THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

EXAMINATION QUESTION PAPER MASTER PROFORMA

Semester: ONE (1) Academic Year: 2021

A. DEPARTMENT SECTION

I ACCEPT THAT THIS EXAMINATION PAPER SATISFACTORILY EXAMINES

Subject Code: CE411 Title: STRUCTURAL ANALYSIS

Number of Questions: 3 Number of Pages: 6 (cover page inclusive)

1. Subject Examiner: PROF. YAIP TELUE
   Signature: _____ Date: ___/___/___
2. Subject Co-Examiner: MR. J. KASADIMI
   Signature: _____ Date: 11/06/21
3. Departmental Examinations Co-ordinator: Checked: YES ✓ NO ___ (Please tick)
   Signature: _____ Date: 11/6/21
4. Head of Department and Chief Examiner: Checked: YES ✓ NO ___ (Please tick)
   Comments: — NIL —

   Signature: _____ Date: 11/06/21

B. EXAMINATIONS OFFICE SECTION

Examination Masters Received: YES ___ NO ___

5. Examinations Officer Signature: _____ Date: _____
6. Witness Signature: _____ Date: _____

THE PNGUNIVERSITY OF TECHNOLOGY
FIRST SEMESTER EXAMINATION – 2021 CIVIL ENGINEERING – 4TH YEAR DEGREE

CE 411 STRUCTURAL ANALYSIS 2

TUESDAY 15TH JUNE 2021 – 8:20 AM

SLT

TIME ALLOWED: 3.0 HOURS

TOTAL MARKS = 75

INFORMATION FOR STUDENTS

1. You have 10 minutes to read the paper. You must not begin writing during this time.
2. There are THREE (3) questions in this paper. Answer ALL THREE (3) questions.
3. Answer all questions in the answer books and graph papers provided. No other written material will be accepted.
4. Calculators and drawing equipment are permitted in the examination room. Notes, Laptops, Mobile Phones, Mobile Devices and textbooks are also allowed.
5. WRITE YOUR NAME CLEARLY ON THE FRONT PAGE – DO IT NOW
6. Marks for each Question are as indicated.

QUESTION ONE

Formulate the structural stiffness matrix (Ks) for the three (3) member truss shown in Figure 1. Calculate the displacements at Node 1 when a horizontal load of 200 kN and a vertical load of 100 kN are applied at Node 1 as shown in Figure 1. All members have the same constant value of EA. The matrix information sheet is attached. (Please use the numbering system as shown below).

(25 MARKS)

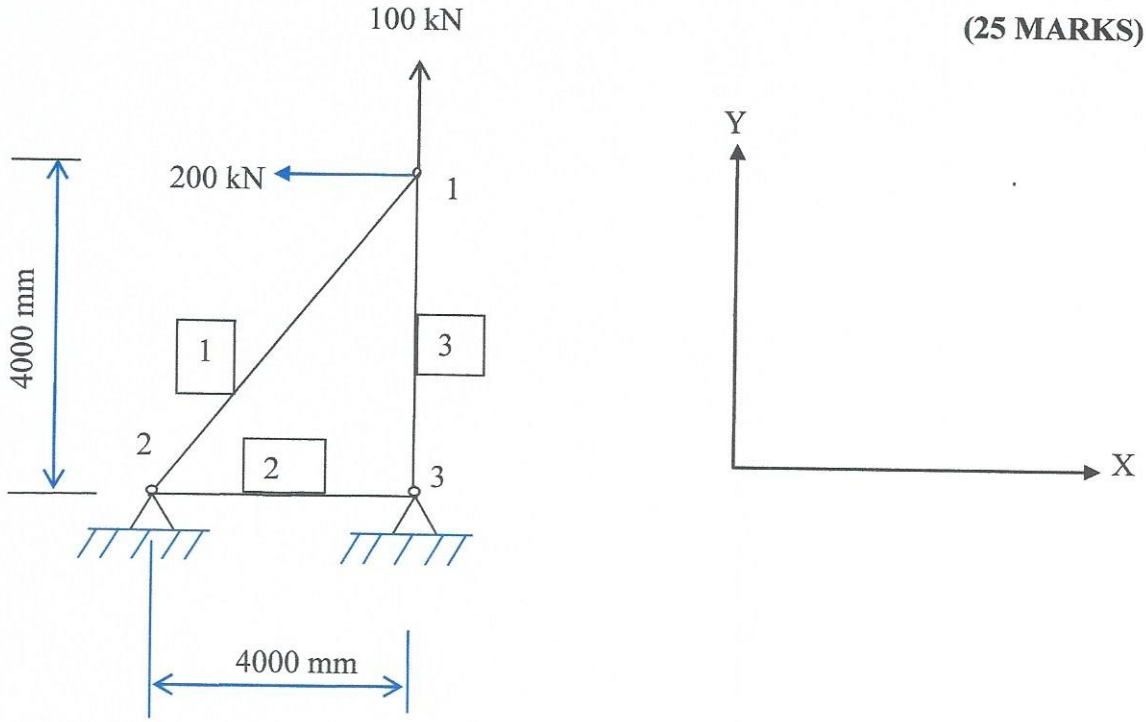

Figure 1

QUESTION TWO

Calculate the collapse load factor (λ) for the continuous beam shown in Figure 2 and draw the bending moment diagram at collapse. The plastic moment (M_p) for each member is also given in Figure 2 where $M_p = 200$ kNm.

(25 MARKS)

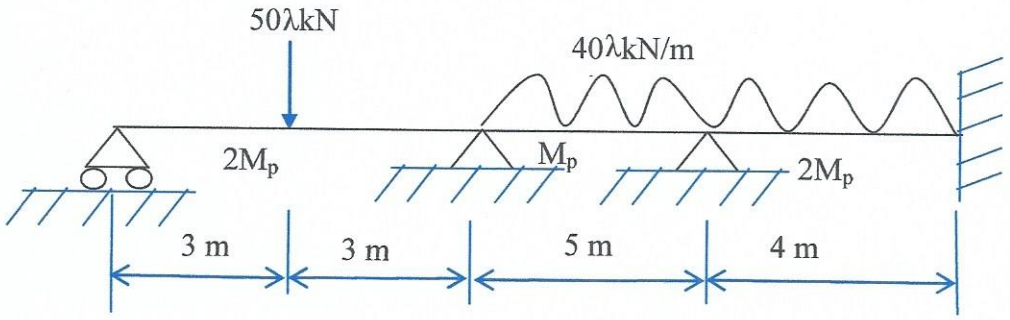

Figure 2

Matrix Information Sheet

For Bar (Truss) elements (members)

$$\begin{Bmatrix} f_{xi} \\ f_{yi} \\ f_{xj} \\ f_{yj} \end{Bmatrix} = \begin{bmatrix} \frac{EA}{L} & 0 & -\frac{EA}{L} & 0 \\ 0 & 0 & 0 & 0 \\ -\frac{EA}{L} & 0 & \frac{EA}{L} & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} u_i \\ v_i \\ u_j \\ v_j \end{Bmatrix}$$

{f} = [k] {d}

For beam elements (members)

$$\begin{Bmatrix} f_{xi} \\ f_{yi} \\ M_{zi} \\ f_{xj} \\ f_{yj} \\ M_{zj} \end{Bmatrix} = \begin{bmatrix} \frac{EA}{L} & 0 & 0 & -\frac{EA}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} & 0 & -\frac{12EI}{L^3} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{4EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{2EI}{L} \\ -\frac{EA}{L} & 0 & 0 & \frac{EA}{L} & 0 & 0 \\ 0 & -\frac{12EI}{L^3} & -\frac{6EI}{L^2} & 0 & \frac{12EI}{L^3} & -\frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{2EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{4EI}{L} \end{bmatrix} \begin{Bmatrix} u_i \\ v_i \\ \theta_i \\ u_j \\ v_j \\ \theta_j \end{Bmatrix}$$

{f} = [k] {d}

Transformation Matrices

For Bar Elements

$$[T]=\begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & \cos\theta & \sin\theta \\ 0 & 0 & -\sin\theta & \cos\theta \end{bmatrix}$$

For Beam Elements

$$[T]=\begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \cos\theta & \sin\theta & 0 \\ 0 & 0 & 0 & -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Member Stiffness Matrix with respect to Global Axis for truss/bar elements.

$$\therefore [K]=T^{-1}kT = \frac{EA}{L}\begin{bmatrix} C^2 & CS & -C^2 & -CS \\ CS & S^2 & -CS & -S^2 \\ -C^2 & -CS & C^2 & CS \\ -CS & -S^2 & CS & S^2 \end{bmatrix}$$

Where C = Cosθ and S = Sinθ

Note that the member forces [q] can be determined using [q] = [k] [T] [D].