ELIZADE UNIVERSITY ILARA MOKIN, ONDO STATE

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIRST SEMESTER EXAMINATION, 2020/2021 ACADEMIC SESSION

COURSE TITLE: ENGINEERING MATHEMATICS III

COURSE CODE: EEE / GNE 315 (3-units)

EXAMINATION DATE:

COURSE LECTURER: DR T. O. ALE

HOD's Signature

TIME ALLOWED: 2½ HOURS

INSTRUCTIONS:

1. *ANSWER QUESTION 1 AND ANY OTHER TWO QUESTIONS.*
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM.
3. YOU ARE NOT ALLOWED TO BORROW ANY WRITING MATERIALS AND CALCULATORS DURING THE EXAMINATION.
4. SMART WATCHES ARE NOT ALLOWED IN THE EXAMINATION HALL

ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA

DEPARTMENT OF MECHANICAL ENGINEERING

FIRST SEMESTER EXAMINATIONS

2020/2021 ACADEMIC SESSION

COURSE:	MEE 525 – Finite Element Methods (3 Units)
CLASS:	500 Level Mechanical Engineering
TIME ALLOWED:	2 Hours 30 Minutes
INSTRUCTIONS:	Attempt any **FIVE** questions **(125 marks)**

HOD's SIGNATURE

Date: March, 2021

Question 1 (25 marks)

a) Briefly itemise the:

i. Pre-processing phase of the Finite Element Method (FEM) procedure, **...2.5 marks**

ii. Approaches to formulate the FEM problems. **...2.5 marks**

b) Use Figure 1-1 to answer the following questions:

i. Discretise the solution domain into four elements. **...5 marks**

ii. Obtain approximate solution to the behaviour of an element. **...5 marks**

iii. If each element is modelled as a spring, obtain the equivalent stiffness. **...5 marks**

iv. Derive the general form of the Finite Element Method approximation in matrix form. **...5 marks**

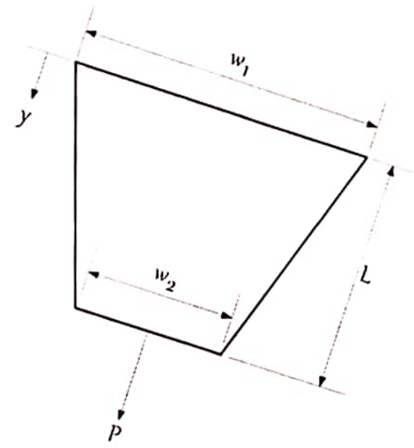


Figure 1-1: Variable cross section supporting a vertical load P; L is the length of the bar, w_1 and w_2 represent thickness of the bar at the two ends. The bar is fixed at the top

Question 2 (25 marks)

a) Itemise the steps required in Finite Element Analysis (FEA).

...5 marks

a) The stress distribution for a two dimensional rectangle element is given as:

$$\sigma^{(e)} = [S_i \quad S_j \quad S_p \quad S_q] \begin{bmatrix} \sigma_i \\ \sigma_j \\ \sigma_p \\ \sigma_q \end{bmatrix}$$

where, σ_i, σ_j, σ_p, and σ_q are stresses at nodes i, j, p, and q respectively. S_i, S_j, S_p, and S_q are shape functions for nodes i, j, p, and q respectively. Answer the following questions:

i. State the expressions for the shape functions in terms of local coordinates x and y.

...4 marks

ii. Shape functions in natural coordinates: If
$g = 2\frac{x}{l} - 1$ and $h = 2\frac{y}{w} - 1$,
Show that the shape functions provided in Question 2(i) can be expressed as:

$$S_i = 0.25(1 - g)(1 - h)$$
$$S_j = 0.25(1 + g)(1 - h)$$
$$S_p = 0.25(1 + g)(1 + h)$$
$$S_q = 0.25(1 - g)(1 + h)$$

...8 marks

iii. Write a C++ code to implement the shape functions S_i and S_j in a FEA software.

...8 marks

Question 3 (25 marks)

a) Write short notes on the steps involved in Finite Element Analysis (FEA).

...5 marks

b) Briefly use equations to describe the two properties of shape functions of linear elements for one dimensional Finite Element Method (FEM).

...5 marks

c) Derive shape functions for quadratic element of one dimensional FEM.

...15 marks

Question 4 (25 marks)

a) Briefly describe the Galerkin method and its application to FEM.

...5 marks

b) Derive from the first principles the shape functions for linear element of one dimensional FEM.

...10 marks

a) Write short notes on the relevance and limitations of analytical and numerical solution methods to engineering problems.

...10 marks

Question 5 (25 marks)

a) If the Galerkin method is applied to a typical physical model given in Equation (4 – 1), where ℵ is the model variable to be determined, X is space domain variable, and arbitrary constants (i.e. a, b, and c) are defined,

$$a\frac{d^2\aleph}{dX^2} = -b\aleph - c + S \qquad (4-1)$$

If the source term S is negligible, show that:

$$R_i^{(e)} = -a\left.\frac{d\aleph}{dX}\right|_{X=X_i} + \left(\frac{bl^2 - 3a}{3l}\right)\aleph_i + \left(\frac{bl^2 + 6a}{6l}\right)\aleph_j + c\frac{l}{2}$$

...25 marks

Question 6 (25 marks)

a) What are the domains of relevance to boundary and initial conditions in FEM.

...5 marks

b) Show that for a typical two dimensional problem, rectangular finite element rectangular approximation can be expressed in matrix form.

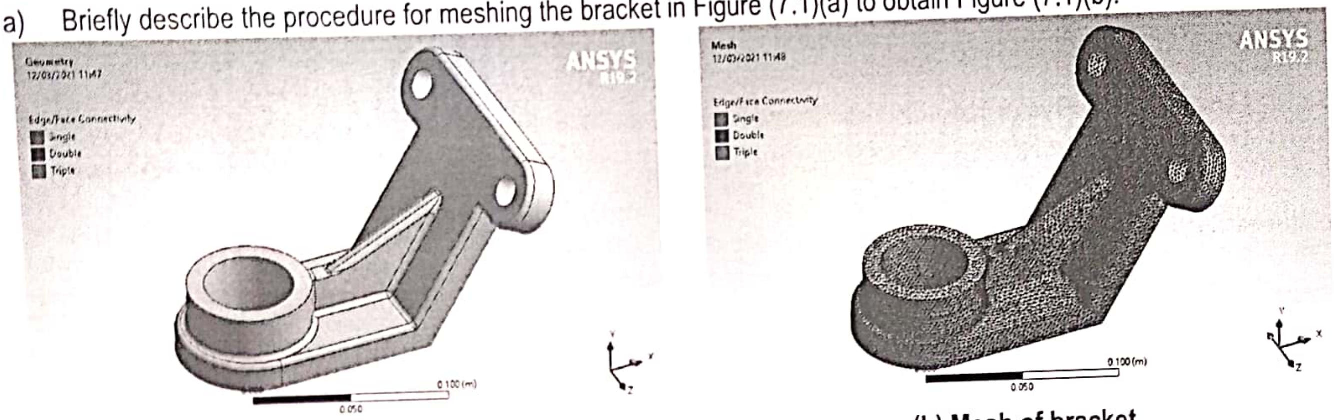
...17 marks

c) Define the key variables for Question 6(b).

...3 marks

Question 7 (25 marks)

a) Briefly describe the procedure for meshing the bracket in Figure (7.1)(a) to obtain Figure (7.1)(b):

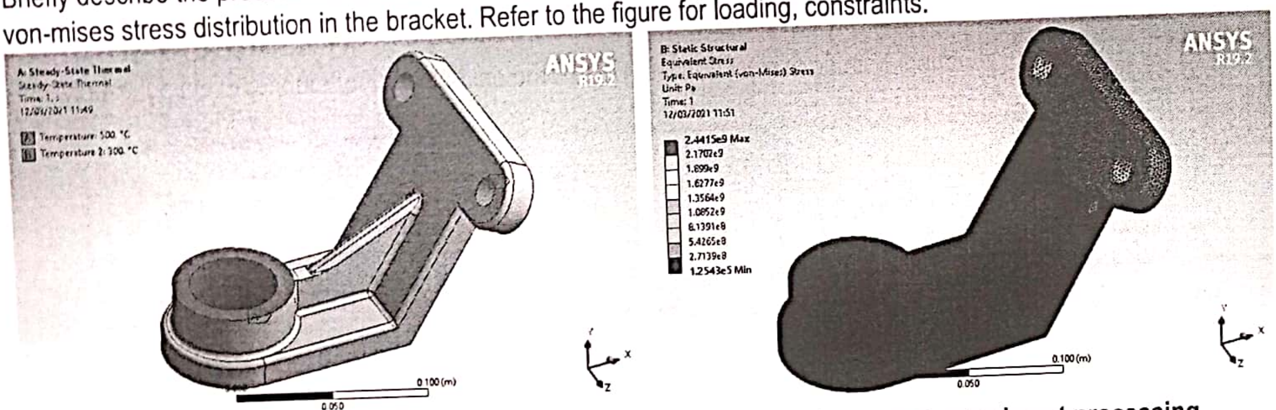


(a) Geometry of bracket (b) Mesh of bracket

Figure 7.1: Geometry and mesh of bracket in ANSYS Mechanical

...10 marks

b) Briefly describe the procedure for structural analysis of a bracket in ANSYS. Figure (7.2) shows the contour plot of von-mises stress distribution in the bracket. Refer to the figure for loading, constraints.



(a) Problem setup (b) Problem solution and post processing

Figure 7.2: Structural analysis of bracket in ANSYS

...15 marks

ELIZADE UNIVERSITY

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

B.Eng (Civil and Environmental Engrg.) Degree 1st Semester Examination 2020/2021 Session

CVE 507: Structural Analysis II **Units: 2** **Time Allowed: 3Hrs**

INSTRUCTION: Answer Question 6 and any other three

HOD'S SIGNATURE

Question 1

Calculate the membrane forces of a warehouse shell roof span 4m of a radius 12m and subtending a total angle of 60°. The shell is 60mm thick and carries a snow load of 500kN/m^2 of horizontal projection in addition to its own weight, taken as 1,500kN/m^2. Using the following formula with or without modification.

i $P_2 = -\omega_o R \sin\Phi$

ii. $S = -2\omega_o x \sin\Phi$

iii. $P_1 = \frac{\omega_o}{R}\left(x^2 - \frac{1}{4}l^2\right)\cos\emptyset$

(20 marks)

Question 2

a. State the limitation of membrane and beam theories for analyzing stresses in a shell. **(4 marks)**
b. The following observations were made in a Southwell test, carried out by a structural engineering student, of a pin-jointed steel tubular strut of length 1.76m.

Load (kN)	0.2	2.22	4.45	6.67	8.90	9.78	10.69	11.12	11.54	11.94
Cantral Def.	-	0.25	2.75	4.75	6.75	8.25	10.25	14.00	14.75	22.50
Load (kN)	12.37									
Central def.	75.00									

Central def. = Central deflection from initial position

Estimate from these observations the critical load of the strut and deduce its flexural rigidity EI. Why is it not necessary to specify the units in which the deflections were determined? **(16 marks)**

Question 3:

a. Derive or convert the following partial differential equations to their counterparts' finite difference equations.

i. $\frac{\partial^2 z}{\partial x \partial y}$

ii. $\nabla^2 Z = \frac{\partial^2 z}{\partial x} + \frac{\partial^2 z}{\partial y}$

iii. $\frac{\partial^4 z}{\partial x^2 \partial y^2}$

iv. $\frac{\partial^4 z}{\partial x^4} + 2\frac{\partial^4 z}{\partial x^2 \partial y^2} + \frac{\partial^4 z}{\partial y^4}$

(16 marks)

b. List four applications of shell roof.

Question 4:

a. Given that $\emptyset = a_1x^3 + a_2x^2y + a_3xy^2 + a_4y^3 + 10$ Demonstrate that the function specifies the stress fields of the plate show in Figure 1 and determine the values of the three stresses.

(15 marks)

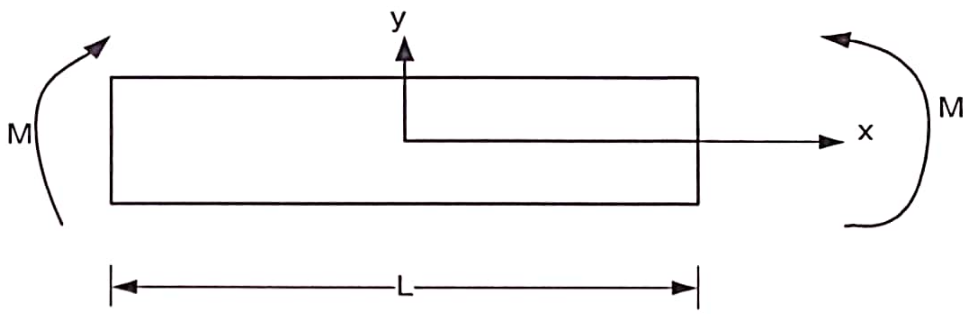


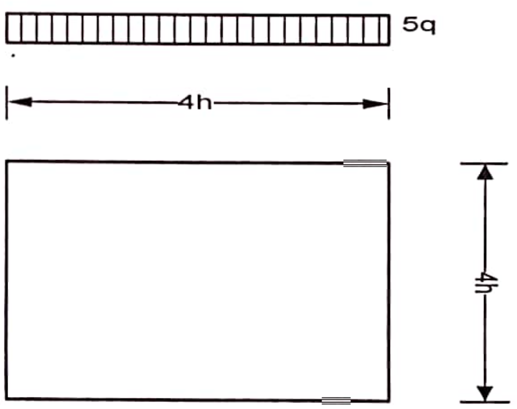
Figure 1

b. State the three procedural steps involved in the determination of stresses distribution on a body.

(4 marks)

Question 5

a. The square plate of constant thickness shown in Figure 2 is built in along the edges. The plate is loaded with a uniformly distributed load of 5q intensity per unit area. Find the deflection at the mesh points of the plate using a square mesh of side h and use the expression $\nabla^4\omega = \frac{q}{D}$. Where ω is the displacement, D is the flexural rigidity of the plate which must be expressed in term of its young modulus, q = 10kN/m^2 and Poission ratio. The finite central difference operator shown by the side of Figure B may be used without derivation. **(15 marks)**



		1			
	2	-8	2		
1	-8	20	-8	1	× w = qh^4/D
	2	-8	2		
		1			

Figure 2

b. What are the causes of eccentricity in a straight member under compressive forces? **(5 marks)**

Question 6

Starting from the theory of elasticity, derive Laplace and Biharmonic equations. **(40 marks)**