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) & VII DE

Date: 27.09.2019
Time: 9:30AM to 10:30AM
Max Marks: 40
Weightage: 20%

Instructions: *All questions are compulsory*

Part A [Memory Recall Questions]

Answer both the Questions. Each question carries ten marks. (2Qx10M=20M)

1. Derive the equations of equilibrium for shear stress on a plane element in two planes xy and yz. [5+5M]

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

2. Derive the strain components acting on the planar element at an angle α from the horizontal surface. [10M]

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

Part B [Thought Provoking Questions]

Answer all the sub Questions. Each sub question carries two marks. (5Qx2M=10M)

3. Fill in the following blanks [10M]

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

a. In a given multi-boundary problem, if the value of stress function phi(x,y)=0 in one boundary , its value in other boundaries________________.

b. The maximum shear stress plane (angle measured w.r.t principal axes) has one of the direction cosines equal to_________________.

c. If at a point ex= 400, ey=200, ez=100, yyz= 50, yzx=yxy=0, then _______ is principal strain.

d. The pricipal stresses at a poinnt are 8MPa, -2MPa, and 5MPa. The normal and shear stress on an oblique plane having l=m= 0.707 are respectively________________.

e. If s1=s2=s3 = 10N/mm2, the normal and shear stress on any oblique plane will be respectively________________.

Part C [Problem Solving Questions]

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

5. Draw the Mohr circle and illustrate the equations of stress both graphically and symbolically. Will the equation remains valid when the element has acceleration and why? [10M]

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

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Date: 27/9/2019

Semester: 7

Time: 9:30-10:30

Course Code: MEC321

Max Marks: 40

Course Name: Theory of Elasticity

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			
Q1.	I	I		10	K							10
Q2.	I	I		10	K							10
Q3	I	I					5	K				5
Q4							5	K				5
Q5										10	K	10
	Total Marks											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 with certify that all the questions are set as per the above guidelines. Ms. Nikhat}

Reviewer's Comments,

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Date:27/9/2019

Semester: 7

Time: 9:30-10:30

Course Code: MEC 321

Max Marks:40

Course Name:THEORY OF ELASTICITY

Weightage: 20

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

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

Q. No. 1 | 5+5 | 10

intersections with the circle give ϵ_1, ϵ_2. The angle 2ϕ is the angle of FA below this axis.

13. Differential Equations of Equilibrium. We now consider the equilibrium of a small rectangular block of edges h, k, and unity (Fig. 19). The stresses acting on the faces 1, 2, 3, 4, and their positive directions are indicated in the figure. On account of the variation of stress throughout the material, the value of, for instance, σ_x is not quite the same for face 1 as for face 3. The symbols σ_x, σ_y, τ_{xy} refer to the point x, y, the mid-point of the rectangle in Fig. 19. The values at the mid-points of the faces are denoted by $(\sigma_x)_1$, $(\sigma_x)_3$, etc. Since the faces are very small, the corresponding forces are obtained by multiplying these values by the areas of the faces on which they act.[1]

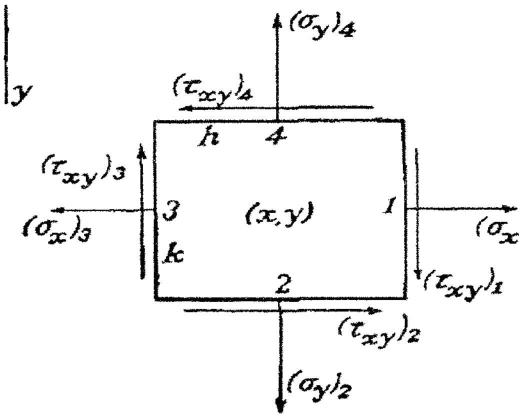

Fig. 19.

The body force on the block, which was neglected as a small quantity of higher order in considering the equilibrium of the triangular prism of Fig. 12, must be taken into consideration, because it is of the same order of magnitude as the terms due to the variations of the stress components which are now under consideration. If X, Y denote the components of body force per unit volume, the equation of equilibrium for forces in the x-direction is

$$(\sigma_x)_1 k - (\sigma_x)_3 k + (\tau_{xy})_2 h - (\tau_{xy})_4 h + Xhk = 0$$

or, dividing by hk,

$$\frac{(\sigma_x)_1 - (\sigma_x)_3}{h} + \frac{(\tau_{xy})_2 - (\tau_{xy})_4}{k} + X = 0$$

If now the block is taken smaller and smaller, *i.e.*, $h \rightarrow 0$, $k \rightarrow 0$, the limit of $[(\sigma_x)_1 - (\sigma_x)_3]/h$ is $\partial\sigma_x/\partial x$ by the definition of such a derivative. Similarly $[(\tau_{xy})_2 - (\tau_{xy})_4]/k$ becomes $\partial\tau_{xy}/\partial y$. The equation of equilibrium for forces in the y-direction is obtained in the same manner. Thus

$$\begin{aligned} \frac{\partial\sigma_x}{\partial x} + \frac{\partial\tau_{xy}}{\partial y} + X &= 0 \\ \frac{\partial\sigma_y}{\partial y} + \frac{\partial\tau_{xy}}{\partial x} + Y &= 0 \end{aligned} \qquad (18)$$

In practical applications the weight of the body is usually the only body force. Then, taking the y-axis downward and denoting by ρ the mass per unit volume of the body, Eqs. (18) become

Q. No. 2

16. Strain at a Point. When the strain components ϵ_x, ϵ_y, γ_{xy} at a point are known, the unit elongation for any direction, and the decrease of a right angle—the shearing strain—of any orientation at the point can be found. A line element PQ (Fig. 17a) between the points (x,y), $(x + dx, y + dy)$ is translated, stretched (or contracted) and rotated into the line element $P'Q'$ when the deformation occurs. The displacement components of P are u, v, and those of Q are

$$u + \frac{\partial u}{\partial x} dx + \frac{\partial u}{\partial y} dy, \qquad v + \frac{\partial v}{\partial x} dx + \frac{\partial v}{\partial y} dy$$

If $P'Q'$ in Fig. 17a is now translated so that P' is brought back to P, it is in the position PQ'' of Fig. 17b, and QR, RQ'' represent the components of the displacement of Q relative to P. Thus

$$QR = \frac{\partial u}{\partial x} dx + \frac{\partial u}{\partial y} dy, \qquad RQ'' = \frac{\partial v}{\partial x} dx + \frac{\partial v}{\partial y} \partial y \qquad (a)$$

The components of this relative displacement QS, SQ'', normal to PQ'' and along PQ'', can be found from these as

$$QS = -QR \sin\theta + RQ'' \cos\theta, \qquad SQ'' = QR \cos\theta + RQ'' \sin\theta \qquad (b)$$

ignoring the small angle QPS in comparison with θ. Since the short line QS may be identified with an arc of a circle with center P, SQ''

ignoring the small angle QPS in comparison with θ. Since the short line QS may be identified with an arc of a circle with center P, SQ''

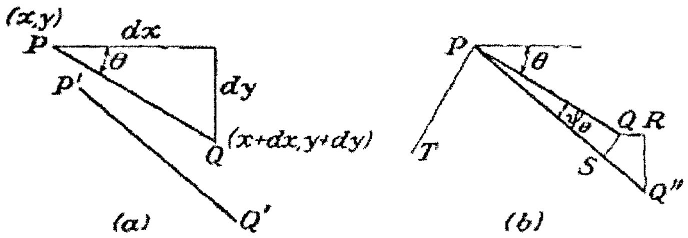

Fig. 17.

gives the stretch of PQ. The unit elongation of $P'Q'$, denoted by ϵ_θ, is SQ''/PQ. Using (b) and (a) we have

$$\begin{aligned}\epsilon_\theta &= \cos\theta\left(\frac{\partial u}{\partial x}\frac{dx}{ds} + \frac{\partial u}{\partial y}\frac{dy}{ds}\right) + \sin\theta\left(\frac{\partial v}{\partial x}\frac{dx}{ds} + \frac{\partial v}{\partial y}\frac{dy}{ds}\right)\\ &= \frac{\partial u}{\partial x}\cos^2\theta + \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)\sin\theta\cos\theta + \frac{\partial v}{\partial y}\sin^2\theta\end{aligned}$$

or

$$\epsilon_\theta = \epsilon_x \cos^2\theta + \gamma_{xy}\sin\theta\cos\theta + \epsilon_y \sin^2\theta \qquad (c)$$

which gives the unit elongation for any direction θ.

The angle ψ_θ through which PQ is rotated is QS/PQ. Thus from (b) and (a),

$$\psi_\theta = -\sin\theta\left(\frac{\partial u}{\partial x}\frac{dx}{ds} + \frac{\partial u}{\partial y}\frac{dy}{ds}\right) + \cos\theta\left(\frac{\partial v}{\partial x}\frac{dx}{ds} + \frac{\partial v}{\partial y}\frac{dy}{ds}\right)$$

or

$$\psi_\theta = \frac{\partial v}{\partial x}\cos^2\theta + \left(\frac{\partial v}{\partial y} - \frac{\partial u}{\partial x}\right)\sin\theta\cos\theta - \frac{\partial u}{\partial y}\sin^2\theta \qquad (d)$$

10 15

Part B(5Q x 2M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
Q3.	a. in a given multi-boundary problem , if the value of stress function phi(x,y)=0 in one boundary , its value in other boundaries----will have non-zero values b. c. 2. the maximum shear stress plane(angle measured w.r.t principal axes) has one of the direction cosines equal to------0 d. 3. if at a point ex= 400, ey=200, ez=100, yyz= 50, yzx=yxy=0, then ------------ ey is principal strain e. 4. the pricipal stresses at a poinnt are 8MPa, -2MPa, and 5MPa. the normal and shear stress on an oblique plane having l=m= 0.707 are respectively---3MPa, 7MPa f. 5. if s1=s2=s3 = 10N/mm2, the normal and shear stress on any oblique plane will be respectively----- 10N/mm2, 0	2*5 =10	5
			5

Part C (Q1 x 10M = 10Marks)

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

Q5.		10	10

A diagram, such as shown in Fig. 13, can be used also for determi[ning] principal stresses if the stress components σ_x, σ_y, τ_{xy} for any two perpendicular planes (Fig. 12) are known. We begin in such a case with the plotting of the two points D and D_1, representing stress conditions on the two coordinate planes (Fig. 16). In this manner the diameter DD_1 of the circle is obtained. Constructing the circle, the principal stresses σ_1 and σ_2 are obtained from the intersection of the circle with the abscissa axis. From the figure we find

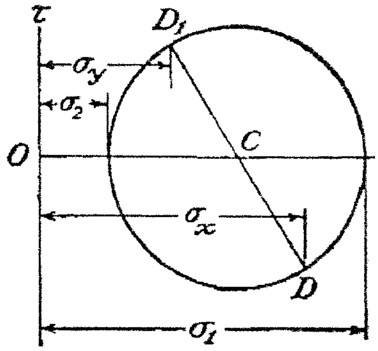

FIG. 16.

$$\sigma_1 = OC + CD = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_2 = OC - CD = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

The maximum shearing stress is given by the radius of the circle,

$$\tau_{max} = \frac{1}{2}(\sigma_1 - \sigma_2) = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

In this manner all necessary features of the stress distribution [at a] point can be obtained if only the three stress components σ_x, σ_y, $\tau_{x[y]}$

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BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

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

Date: 16.11.2019
Time: 9.30 AM to 10.30 AM
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. State and explain Saint Venant's Principle (C.O.NO.1) [Knowledge]
2. State and explain Compatibility conditions. (C.O.NO.1) [Comprehension]
3. State and explain stress function with an example. (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 2-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. Derive the expressions for stresses for the case of pure bending of a curved bar stating all necessary boundary conditions. (C.O.NO.2) [Application]

SCHOOL OF ENGINEERING

Sem AY: Odd Sem 2019-20
Course Code: MEC 321
Course Name: Theory of Elasticity
Program & Sem: B.Tech (Mech) & VII DE

Date: 16/11/2019
Time: 1.00hr
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

SCHOOL OF ENGINEERING

SOLUTION

Sem AY: Odd Sem 2019-20

Course Code: MEC-321

Course Name: Theory of Elasticity

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

Date: 16/11/2019

Time: 1.00 hr

Max Marks: 40

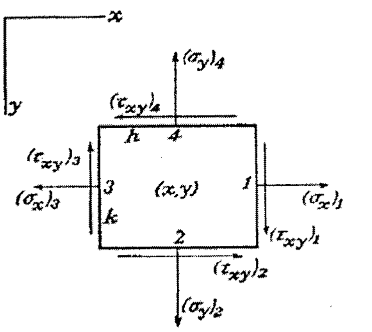
Weightage: 20%

Part A

(3Q x 6M = 18Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Statement of Saint Venant's Principle** **Explanation**	**03M** **03M**	**08 Min**
2	• Strain compatibility equations in 3D space are; $\frac{\partial^2 \gamma_{xy}}{\partial x \partial y} = \frac{\partial^2 \varepsilon_y}{\partial x^2} + \frac{\partial^2 \varepsilon_x}{\partial y^2}$ $2\frac{\partial^2 \varepsilon_x}{\partial y \partial z} = \frac{\partial}{\partial x}\left(-\frac{\partial \gamma_{yz}}{\partial x} + \frac{\partial \gamma_{zx}}{\partial y} + \frac{\partial \gamma_{xy}}{\partial z}\right)$ $\frac{\partial^2 \gamma_{yz}}{\partial y \partial z} = \frac{\partial^2 \varepsilon_y}{\partial z^2} + \frac{\partial^2 \varepsilon_z}{\partial y^2}$ $2\frac{\partial^2 \varepsilon_y}{\partial x \partial z} = \frac{\partial}{\partial y}\left(\frac{\partial \gamma_{yz}}{\partial x} - \frac{\partial \gamma_{zx}}{\partial y} + \frac{\partial \gamma_{xy}}{\partial z}\right)$ $\frac{\partial^2 \gamma_{xz}}{\partial x \partial z} = \frac{\partial^2 \varepsilon_z}{\partial x^2} + \frac{\partial^2 \varepsilon_x}{\partial z^2}$ $2\frac{\partial^2 \varepsilon_z}{\partial x \partial y} = \frac{\partial}{\partial z}\left(\frac{\partial \gamma_{yz}}{\partial x} + \frac{\partial \gamma_{zx}}{\partial y} - \frac{\partial \gamma_{xy}}{\partial z}\right)$	**Explanation with equations=06M**	**08 Min**
3	Definition of stress function Explanation with an example	**02M** **04M**	**0 8Min**

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

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

Part C (1Q x12 M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	Neat figure with details of loading Stating necessary boundary conditions Deriving expressions for σ_r, σ_θ and $\tau_{r\theta}$	04M 02M 06M	18 Min

Roll No												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

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) & VII (DE-III)

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 plane strain. (C.O.No.1) [Knowledge]
2. What are elastic constants briefly explain. (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. State the equations of equilibrium in three dimensions. (C.O.No.2) [Knowledge]
6. Briefly explain what you mean compatibility condition. (C.O.No.2) [Knowledge]
7. Define stress Invariants. (C.O.No.2) [Knowledge]
8. Define strain at point. (C.O.No.2) [Knowledge]
9. Briefly explain "Torsion formula". (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. Giving equations. [7M] (C.O.No.1) [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 σ_x , σ_y and τ_{xy} for rectangular beam in Cartesian coordinates using 4th order Polynomial. [8M] (C.O.No.2) [Comprehension]

Part C [Problem Solving Questions]

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

15. $$\sigma_{ij} = \begin{bmatrix} 18 & 24 & 0 \\ 24 & 32 & 0 \\ 0 & 0 & -20 \end{bmatrix} \text{MPa}$$

Determine a) The Principal Invariants of σ b) Principal stresses and value maximum shear stress (C.O.No.2) [Application]

16. A hollow circular shaft 200mm external diameter and metal thickness 25 mm is transmitting power at 200 rpm. The angle of twist over a length of 2 m was found to be 0.5 degrees. Calculate the power transmitted and the maximum shear stress induced in the section. Take modulus of rigidity of the material as 84 kN/mm^2. (C.O.No.3) [Application]

17. The uniformly tapering shaft as shown in the Fig.1 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]

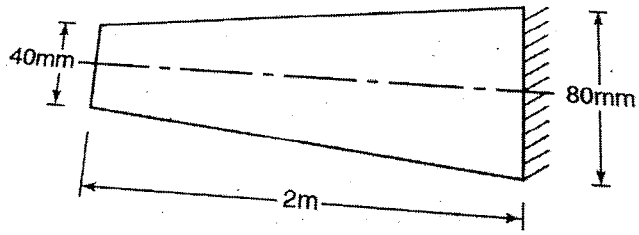


Fig. 1

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

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	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
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) & 5^{th}

Date: 20/12/2019

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 plane strain**	**02**	**50 min**
2	**E, G ,K and brief explanation**	**02**	
3	**Statement of Saint Venants principle**	**02**	
4	Significance of bi harmonic equation	**02**	
5	3 Equilibrium Equations in X,Y & Z directions	**02**	
6	Brief Explanation regarding compatibility conditions	**02**	
7	Definitions of I_1, I_2 & I_3	**02**	
8	Definition of strain at a point	**02**	
9	Torsion formula T/J=Gθ/L=fs/r	**02**	
10	Define polar moment of Inertia	**02**	

Part B (2Q x 7M+2Qx8M = 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; $\frac{\partial^2 \gamma_{xy}}{\partial x \partial y} = \frac{\partial^2 \varepsilon_y}{\partial x^2} + \frac{\partial^2 \varepsilon_x}{\partial y^2}$ $2\frac{\partial^2 \varepsilon_x}{\partial y \partial z} = \frac{\partial}{\partial x}\left(-\frac{\partial \gamma_{yz}}{\partial x} + \frac{\partial \gamma_{zx}}{\partial y} + \frac{\partial \gamma_{xy}}{\partial z}\right)$ $\frac{\partial^2 \gamma_{yz}}{\partial y \partial z} = \frac{\partial^2 \varepsilon_y}{\partial z^2} + \frac{\partial^2 \varepsilon_z}{\partial y^2}$ $2\frac{\partial^2 \varepsilon_y}{\partial x \partial z} = \frac{\partial}{\partial y}\left(\frac{\partial \gamma_{yz}}{\partial x} - \frac{\partial \gamma_{zx}}{\partial y} + \frac{\partial \gamma_{xy}}{\partial z}\right)$ $\frac{\partial^2 \gamma_{zx}}{\partial x \partial z} = \frac{\partial^2 \varepsilon_z}{\partial x^2} + \frac{\partial^2 \varepsilon_x}{\partial z^2}$ $2\frac{\partial^2 \varepsilon_z}{\partial x \partial y} = \frac{\partial}{\partial z}\left(\frac{\partial \gamma_{yz}}{\partial x} + \frac{\partial \gamma_{zx}}{\partial y} - \frac{\partial \gamma_{xy}}{\partial z}\right)$	**Explanation with equations=07M**	20
13	Torsional Rigidity Explannation with Equation Torsional strenght Explannation with Equation	**Explanation with equation** **Gθ = 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)**	

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=30MPa, I2 = 1000MPa, I3 = 0 MPa (03M) σ_1=50MPa, σ_2 = 0MPa σ_3 = -20MPa (03M) τ_{max}= 35 MPa	20
16	Determination of Power transmitted Determination of maximum shear stress induced	Formula (01M) P = 824.27 kW (04M) Formula (01M) q_s= 36.652 N/mm^2 (04M)	30

17	Determination of angle of twist Determination of maximum shear stress Determination of %error	Formula (01M) $\theta = 0.0580$ radians (04M) Formula (01M) $\tau_{max} = 565.88MPa$ (02M) %error = 32.25 (02M)	20