POORNIMA COLLEGE OF ENGINEERING

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Sample Internal Answer sheet

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Theory

POORNIMA
GROUP OF COLLEGES

A/B. No. PGC/18/ 77493

Name of Institution: Poornima College of Engineering

Course: B.Tech	Branch: ME	Year: 2nd	Sem: 3rd	Sec: -	Roll No.: 20/ME/09

Name of Exam: 1st mid term

Name of Candidate: Jagrati Agarwal

Name of Subject/Paper: Mechanics of solid

Signature of Candidate: Jagrati

Day & Date: 27/Nov/2021, Saturday

College Registration No.: PCE20ME007

Subject/Paper Code: 3ME4-07

Name & Signature of Invigilator: 27/11/21

Question No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum Marks	80	Signature of Examiner
Marks Obtained	2	2	2	2	2	7	7	7			7	14		12	14	Total Marks Obtained	78	

INSTRUCTIONS :

1. No Supplementary answer books will be issued. Write on each ruled line on both sides of the leaf. Please do not waste pages ... Non programmable calculator (i.e. having memory capacity of more than six ...
2. Bringing cell phone / communication devices / programmable calculator (i.e. having memory capacity of more than six ...) strictly prohibited Exam. Conducting authorities will not keep them under their custody.
3. During the course of examination the candidate shall be under the discipline & control of the invigilator & shall ob... invigilators on all matters relating to the examinations.
4. Make all due entries on the cover page very carefully only at the space provided for the purpose.

Dr. Mahesh Bundele
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Director
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Seal

part - A

1) Stress is the internal resistance offered by a body to deformation is called stress. (σ).

$$\text{stress} = \frac{\text{pressure}}{\text{Area}}$$

strain is ratio of change in dimension to its original dimension. Denoted by e.

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stress
- Tensile stress
- Compressive stress
- ~~Volumetric stress~~
- shear stress

strain
- Tensile strain
- Compressive strain
- shear strain
- Volumetric strain

5) Temp. strain $= \alpha T$

$\delta l = \alpha T L$.

Tempr. stress $= \alpha T E$

E → Modulus of elasticity

α → coefficient of linear expansion

T = change in Temperature

2

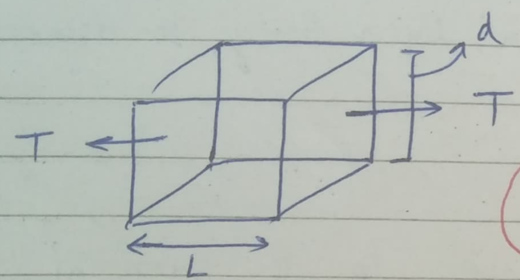
$e \propto T$

$e = \alpha T$

with an increase in temperature there is change in dimension of body. hence Temperature ↑ ⇒ strain ↑

$\therefore e \propto T$

3.> $\dfrac{\text{lateral strain}}{\text{longitudinal strain}} = \dfrac{1}{m} = \mu$ where μ = poisson's ratio



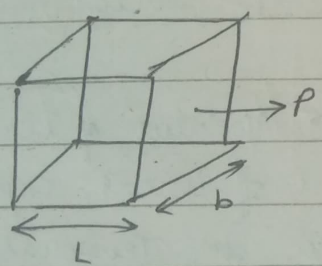
Here,

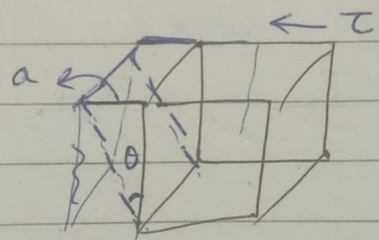
* longitudinal strain $= \dfrac{\delta l}{L} = \dfrac{\sigma}{E}$

* lateral strain $= -\dfrac{\mu\sigma}{E} = \dfrac{\delta d}{d}$

4.> Modulus of Elasticity – Ratio of tensile / compressive stress to tensile / compression strain within elastic limit is (E). Modulus of Elasticity.

Modulus of Rigiditty – Ratio of shear stress to the shear strain within elastic limit is (G). Modulus of rigidity.





$E = \dfrac{\sigma}{e} = \dfrac{P \times l}{A \times \delta l}$

$G = \dfrac{\tau}{\phi} = \dfrac{\text{shear stress}}{\text{shear strain}}$

6.>

6.)

$d = 25\,mm$

$P = 40\,KN$

$L = 200\,mm$

$\delta l = 0.085\,mm$

$\delta d = 0.003\,mm$

$$E = \frac{\text{stress}}{\text{strain}} = \frac{P}{A(e_1+e_2)} \quad \text{—— (1)}$$

$$A = \frac{\pi}{4}(25)^2 = 490.873\ mm^2$$

$$e_1 = \frac{\delta l}{l} = \frac{0.085}{200} = 0.000425\ mm$$

$$e_2 = \frac{\delta d}{d} = \frac{0.003}{25} = 0.000120\ mm$$

$$\text{strain} = e_1 + e_2 = 0.000545\ mm$$

Now, Modulus of Elasticity $= \dfrac{40 \times 10^3}{(490.873) \times 0.000545}$

$$\boxed{E = 149.5182978 \times 10^3\ N/mm^2}$$

Also, $E = 2G(1+\mu)$

$\mu = \dfrac{\text{lateral strain}}{\text{longitudinal strain}} = \dfrac{0.00012}{0.000425}$

μ = [illegible]

$$\text{Modulus of rigidity } (G) = \frac{E}{2(1+\mu)}$$

$$\boxed{G = 58{,}300.825 \ N/mm^2}$$ (using previous results)

$$E = 3K(1-2\mu)$$

$$K = \frac{E}{3(1-2\mu)} = \frac{149.5782978 \times 10^3}{3(1-2(0.2823))}$$

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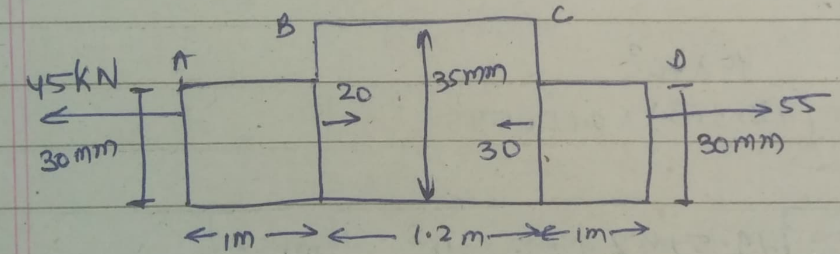
$$\boxed{K = 114{,}468.1502 \ N/mm^2}$$

↓ volumetric strain

7.)



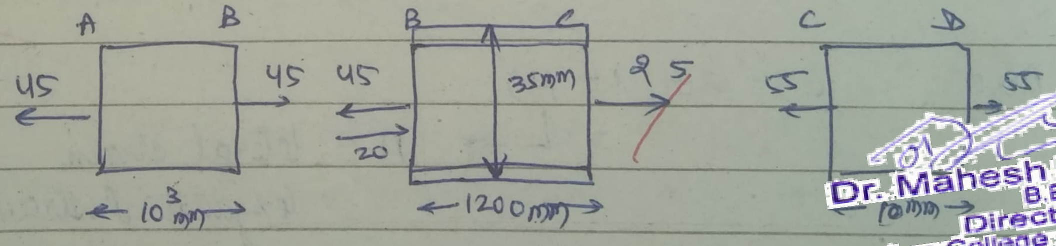
~~E = 2×10^5 N/mm^2~~

$E = 205 \times 10^3$

$= 205 \times 10^3$

$= 205 \times 10^3$

Free Body diagram



(Tensile) (Tensile) (Tensile)

c/s area of AB & CD $= \frac{\pi}{4}(30)^2$; c/s area of BC $= \frac{\pi}{4}(35)^2$

$= \underline{\underline{706.858 \text{ mm}^2}}$ $\qquad = 962.11275 \text{ mm}^2$

Elongation $\delta l = \delta l_1 + \delta l_2 + \delta l_3$

$$= \frac{1}{E}\left(\frac{P_1 L_1}{A_1} + \frac{P_2 L_2}{A_2} + \frac{P_3 L_3}{A_3}\right) \qquad \boxed{A_1 = A_3}$$

$$= \frac{1}{205 \times 10^{-3}}\left(\frac{45\times10^3 \times 10^3}{706.858} + \frac{25\times10^3 \times 1200}{962.11275} + \frac{55\times10^3 \times 10^3}{706.858}\right)$$

$E = 205 \times 10^3 \text{ N/m}^2$
$= 205 \times 10^{3-6} \text{ N/mm}^2$
$= \underline{\underline{205 \times 10^{-3} \text{ N/mm}^2}}$

$$= \frac{10^{5+3}}{205}\left(\frac{450}{706.858} + \frac{25\times12}{962.11275} + \frac{550}{706.858}\right)$$

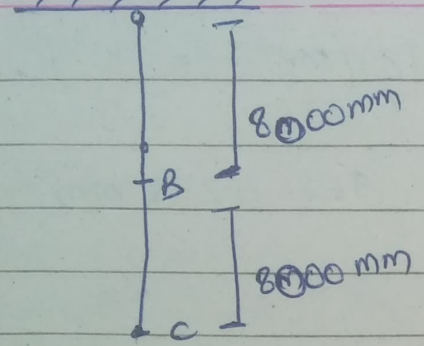
$$= \underline{\underline{0.00842207 \times 10^8 \text{ mm}}}$$

$\delta l_1 = 310,546.3829$; $\delta l_2 = 152104.2762$; $\delta l_3 = 379,556.6902$

$\delta l = \underline{\underline{842207.3493 \text{ mm}}}$

7

6.>



$A = 4 mm^2$

$P = 20 N$

$E = 200 \times 10^3 \ N/mm^2$

At C, deflection is due to self weight of the material.

$$\frac{\sigma\,(\text{stress})}{\text{strain}} = E$$

P = weigh = 20

$$\frac{Pl}{2AE} = \delta l_c$$

$$\frac{20 \times 16000}{2 \times 4 \times 200 \times 10^3} = \delta l_c$$

$$\boxed{\delta l_c = \frac{1}{5} = 0.2\,mm}$$

11.>

Deflection at pt. B is due to self weight produce by AB & load produce by BC

$$\delta l_B = \left(\frac{W/2 \times l/2}{2 \times A \times E}\right)_{AB} + \left(\frac{W/2 \times l/2}{AE}\right)_{BC}$$

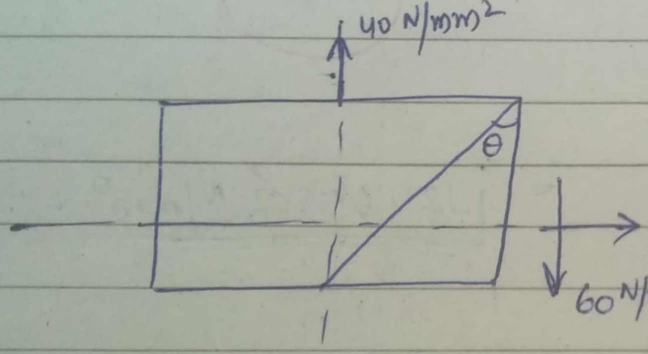
$$\delta l_B = \frac{W/2 \times l/2}{AE}\left(\frac{1}{2}+1\right) \Rightarrow \frac{Wl}{4AE} \times \frac{3}{2} \Rightarrow \frac{3Wl}{8AE}$$

7

$$= \frac{3 \times \cancel{20} \times \cancel{16} \times \cancel{10^3}}{\cancel{8} \times \cancel{4} \times \cancel{200} \times \cancel{10^3}}$$

$$= \frac{3}{20} = \boxed{0.15\ mm = \delta l_B}$$

11)



$\theta = 45^\circ$

$\sigma_1 = 80\ N/mm^2$

$\sigma_2 = 40\ N/mm^2$

$\tau = 60\ N/mm^2$

Find – σ_n, σ_t, σ_R, $\tan\phi = \frac{\sigma_t}{\sigma_n}$ or $\cos\phi = \frac{\sigma_n}{\sigma_R}$

normal stress (σ_n)

using formula $= \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2} \cos 2\theta$

$\cos 2(45)$
$\cos 90^\circ = 0$

$$= \frac{80+40}{2} + \left(\frac{80-40}{2}\right)\cos 2\theta$$

$$\boxed{\sigma_n = 120\ N/mm^2}$$

shear stress (σ_t) = using formula

$$= \frac{\sigma_1 - \sigma_2}{2} \sin 2\theta - \cancel{\tau \cos 2\theta}$$ 12.>

$$= \frac{80 - 40}{2} \sin(90)$$

$$\boxed{\sigma_t = 20\ N/mm^2}$$

7

Resultant (σ_R) $= \sqrt{(\sigma_n)^2 + (\sigma_R)^2}$

$$= \sqrt{(120)^2 + (20)^2} = \boxed{121.6552\ N/mm^2 = \sigma_R}$$

Obliquity (ϕ) $= \tan^{-1}\left(\frac{\sigma_t}{\sigma_n}\right)$

$$= \tan^{-1}\left(\frac{20}{120}\right)$$

[angle b/w σ_n & σ_R]

$$\boxed{\cancel{\phi = 0.9548^\circ}}$$

$$\boxed{\phi = 9.4623}$$

$$\boxed{\phi \approx 9.5^\circ}$$

$$\left\{ \cos^{-1}\left(\frac{\sigma_n}{\sigma_R}\right) \right.$$

$= 9.462$

$=$

part – c

12.) $A_r = \frac{\pi}{4}(20)^2 = 314.159\ mm^2$

$E = 2 \times 10^5\ N/mm^2$

$A_t = \frac{\pi}{4}\left((30)^2 - (25)^2\right) = 215.9844\ mm^2$

$L = 800\ mm$

$P = 20 \times 10^3\ N$

σ_t & $\sigma_r = ?$

$\sigma_{t\,new}^{*}$ & $\sigma_{r\,new}^{*} = ?$

$\left[\delta l = \frac{10}{4}\ mm\right]$ given

A_r = area of rod

A_t = area of tube

σ_r = stress in rod

σ_t = stress in tube

As per given condition, at static equilibrium load are equal

$$\sigma_r A_r = \sigma_t A_t$$

$$\sigma_r (314.159) = \sigma_t \times 215.9844$$

$$\sigma_r = \left(\frac{900 - 625}{400}\right)\sigma_t$$

$$\boxed{\sigma_r = 0.6875\ \sigma_t} \quad \text{—— (1)}$$

Also, given load on tube $= 20 \times 10^3\ N$

$P_t = \sigma_t A_t = 20 \times 10^3 \Rightarrow \sigma_t = \frac{20 \times 10^3}{215.9844}$

$$\sigma_t = \frac{4 \times (20 \times 10^3)}{\pi \times (275)} = 92.599 \ N/mm^2$$

By 1^{st} eq^n

$$\sigma_r = 0.6875 (\sigma_t)$$

$$\boxed{\sigma_r = 63.661977} \ N/mm^2$$

Now, new stress of ~~new~~ nuts & bolts is calculated by given condition

$$\delta l = \frac{10}{4} \ mm$$

& 1 nut is tightened by 1 Quarter hence, $\delta l = \frac{10}{4}\left(\frac{1}{4}\right)$

$$\frac{\sigma_r^* L}{E} + \frac{\sigma_t^* L}{E} = \frac{10}{4}\left(\frac{1}{4}\right) \qquad (\sigma_r = 0.6875 \ \sigma_t)$$

$L = 800 \ mm$

$E = 2 \times 10^5 \ N/mm^2$

$$(1.6875) \ \sigma_t^* = \frac{10}{4}\left(\frac{1}{4}\right) \times \frac{E}{L}$$

$$\sigma_t^* = \frac{10}{16} \times \frac{2 \times 10^5}{800} \times \frac{1}{1.6875}$$

$$\sigma_t^* = \frac{0.0370370 \times 10^6}{4 \times 10^2} = 92.59259 \ N/mm^2$$

$\sigma_s^* = 63.6574 \ N/mm^2$ (14)

14.> $A_s = \frac{\pi}{4}\left((30)^2 - (20)^2\right) = \underline{125\pi \ mm^2}$

$A_c = \frac{\pi}{4}\left((15)^2\right) = \underline{56.25\pi \ mm^2}$

$\Delta T = 190^\circ C$

$E_s = 2.1 \times 10^5 \ N/mm^2$

$E_c = 1 \times 10^5 \ N/mm^2$

$\alpha_s = 11 \times 10^{-6}$ per °C

$\alpha_c = 18 \times 10^{-6}$ per °C

$\alpha_c > \alpha_s$

$\downarrow$ compress $\quad \downarrow$ Tensile

At static equilibrium, load is equal

$\sigma_s A_s = \sigma_c A_c$

$\sigma_s (125\pi) = \sigma_c (56.25)\pi$

$\boxed{2.22 \sigma_s = \sigma_c}$

By Thermal expansion method

$\cancel{\frac{\sigma_s L_s}{E_s}} \left(\alpha_s T + \frac{\sigma_s}{E_s}\right) L = \left(\alpha_c T + \frac{\sigma_c}{E_c}\right) L$

(+ve) (Tensile) $\quad$ (−ve) $\longrightarrow$ as compressive

$$= (11\times10^{-6}\times 190) + \frac{\sigma_s}{2.1\times10^5} = +\frac{(2.22\,\sigma_s)}{10^5}\cancel{\times 190} - (18\times10^{-6}\times 190)$$

$$5510\times10^{-6} = \frac{\sigma_s}{10^5}\left(\frac{1}{2.1} + 2.22\right)$$

$$\sigma_s = \frac{5510\times10^{-1}\times 2.1}{5.662} = \boxed{204.362416\ N/mm^2 = \sigma_s}$$

12

$$\sigma_c = 2.22\,\sigma_s$$

$$\boxed{\sigma_c = 453.68\ N/mm^2}$$

15.> 1) Make axis
2.> Mark pt. A on it
3.> Measure $AC = \sigma_1$ & $AB = \sigma_2$ on the axis
4.> From B & C measure 2.5 cm ~~from~~ ⊥r to show shear stress
5.> Taking EO as radius make circle
6.> Measure 2θ angle as shown in figure
7.> Which gives pt. E
8.> Make ⊥r from E = σt & ~~make~~ mark it as pt. D
9.> Measure AD = normal stress

σ_1
σ_2
τ
θ

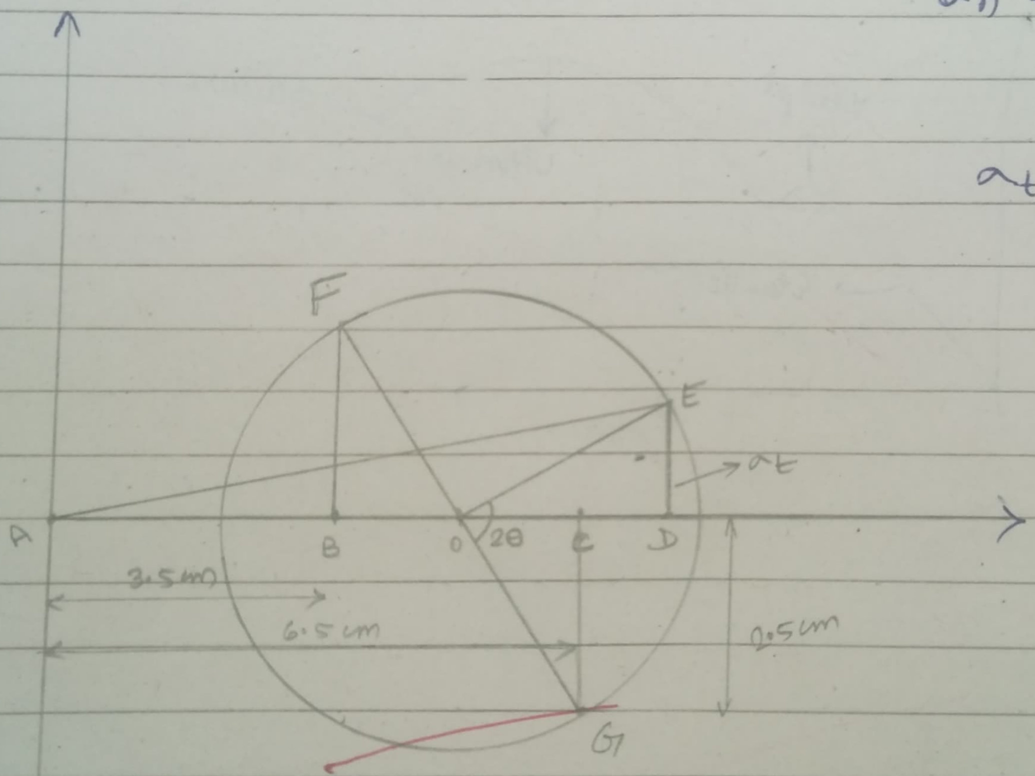
Theor

$\sigma_1 = 65\ N/mm^2 = 6.5\ cm$ (Tensile) Scale $\underline{10\ N/mm^2 = 1\ cm}$

$\sigma_2 = 35\ N/mm^2 = 3.5\ cm$ (Tensile)

$\tau = 25\ N/mm^2 = 2.5\ cm$

$\theta = 45^\circ$



$\sigma_n = AD = 7.5\ cm$

$\boxed{\sigma_n = 75\ N/mm^2}$

$\sigma_t = ED = 1.5\ cm$

$= \underline{15\ N/mm^2}$

14

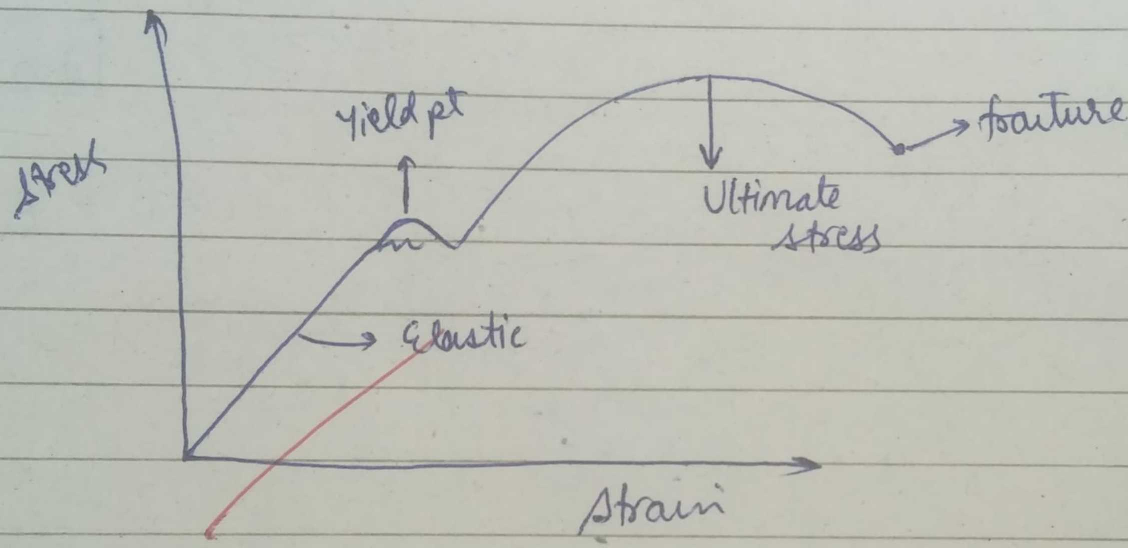
Theoritical method $= \sigma_n = \dfrac{\sigma_1 + \sigma_2}{2} + \left(\dfrac{\sigma_1 - \sigma_2}{2}\right)\sin 2\theta + \tau \cos 2\theta$

$= \underline{75\ N/mm^2}$

$\sigma_t = \left(\dfrac{\sigma_1 - \sigma_2}{2}\right)\sin 2\theta - \tau \sin 2\theta = 15\ N/mm^2$

part-A

mild steel shows ductile nature
↓
undergoes plastic deformation by Tensile load without fracturing.



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