplification	4
		5
(b)	Assumptions	5
	$P = \frac{\pi^2 EI}{L_{eff}^2} = \frac{\pi^2 EAk^2}{L_{eff}^2} \Rightarrow \frac{P}{A} = \sigma = \frac{\pi^2 E}{\left(\frac{L_{eff}}{K}\right)^2}$  + Explaination	5
10(a)	Strain Energy & explaination	5
(b)	Derivation of, Shearing $SE = \frac{1}{2}\frac{\tau^2}{G}V$	5
(c)	(i) $SE_{(i)} = \frac{\sigma^2}{2E} \times V = \frac{1}{2E}\left[\frac{P}{\frac{\pi}{4}\times 30^2}\right]^2 \frac{\pi}{4} 30^2 \times 600$	
	$= \frac{P^2}{E}(0.4244)$	4
	(ii) $SE_{(ii)} = \frac{\sigma_1^2}{2E}V_1 + \frac{\sigma_2^2}{2E}V_2 = 0.6897\frac{P^2}{E}$	5
	$\frac{SE_{(ii)}}{SE_{(i)}} = 1.625$	1

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