Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem 2019-20
Course Code: MEC 321
Course Name: THEORY OF ELASTICITY
Program & Sem: B.Tech. (MEC) & V DE

Date: 27.09.2019
Time: 11.00AM to 12.00PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) ***All the questions are compulsory.***

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries six marks. **(3Qx6M=18M)**

1. Define Stress tensor and Strain tensor & explain with their matrix notation.
(C.O.NO.1) [Knowledge]

2. State all strain-displacement relations for three dimensions in Cartesia Coordinates.
(C.O.NO.1) [Knowledge]

3. Explain the following

i) Plane stress condition and ii) Plane strain conditions

(C.O.NO.1) [Comprehension]

Part B [Thought Provoking Questions]

Answer the Question. The Question carries ten marks. **(1Qx10M=10M)**

4. Derive the equilibriums equation in Cartesian co-ordinates from the fundamentals for 2-Dimensions with usual notations taking into consideration of body forces.

(C.O.NO.1) [Application]

Part C [Problem Solving Questions]

Answer the Question. The Question carries twelve marks. **(1Qx12M=12M)**

5. Determine the maximum Principal stress, minimum Principal stress and maximum Shear stress for a rectangular block subjected to following state of stress using Mohr's Circle method, $\sigma_x = 80\ N/m^2$, $\sigma_y = 40\ N/m^2$ & $\tau_{xy} = 30\ N/m^2$ Check the results analytically.

(C.O.NO.2) [Application]

SCHOOL OF ENGINEERING

Semester: Odd

Course Code: MEC-321

Course Name: Theory of

Date:

Time:

Max Marks:

Weightage:

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
1	CO1	1	06			06
2	CO2	2	06			06
3	CO1	1		06		06
4					10	10
5					12	12
	Total Marks		12	06	22	40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

[I hereby certify that All the questions are set as per the above guide lines. Dr. Rajendrakumar]

Reviewers' Comments

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

Semester: V

Course Code: MEC-321

Course Name: Theory of Elasticity

Date: 27/09/2019

Time: 1 hour

Max Marks: 40

Weightage: 20%

Part A (3Q x 6M = 18Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	Stress tensor definition and explaination with matrix notation Stress tensor definition and explaination with matrix notation	03 Marks 03 Marks	08 Min
2	Explaination of the Generalized Hooke's law	06 Marks	08 Min
3	Plane stress condition explaination Plane strain condition explaination Examples for each	02 Marks 02 Marks 02 marks	08 Min

Part B

(1Q x 10M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
4	Derivation of three stress equilibrium equations with neat sketch OR Mohr's Circle Diagram $\sigma_1 = 114\ N/m^2$, $\sigma_2 = -13\ N/m^2$ & $\tau_{max} = 64\ N/m^2$	Sketch (03) · Derivation (07) Diagram with values 07 Marks Checking analytically– 03 marks	16 Min
5	Fourth order polynomial Satisfying the Biharmonic Equation and establishing the condition between the coefficients of the polynomial. Stating the Boundary conditions Determination of expressions for σ_x , σ_y & τ_{xy}	02 Marks 02 Marks 02 Marks 06 Marks	20 Min

Part C (1Q x15 M = 15Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question

$\varepsilon 1=351.25 \qquad \varepsilon 2 =35.75$

$$\gamma_{max} = \sqrt{(\varepsilon_a - \varepsilon_c)^2 + (2\varepsilon_b - \varepsilon_a - \varepsilon_c)^2}$$

$$= 315.5 \times 10^{-6} \text{ rad}$$

$$\theta_1 = \frac{1}{2}\tan^{-1}\left(\frac{2\varepsilon_b - \varepsilon_a - \varepsilon_c}{\varepsilon_a - \varepsilon_c}\right)$$

$$= \frac{1}{2}\tan^{-1}\left(\frac{130 - 285 - 102}{285 - 102}\right)$$

$$= \frac{1}{2}\tan^{-1}(-1.4037)$$

$\theta_1 = -(27° 16')$

$\theta_2 = (117° 16')$

$$\sigma_1 = \frac{E}{1-\nu^2}(\varepsilon_1 + \nu\varepsilon_2)$$

$$= \frac{70 \times 10^9}{1-(0.32)^2}(351.25 + 0.32 \times 35.75) \times 10^{-6}$$

$$= 28.285 \text{ MPa}$$

$$\sigma_2 = \frac{E}{1-\nu^2}(\varepsilon_2 + \nu\varepsilon_1)$$

$$= \frac{70 \times 10^9}{1-(0.32)^2}(35.75 + 0.32 \times 351.25) \times 10^{-6}$$

$$= 11.553 \text{ MPa}$$

$$\tau_{max} = \frac{E}{2(1+\nu)}\gamma_{max} = \frac{70 \times 10^9}{2(1+0.32)} \times 315.5 \times 10^{-6}$$

$$= 8.365 \text{ MPa}$$

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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem. 2019-20 | **Date**: 16.11.2019

Course Code: MEC 321 | **Time**: 11.00 AM to 12:00 PM

Course Name: THEORY OF ELASTICITY | **Max Marks**: 40

Program & Sem: B.Tech (MEC) & V DE | **Weightage**: 20%

Instructions:

I. All the questions are compulsory.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries six marks. (3Qx6M=18M)

1. What are stress invariants. Write the expressions for stress invariants in terms of stress components for a given state of stress at a point. (C.O.NO.1) [Knowledge]
2. State and explain Strain Compatibility conditions. (C.O.NO.1) [Knowledge]
3. Explain the following briefly giving necessary equations

   1) Castiglino's theorem 2) Principle of Virtual work. (C.O.NO.1) [Comprehension]

Part B [Thought Provoking Questions]

Answer the Question. The Question carry ten marks. (1Qx10M=10M)

4. Derive the equilibrium equation in Cartesian co-ordinates from the fundamentals for 3-Dimensions taking into consideration of body forces. (C.O.NO.2) [Application]

Part C [Problem Solving Questions]

Answer the Question. The Question carry twelve marks. **(1Qx12M=12M)**

5. The stress at a point is given with respect to the axes $Ox_1x_2x_3$ by the values Determine (C.O.NO.2) [Application]

$$\sigma_{ij} = \begin{bmatrix} 5 & 0 & 0 \\ 0 & -6 & -12 \\ 0 & -12 & 1 \end{bmatrix} \text{MPa}$$

a) The Deviotoric and Hydrostatic stress tensors b) Maximum shear Stress.

SCHOOL OF ENGINEERING

Sem AY: Odd Sem 2019-20

Course Code: MEC 321

Course Name: Theory of Elasticity

Program & Sem: B.Tech (Mech) & V DE

Date: 16/11/2019

Time: 1.00 hr

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	CO1	4	06									06
2	CO1	3	06									06
3	CO1	4				06						06
4	CO2	3							10			10
5	CO2	4							12			12
	Total Marks		12			06			22			40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

SOLUTION

Semester: V

Course Code: MEC-321

Course Name:Theory of Elasticity

Program & Sem: B.Tech (Mech) & V

Date: /2019

Time:

Max Marks: 40

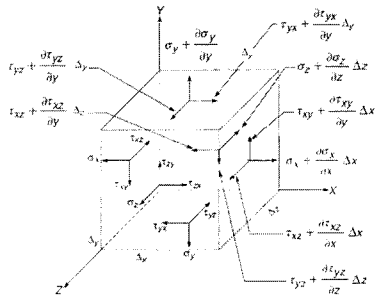
Weightage: 20%

Part A (3Q x 6M = 18Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**a)Definition of stress Invariants I_1, I_2, I_3** **b) Expressions for the Invariants I_1, I_2, I_3**	**03M** **03M**	**08**
2	• Strain compatibility equations in 3D space are; $\frac{\partial^2\gamma_{xy}}{\partial x\partial y} = \frac{\partial^2\varepsilon_y}{\partial x^2} + \frac{\partial^2\varepsilon_x}{\partial y^2}$ $\quad 2\frac{\partial^2\varepsilon_x}{\partial y\partial z} = \frac{\partial}{\partial x}\left(\frac{\partial\gamma_{yz}}{\partial x} + \frac{\partial\gamma_{zx}}{\partial y} - \frac{\partial\gamma_{xy}}{\partial z}\right)$ $\frac{\partial^2\gamma_{yz}}{\partial y\partial z} = \frac{\partial^2\varepsilon_z}{\partial y^2} + \frac{\partial^2\varepsilon_y}{\partial z^2}$ $\quad 2\frac{\partial^2\varepsilon_y}{\partial z\partial x} = \frac{\partial}{\partial y}\left(\frac{\partial\gamma_{zx}}{\partial x} + \frac{\partial\gamma_{xy}}{\partial y} - \frac{\partial\gamma_{yz}}{\partial z}\right)$ $\frac{\partial^2\gamma_{zx}}{\partial z\partial x} = \frac{\partial^2\varepsilon_x}{\partial z^2} + \frac{\partial^2\varepsilon_z}{\partial x^2}$ $\quad 2\frac{\partial^2\varepsilon_z}{\partial x\partial y} = \frac{\partial}{\partial z}\left(\frac{\partial\gamma_{xy}}{\partial x} + \frac{\partial\gamma_{yz}}{\partial y} - \frac{\partial\gamma_{zx}}{\partial z}\right)$	**Explanation with Equations=06M**	**08**
3	a) Statement and Explanation of Castiglino's theorem	**03M**	**08**

	b) **b)** Statement and Explanation of principle of virtual work	**03M**	

Part B (1Q x 10M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
4		Fig =04M,	18 Min
	$\frac{\partial \sigma_x}{\partial x}+\frac{\partial \tau_{xy}}{\partial y}+\frac{\partial \tau_{xz}}{\partial z}+F_x=0$ $\frac{\partial \sigma_y}{\partial y}+\frac{\partial \tau_{xy}}{\partial x}+\frac{\partial \tau_{yz}}{\partial z}+F_y=0$ $\frac{\partial \sigma_z}{\partial z}+\frac{\partial \tau_{xz}}{\partial x}+\frac{\partial \tau_{yz}}{\partial y}+F_z=0$	Derivation =06M	

Part C (1Q x12 M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	a) Deviatoric stress matrix & Spherical Stress matrix The principal stresses were found to be $\sigma_1 = 10, \sigma_2 = 5, \sigma_3 = -15$ and so the maximum shear stress is $\tau_{max} = \frac{1}{2}(\sigma_1 - \sigma_3) = \frac{25}{2}$	03M 03M 06M	18 Min

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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20
Course Code: MEC 321
Course Name: THEORY OF ELASTICITY
Program & Sem: B.Tech (MEC) & V (DE-I)

Date: 20 December 2019
Time: 9:30 AM to 12:30 PM
Max Marks: 80
Weightage: 40%

Instructions:
(i) Read the all questions carefully and answer accordingly.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 2 marks. (10Qx2M=20M)

1. Define stress at a point. (C.O.No.1) [Knowledge]
2. Define plane stress. (C.O.No.1) [Knowledge]
3. State Saint Venant's principle. (C.O.No.2) [Knowledge]
4. Significance of Biharmonic equation. (C.O.No.2) [Knowledge]
5. What is pure bending of a curved bar explain very briefly. (C.O.No.2) [Knowledge]
6. Write the dynamic equilibrium equation for a rotating Disc. (C.O.No.2) [Knowledge]
7. Define Hydrostatic stress tensor. (C.O.No.2) [Knowledge]
8. Define Deviotoric stress tensor. (C.O.No.2) [Knowledge]
9. Briefly explain the term "Torsion" with an example. (C.O.No.3) [Knowledge]
10. Briefly explain Polar moment of Inertia of Shaft. (C.O.No.3) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. (4Q=30M)

11. Explain generalized Hooke's law. [7M] (C.O.No.2) [Comprehension]
12. State and explain compatibility conditions [7M] (C.O.No.2) [Comprehension]
13. Write notes on: 1) Torsional rigidity and Torsional strength giving equations. [8M] (C.O.No.3) [Comprehension]
14. Derive σx, σ_y and τ_{xy} for rectangular beam in Cartesian coordinates using 4^{th} order Polynomial. [8M] (C.O.No.1) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 10 marks. **(3Qx10M=30M)**

15. $$\sigma_{ij} = \begin{bmatrix} 2.5 & -0.5 & 0 \\ -0.5 & 2.5 & 0 \\ 0 & 0 & 1 \end{bmatrix} \text{MPa}$$

Determine

a) The Principal Invariants of σ

b) Principal stresses and value maximum shear stress

(C.O.No.2) [Application]

16. The uniformly tapering shaft as shown in the figure below is subjected to a torque of 2kN-m at its free end. Find the angle of twist and maximum shear stress in the shaft if G= 80 kN/mm^2. What is the percentage error if is calculated as a shaft of average diameter.

(C.O.No.3) [Application]

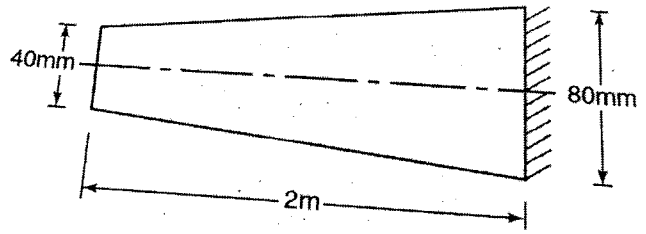

Fig.16

17. A hollow propeller shaft of a steam ship is to transmit 3750kW at 240 rpm. If the internal diameter is 0.8 times the external diameter and if the maximum shear stress developed is to be limited to 160 N/mm^2, determine the size of the shaft. (C.O.No.3) [Application]

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels K	Thought provoking type [Marks allotted] Bloom's Levels C	Problem Solving type [Marks allotted] A	Total Marks
PART A Q. NO1 TO 10	CO 01 CO 02 CO 03	All the 5 modules	20			20
PART B Q.NO.11	CO 01	MODULE 01 Per Unit System		7		7
PART B Q.NO.12	CO 02	MODULE 03 Load Flow Studies		7		7
PART B Q.NO.13	CO 03	MODULE 05 Load Flow Studies		8		8
PART B Q.NO.14	CO 02	MODULE 02 Fault		8		8

		Analysis				
PART C Q.NO.15	CO 02	MODULE 04 Stability studies			10	10
PARTC Q.NO.16	CO 03	MODULE 02 Load Flow Studies			10	10
PARTC Q.NO.17	CO 03	MODULE 03 Fault Analysis			10	10
	Total Marks		20	30	30	80

K =Knowledge Level C = Comprehension Level, A = Application Level

C.O WISE MARKS DISTRIBUTION:

CO 01: 10 MARKS, CO 02: 26 MARKS, CO 03: 27 MARKS, CO 04:17 MARKS

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must

be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature:

Reviewer Commend:

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

SOLUTION & SCHEME

Sem AY: Odd Sem 2019-20

Course Code: MEC-321

Course Name:Theory of Elasticity

Program & Sem: B.Tech (Mech) & 5th

Date: 20 December2019

Time: 9.30AM TO 12.30PM

Max Marks: 80

Weightage: 40%

Instructions:

Read the all questions carefully and answer accordingly

Part A (10Q x 2M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Definition of stress at a point**	**02**	**40**
2	**Definition of plane stress**	**02**	
3	**Statement of Saint Venants principle**	**02**	
4	Significance of bi harmonic equation	**02**	
5	Explanation for pure bending of curved bar	**02**	
6	Stating Dynamic Equilibrium Equations for rotating disc	**02**	
7	Definitions of Hydrostatic stress tensor	**02**	
8	Definition Deviotoric stress tensor.	**02**	
9	Definition and Explanation of Torsion by giving one example	**02**	
10	Define polar moment of Inertia and explain	**02**	

Part B (2Q x7+2Qx8 = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
11	Hooke's law in 2 Dimensions and 3 Dimensions giving matrix equation taking in to considerations of [D] Matrix, also state the effects isotropy	2D & 3D Equations(03M)+Generalized Hooke's law with [D] Matrix[03M]+stating the effect of the isotropy[01M]	20
12	Strain compatibility equations in 3D space are; $\frac{\partial^2 \gamma_{xy}}{\partial x \partial y} = \frac{\partial^2 \varepsilon_y}{\partial x^2} + \frac{\partial^2 \varepsilon_x}{\partial y^2}$ $\quad 2\frac{\partial^2 \varepsilon_x}{\partial y \partial z} = \frac{\partial}{\partial x}\left(\frac{\partial \gamma_{yz}}{\partial x} + \frac{\partial \gamma_{zx}}{\partial y} - \frac{\partial \gamma_{xy}}{\partial z}\right)$ $\frac{\partial^2 \gamma_{yz}}{\partial y \partial z} = \frac{\partial^2 \varepsilon_z}{\partial y^2} + \frac{\partial^2 \varepsilon_y}{\partial z^2}$ $\quad 2\frac{\partial^2 \varepsilon_y}{\partial x \partial z} = \frac{\partial}{\partial y}\left(\frac{\partial \gamma_{yz}}{\partial x} + \frac{\partial \gamma_{xz}}{\partial y} - \frac{\partial \gamma_{xy}}{\partial z}\right)$ $\frac{\partial^2 \gamma_{zx}}{\partial x \partial z} = \frac{\partial^2 \varepsilon_x}{\partial z^2} + \frac{\partial^2 \varepsilon_z}{\partial x^2}$ $\quad 2\frac{\partial^2 \varepsilon_z}{\partial x \partial y} = \frac{\partial}{\partial z}\left(\frac{\partial \gamma_{yz}}{\partial x} + \frac{\partial \gamma_{xz}}{\partial y} - \frac{\partial \gamma_{xy}}{\partial z}\right)$	**Explanation with equations=07M**	20

13	Torsional Rigidity Explannation with Equation Torsional strenght Explannation with Equation	**Explanation with equation** **$G\theta = TL/J$ (04M)** **Explanation with equation** **$T/J = fs/R$ (04M)**	20
14	Derivation of σ_x Derivation of σ_y and τ_{xy}	Choosing appropriate 4th order polynomial (02M) Stating boundry conditions (01M) Derivation of σ_x (02M) Derivation of σ_y and τ_{xy} **(03M)**	20

Part C (3Q x10 M = 30Marks)

Q No	**Solution**	**Scheme of Marking**	**Max. Time required for each Question**
15	Determination of Principal Invariants of σ Determination of principal stresses Determination of maximum shear stress	I1=6MPa, I2 = 11MPa, I3 = 6 MPa (03M) σ_1=3MPa, σ_2 = 2MPa σ_3 = 1MPa (03M) τ_{max}= 1 MPa	20

16	Determination of angle of twist Determination of maximum shear stress Determination of %error	Formula (01M) $\theta = 0.0580$ radians (04M) Formula (01M) $\tau_{max} = 565.88$MPa (02M) %error = 32.25 (02M)	20
17	Determination of the size of the shaft	Calculation of $J = 0.05796 d_1^4$ [02M] Calculation of Torque T = 1.49207 N-mm [03M] Calculation of d1 & d2 using Torsion formula d1 = 200.37 mm, d2 = 160.3 mm [05M]	20