Roll No.												

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem. 2019-20 | **Date**: 01.10.2019
Course Code: MEC 220 | **Time**: 2.30PM to 3.30PM
Course Name: FINITE ELEMENT ANALYSIS | **Max Marks**: 40
Program & Sem: B.Tech (MEC) & V | **Weightage**: 20%

Instructions:

i. Answer all the Questions.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries five marks. (3Qx5M=15M)

1. Enumerate the steps involved in FEA. (C.O.NO.1) (Knowledge)
2. Define Plane Stress with a neat sketch, and write the constitutive equation for a plane stress condition. (C.O.NO.1) (Comprehension)
3. Explain briefly the various types of elements used in FEA along with their degrees of freedom. (C.O.NO.1) (Knowledge)

Part B [Thought Provoking Questions]

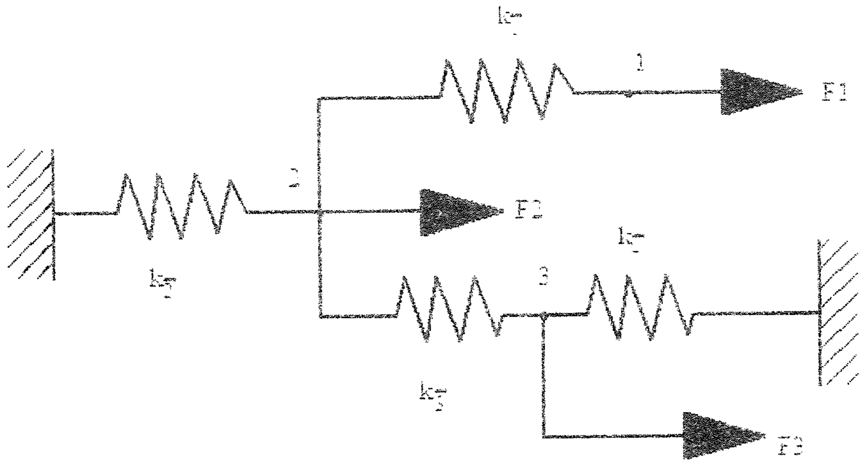
Answer the Question. The Question carries fifteen marks. (1Qx15M=15 M)

4. As a part of the smart city project, it is necessary to build the indoor stadium at Tumkur with a seating capacity of 3000 people. The frames used for the seating arrangement will be suspended freely at one end whereas the other end will be fixed to the walls, so that the each frame represents a cantilever beam. As a FEA engineer determine the maximum deflection that the cantilever beam may undergo using Rayleigh Ritz method if the load at the tip of the beam is P. Assume the span of the beam be as "L", E = Young's modulus of the beam, I = moment of inertia of the beam. (C.O.NO.1) [Application]

Part C [Problem Solving Questions]

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

5. Solve for the nodal displacement in the following spring system. Where k_1 = 50N/mm, k_2 = 50N/mm, k_3 = 60N/mm, k_4 = 80N/mm, F_1= 100N, F_2 = 0, F_3 = 60N, ∂_1, ∂_2, ∂_3, and ∂_4, are the deflections of the springs with stiffness k_1, k_2, k_3 and k_4 respectively shown in the diagram below. (C.O.NO.1) (Application)



SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: V

Course Code: MEC220

Course Name: **FINITE ELEMENT ANALYSIS**

Date: 01-10-2019

Time: 2.30PM to 3.30PM

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	1	1	1	5	K							5
2	1	1	1	5	C							5
3	2	2	1	5	K							5
4	1	1							15			15
5	1	1							15			15
6	1	1							10			10
	Total Marks	40	15						25			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. Mr. Shylesh K S]

Reviewers' Comments

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

Semester: V
Course Code: MEC220
Course Name: FINITE ELEMENT ANALYSIS

Date: 01-10-2019
Time: 2.30PM to 3.30PM
Max Marks: 40
Weightage: 20%

Part A **(3 x 5M = 15 Marks)**

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Step-1 Modeling** **i.** Mathematical modelling **ii.** Geometric Modelling **Step-2** Discretization of the Model **Step-3** Selection of Displacement Model or Formulation of Elemental Displacement Model **Step 4:** Derivation of Elemental Stiffness Matrix **Step 5:** Assembly Elemental Stiffness Matrix or Formation of Global Stiffness Matrix **Step 6:** Applying the Boundary Conditions **Step 7:** Obtaining the Stress and Strain	Only listing is sufficient totally 7 steps should be mentioned 5 Marks	**2 Mins**

2	Plane stress condition [illegible] defined to be a state of stress in which the normal stress (σ) and shear [illegible] directed perpendicular to the plane are assumed to be zero Here σ_x, σ_y, τ_{xy} is given by $\sigma_x = \frac{E}{(1-\nu^2)}(\varepsilon_x+\nu\varepsilon_y)$ $\sigma_y = \frac{E}{(1-\nu^2)}(\nu\varepsilon_x+\varepsilon_y)$ $\tau_{xy} = \frac{E}{(1-\nu^2)}\frac{(1-\nu)}{2}\gamma_{xy}$ In matrix form it is written as $\begin{Bmatrix}\sigma_x\\ \sigma_y\\ \tau_{xy}\end{Bmatrix} = \frac{E}{(1-\nu^2)}\begin{bmatrix}1 & \nu & 0\\ \nu & 1 & 0\\ 0 & 0 & \frac{1-\nu}{2}\end{bmatrix}\begin{Bmatrix}\varepsilon_x\\ \varepsilon_y\\ \gamma_{xy}\end{Bmatrix}$	**Definition of plane stress 2Marks** **Constitutive Equation 3 Marks**	**3 Mins**
3	[illegible]	**5 Marks**	**7 Mins**

Part B **(1 Q x 15M = 15 Marks)**

Q No	Solution	Scheme of Marking	Max. time required for each Question
4	Writing down the beam diagram with all the loading arrangements Equation for potential energy functional π = Strain Energy + Work Potential Strain Energy (SE) = $\frac{1}{2}\int EI\,(\frac{\partial^2 y}{\partial x^2})^2\,dx$ Work Potential (WP) = - PYmax $\pi = \{\frac{1}{2}\int EI\,(\frac{\partial^2 y}{\partial x^2})^2\,dx + (-\,PY_{max})\}$ ----------------------1 Assumed Polynomial Function $Y = a_o + a_1 x + a_2 x^2 + a_3 x^3$---------------------------2 Boundary Conditions at **i.** X=O; Y=0. ➔ $a_0 = 0$-----------------------------3 **ii.** X=0; dy/dx=0 ➔ $a_1 = 0$ ---------------------------4 **iii.** X=L, Y = Y_{MAX} **iv.** $\frac{\partial^2 y}{\partial x^2} = 0$ $a_2 = -3a_3L$ ---5 therefore $\frac{\partial^2 y}{\partial x^2} = 6a_3\,(X-L)$ $SE = \frac{36a_3EIL^3}{6}$ $\pi = \frac{36a_3EIL^3}{6} + 2a_3PL^3$ --------------------------------6 minimize the potential energy equation with respect to a_3 thereby $a_3 = \frac{-P}{6EI}$ ---7 Substituting the values of a_0, a_1, a_2, and a_3 in equation "2" we get	1 Mark 3 Marks 2 Marks 3 Marks 3 Marks	20 Mins

	$Y_{max} = \frac{PL^3}{3EI}$ ----------------------------------8 Equation gives the final answer, i.e. maximum deflection at the free end in cantilever beam.	3 Marks	
5	Writing down the bar diagram with all the loading arrangements Equation for potential energy functional π = Strain Energy + Work Potential Strain Energy (SE) = $\frac{1}{2}\int EA(\frac{\partial u}{\partial x^2})^2 dx$ Work Potential (WP) = - $2U_1$ $\pi = \{\frac{1}{2}\int EA(\frac{\partial u}{\partial x^2})^2 dx - 2U_1)\}$ Assumed Polynomial Function $U = a_o + a_1 x + a_2 x^2 + a_3 x^3$ Boundary Conditions at **i.** X=O; U=0, → $a_0 = 0$ **ii.** X=2; U=0, → $a_1 = -2a_2$ **iii.** X=1; U=U_1, → $U_1 = -a_2$ Then Value of "π" will become: **$\pi = 1.33a_2^2 + 2a_2^2$** Minimizing the potential energy functional, we get **a_2 = -0.75 units** Therefore displacement at the loading point is given by $U_1 = -a_2$ **U_1 = 0.75 units**	3 Marks 6 Marks 6 Marks	20 Mins

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

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	Q6 [illegible]	Expressing the relationship between U_1, U_2, and U_3 and ∂_1, ∂_2, ∂_3, & ∂_4. 3 Marks Arriving at Equation 3 2 Marks Arriving at Equation 5, 7 and 8 2 Marks Solving for U_1, U_2, and U_3 1 mark each	15 mins

[illegible]

$= 3000 U_2$ [illegible]

$= 11800 U_2$

$U_2 = 1.18 \text{ mm}$

[illegible] $= 140$ [illegible]

[illegible]

$U_2 =$ [illegible] mm

[illegible]

$U = 3.$ [illegible] mm

$U_1 = 3.6$ [illegible] mm

$U_2 = $ [illegible] 61 [illegible] mm

$U_3 = 1.19$ mm

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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20
Course Code: MEC 220
Course Name: FINITE ELEMENT ANALYSIS
Program & Sem: B.Tech. (MEC) & V

Date: 19.11.2019
Time: 2.30 PM to 3.30 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) All the questions compulsory.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries five marks. (3Qx5M=15M)

1. Write down the expression for shape functions for 2-D four noded (linear) quadrilateral element with usual notations. Sketch the element diagram (C.O.NO.3) [Knowledge]

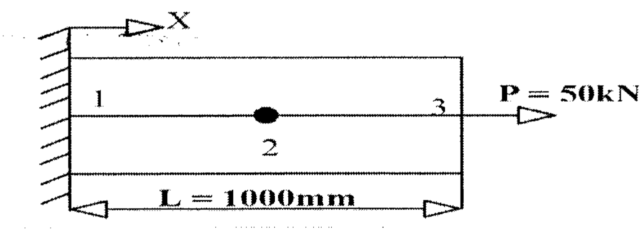
2. Define Shape functions and briefly explain the characteristics of shape functions in FEM. (C.O.NO.3) [Knowledge]

3. Define Truss and write down the equilibrium equation for truss element in the expanded form. (C.O.NO.4) [Knowledge]

Part B [Thought Provoking Questions]

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

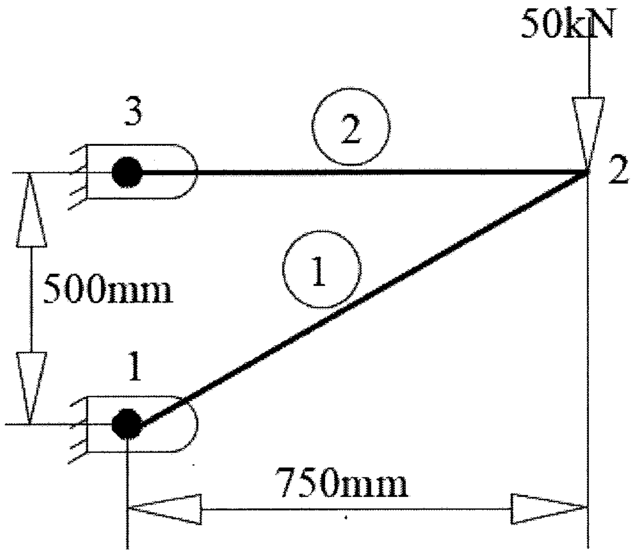
4. Determine the nodal displacement, stresses and reaction forces for the one-dimensional bar element made up of mild steel with Young's modulus 200GPa and cross sectional area of 200mm^2 shown in the below figure. (Consider the given bar as a two element). (C.O.NO.3) [Application]



Part C [Problem Solving Questions]

Answer the Question. The Question carry fifteen marks. **(1Qx15M=15M)**

5. Determine the nodal displacements of the truss member made up of mild steel with Young's modulus 200GPa and cross sectional area of A_1=1000mm^2 A_2= 1250mm^2 as shown in the below figure. (C.O.NO.4) [Application]



SCHOOL OF ENGINEERING

Semester: V

Course Code: MEC 220

Course Name: Finite Element Analysis

Date: 19-11-2019

Time: 2.30PM to 3.30 PM

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	K	C	A	K	C	A	
1	CO-3	MODULE-	5									5
2	CO-3	MODULE-3	5									5
3	CO-4	MODULE-4	5									5
4	CO-3	MODULE-3						10				10
5	CO-3	MODULE-2									15	15
6	CO-3	MODULE-3										
7	CO-3	MODULE-3										
	Total Marks		**15**					**10**			**15**	**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

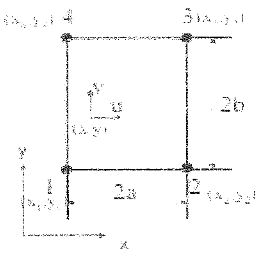
SCHOOL OF ENGINEERING

SOLUTION

Semester: V
Course Code: MEC207
Course Name: Finite Element Analysis
Program & Sem: B.TECH. MECH ENGINEERING

Date: 19-11-2019
Time: 2.30 PM to 3.30PM
Max Marks: 40 MARKS
Weightage: 20%

Part A **(3Q x 5M = 15Marks)**

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	Diagram with usual notations  $u(x,y)=\sum_{i=1}^{4} N_i(x,y)u_i$ $v(x,y)=\sum_{i=1}^{4} N_i(x,y)v_i$ $N_1=\frac{1}{2}(1-\xi)\cdot\frac{1}{2}(1-\eta),\quad N_2=\frac{1}{2}(1+\xi)\cdot\frac{1}{2}(1-\eta)$ $N_3=\frac{1}{2}(1+\xi)\cdot\frac{1}{2}(1+\eta),\quad N_4=\frac{1}{2}(1-\xi)\cdot\frac{1}{2}(1+\eta)$	1Marks 4 Marks for the expression	2 Mins 2 Mins
2	Definition of the Shape Function 4 Characteristics of the shape functions	1Marks 4 Marks for shape function characteristics	1 Mins 1 Mins

3	Definition of the Truss Element	1 Marks	1 Mins
	Stiffness equation of a truss element: $[k_e] = \frac{E_e A_e}{l_e}\begin{bmatrix} l^2 & lm & -l^2 & -lm \\ lm & m^2 & -lm & -m^2 \\ -l^2 & -lm & l^2 & lm \\ -lm & -m^2 & lm & m^2 \end{bmatrix}$	4 Marks	1 Mins
	Part B	**(1Q x 10M = 10Marks)**	
4	1. Writing down the finite element model of the given continuum with two element discretization.	1Marks	1 Mins
	2. Determination of elemental stiffness matrix for two elements and global stiffness matrix. $[k_1] = 10^4 \begin{bmatrix} 8 & -8 \\ -8 & 8 \end{bmatrix}$	1Marks	
	$[k_2] = 10^4 \begin{bmatrix} 8 & -8 \\ -8 & 8 \end{bmatrix}$	1Marks	4 Mins
	$[k] = 10^4 \begin{bmatrix} 8 & -8 & 0 \\ -8 & 16 & -8 \\ 0 & -8 & 8 \end{bmatrix}$	2Marks	1 Mins
	3. Writing down the global displacement vector and global force vector.	1Marks	
	4. Solving the equilibrium equation with the boundary conditions (elimination approach or penalty approach). $10^4 \begin{bmatrix} 8 & -8 & 0 \\ -8 & 16 & -8 \\ 0 & -8 & 8 \end{bmatrix} \begin{Bmatrix} 0 \\ q_2 \\ q_3 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 50 * 10^3 \end{Bmatrix}$	2Marks	3 Mins
	5. Arriving at the values for q_2 = 0.625mm and q_3 = 1.25mm	2Marks	2 Mins

Part C (1Q x 15M = 15Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	(see below)	4 Marks; 8 Marks	5 Mins; 15 Mins

1. Writing down the finite element model of the given continuum with two element discretization.
2. Tabulating the node data and determination of elemental data

Node Number	X (mm)	Y(mm)
1	0	0
2	750	500
3	0	500

Element Number	Initial node	Final node	Length of the element	l (mm)	m(mm)
1	1	2	901.39	0.832	0.555
2	2	3	750	-1	0

4 Marks — 5 Mins

3. **Determination of elemental stiffness matrix for two elements and global stiffness matrix.**

$$[k_1] = 10^5 \begin{bmatrix} 1.53 & 1.02 & -1.53 & -1.02 \\ 1.02 & 0.681 & -1.02 & -0.681 \\ -1.53 & -1.02 & 1.53 & 1.02 \\ -1.02 & -0.681 & 1.02 & 0.681 \end{bmatrix}$$

$$[k_2] = 10^5 \begin{bmatrix} 3.2 & 0 & -3.2 & 0 \\ 0 & 0 & 0 & 0 \\ -3.2 & 0 & 3.2 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$[k] = 10^5 \begin{bmatrix} 1.53 & 1.02 & -1.53 & -1.02 & 0 & 0 \\ 1.02 & 0.681 & -1.02 & -0.681 & 0 & 0 \\ -1.53 & -1.02 & 4.73 & 1.02 & -3.2 & 0 \\ -1.02 & -0.681 & 1.02 & 0.681 & 0 & 0 \\ 0 & 0 & -3.2 & 0 & 3.2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

8 Marks — 15 Mins

4. Writing down the global displacement vector and global force vector.
5. Solving the equilibrium equation with the boundary conditions (elimination approach or penalty approach).

$$10^5\begin{bmatrix} 1.53 & 1.02 & -1.53 & -1.02 & 0 & 0 \\ 1.02 & 0.681 & -1.02 & -0.681 & 0 & 0 \\ -1.53 & -1.02 & 4.73 & 1.02 & -3.2 & 0 \\ -1.02 & -0.681 & 1.02 & 0.681 & 0 & 0 \\ 0 & 0 & -3.2 & 0 & 3.2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}\begin{Bmatrix} 0 \\ 0 \\ q_3 \\ q_4 \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -50 * 10^3 \\ 0 \\ 0 \\ 0 \end{Bmatrix}$$

Arriving at the values for displacements at node 2 as

q_3 = 0.25mm and q_4 = -1.09mm

3 Marks **10 Mins**

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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20 | **Date**: 28 December 2019

Course Code: MEC 220 | **Time**: 9.30 AM to 12.30 PM

Course Name: FINITE ELEMENT ANALYSIS | **Max Marks**: 80

Program & Sem: B.Tech (MEC) & V | **Weightage**: 40%

Instructions:

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

(ii) Scientific and non-programmable calculators are permitted.

Part A [Memory Recall Questions]

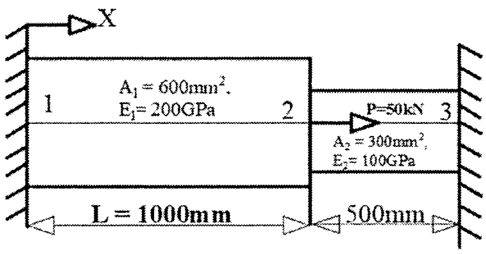
Answer all the Questions. Each Question carries 2 marks. (5Qx2M=10M)

1. Mention any four softwares used for Finite Element Analysis. (C.O.No.1) [Knowledge]
2. Write down the shape functions for 1-D two noded bar element. (C.O.No.2) [Knowledge]
3. Write down the stiffness matrix for 1D linear bar element. (C.O.No.3) [Knowledge]
4. Write down the equilibrium equation for truss element in the expanded form. (C.O.No.4) [Knowledge]
5. Write down the finite element equation for 1-D heat conduction with free end convection. (C.O.No.5) [Knowledge]

Part B [Thought Provoking Questions]

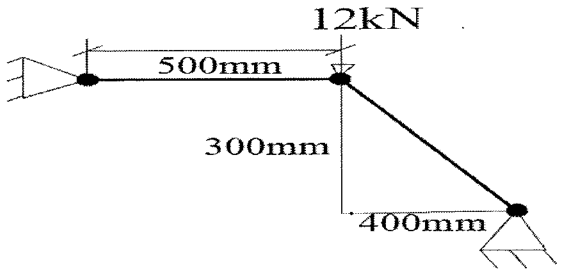
Answer both Questions. Each Question carries 15 marks. (2Qx15M=30M)

6. Determine nodal displacements in stepped bar given below which is constrained on both ends.



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

7. Determine the nodal displacements for the following two member truss element given below. (E= 2 X 10^2 N/mm^2, A = 200mm^2)

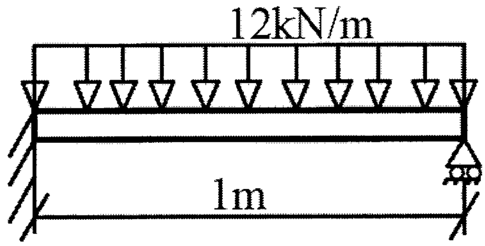


(C.O.No.4) [Application]

Part C [Problem Solving Questions]

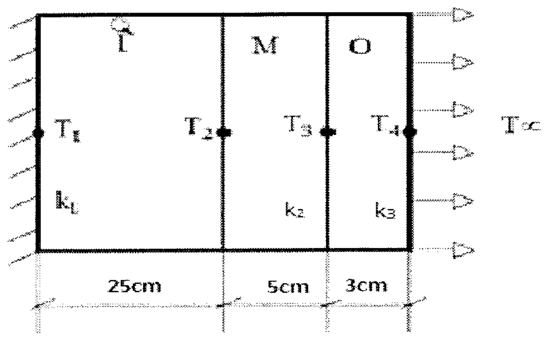
Answer both Questions. Each Question carries 20 marks. **(2Qx20M=40M)**

8. For the beam shown below, obtain the maximum deflection due to the uniformly distributed load. Take young's modulus E=200GPa, and Moment of Inertia I = 2x10^6 mm^4.



(C.O.No.4) [Application]

9. An induction furnace wall is made up of three layers, inside, middle and outer layer with thermal conductivity k_1, k_2 and k_3 respectively as shown in figure below. Determine the nodal temperature. Given k_1 = 8.5W/m-K, k_2 = 0.25 W/m K and k_3 = 0.08 W/m-K, T_1 = 600^0C T_∞ = 300^0C, h= 45W/m^2K.



(C.O.No.5) [Application]

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	
1	1	1	2			2
2	2	2	2			2
3	3	3	2			2
4	4	4	2			2
5	5	5	2			2
6	3	3		15		15
7	4	4			15	15
8	4	4			20	20
9	5	5			20	20
	Total Marks		10	15	55	80

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 guidelines.

Faculty Signature:

Reviewer Commend:

Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

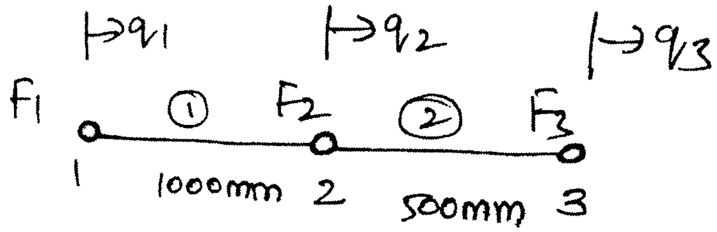
Semester: Odd Sem. 2019-20
Course Code: MEC 220
Course Name: FINITE ELEMENT ANALYSIS
Program & Sem: BTECH-5TH

Date: 28.12.2019
Time: 3 HRS
Max Marks: 80
Weightage: 40%

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

Q No	Solution	Scheme of Marking	Max. Time required fo each Question
1	Softwares • LS-Dyna • Ansys • ABAQUS • Openfoam • Hyperworks • Fusion 360 • Pam crash • Nastran	**0.5 mark for each software**	**5min**
2	N1=(1- ξ)/2, N2=(1+ ξ)/2	**1mark for each**	**5min**
3	$k = \frac{AE}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$	**2M**	**5min**
4	$[k_e] = \frac{E_e A_e}{l_e}\begin{bmatrix} l^2 & lm & -l^2 & -lm \\ lm & m^2 & -lm & -m^2 \\ -l^2 & -lm & l^2 & lm \\ -lm & -m^2 & lm & m^2 \end{bmatrix}$	**2M**	**5min**
5	$\left[\frac{Ak}{le}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} + hA\begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}\right]\begin{Bmatrix} T_1 \\ T_2 \end{Bmatrix} = AhT_\infty\begin{Bmatrix} 0 \\ 1 \end{Bmatrix}$	**2M**	**5min**

Part B (2Q x 15M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	 $[K] = 10^5 \begin{bmatrix} 1.2 & -1.2 & 0 \\ -1.2 & 1.8 & -0.6 \\ 0 & -0.6 & 0.6 \end{bmatrix}$ $[Q] = [0 \quad q_2 \quad 0]^T$ $[F] = [0 \quad 5\times10^4 \quad 0]^T$ $q_2 = 0.278\ mm$	15M	**35min**

7		15M	40min

(i) Nodal coordinate data

Node No	x	y
1	900	0
2	500	300
3	0	300

(ii) Element conectivity data

Element	Initial node	Final node	le	l	m
1	1	2	500	-0.8	0.6
2	2	3	500	-1	0

$$[K] = 10^4 \begin{bmatrix} 5.12 & -3.84 & -5.12 & 3.84 & 0 & 0 \\ -3.84 & 2.88 & 3.84 & -2.88 & 0 & 0 \\ -5.12 & 3.84 & 13.12 & -3.84 & -8 & 0 \\ 3.84 & -2.88 & -3.84 & 2.88 & 0 & 0 \\ 0 & 0 & -8 & 0 & 8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$[F] = \{0 \quad 0 \quad 0 \quad -12\times10^3 \quad 0 \quad 0\}^T$$

$$[Q] = \{0 \quad 0 \quad q_3 \quad q_4 \quad 0 \quad 0\}^T$$

$$q_3 = -0.2$$

$$q_4 = -0.683$$

Part C (2Q x 20M = 40Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
8	$[K] = 400 \begin{bmatrix} 12 & 6 & -12 & 6 \\ 6 & 4 & -6 & 2 \\ -12 & -6 & 12 & -6 \\ 6 & 2 & -6 & 4 \end{bmatrix}$ $[F] = \{-6 \ -1 \ -6 \ 1\}^T$ $[Q] = \{v_1 \ \theta_1 \ v_2 \ \theta_2\}^T$ $= \{0 \ 0 \ 0 \ \theta_2\}^T$ $\theta_2 = 6.25 \times 10^{-4}$ rad. maximum deflection $v_{max} = \frac{l_e}{2} H_4 \theta_2$ $= \frac{1}{2}\left(\frac{-1}{4}\right) 6.25 \times 10^{-4}$ $v_{max} = 7.8125 \times 10^{-5}$ m.	20M	40min

9	$$[k_c] = \begin{bmatrix} 34 & -34 & 0 & 0 \\ -34 & 39 & -5 & 0 \\ 0 & -5 & 7.66 & -2.66 \\ 0 & 0 & -2.66 & 2.66 \end{bmatrix}$$ $$[k_h]_{end} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 45 \end{bmatrix}$$ $$[K] = \begin{bmatrix} 34 & -34 & 0 & 0 \\ -34 & 39 & -5 & 0 \\ 0 & -5 & 7.66 & -2.66 \\ 0 & 0 & -2.66 & 47.66 \end{bmatrix}$$ $$[F] = \{0 \quad 0 \quad 0 \quad 13635\}^T$$ T2=846K T3=664K T4=323K	20M	**40min**