UNIVERSITY OF JOHANNESBURG

PROGRAMME	:	BTECH: ENGINEERING: CIVIL: STRUCTURES
SUBJECT	:	STRUCTURAL ANALYSIS 4
CODE	:	AIS411
DATE	:	SUMMER SSA EXAMINATION 2015 9 DECEMBER 2015
DURATION	:	(SESSION 2) 11:30 - 15:30
WEIGHT	:	40:60
TOTAL MARKS	:	100%

ASSESSOR	:	DR SALIM RW
MODERATOR	:	DR WEKESA BW
NUMBER OF PAGES	:	8 PAGES

INSTRUCTIONS	:	ONLY ONE ANY TYPE CALCULATOR PER CANDIDATE MAY BE USED.
REQUIREMENTS	:	NONE.

INSTRUCTIONS TO STUDENTS

1. PLEASE ANSWER QUESTIONS ONE AND FOUR AND ANY OTHER TWO QUESTIONS. THUS IN TOTAL PLEASE ANSWER ONLY FOUR QUESTIONS
2. STIFFNESS COEFFICIENTS AND FIXED END MOMENTS ARE ATTACHED AS PAGES 6 AND 7

QUESTION ONE (STIFFNESS METHOD) (25 Marks)

For the beam shown in Figure Q1:

(a) Use the stiffness method to determine all the reactions at supports.

(b) Draw the quantitative free-body diagram of member.

(c) Draw the shear diagram, bending moment diagram and deflected shape indicating the critical quantitative values.

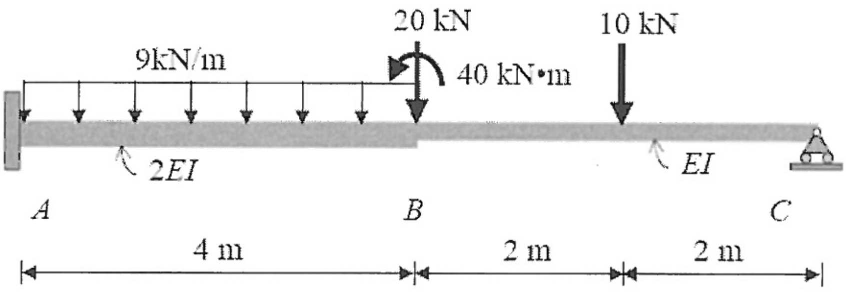
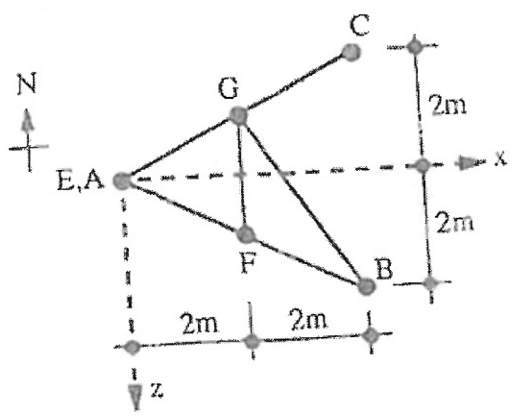


Figure Q1

Total Marks for Question 1 (25 Marks)

QUESTION TWO (SPACE PINNED FRAMES) (25 Marks)

Figure Q2 (a, b and c) shows a prismatic pin-jointed space frame whose circular solid elements are 50 mm in radius with a modulus of elasticity of 210 GPa. The supports at A, B and C are constructed from ball & sockets. The frame members are connected at their ends by frictionless ball-and-socket at joints E, F and G. Compute the vertical displacement of joint G by using Virtual Work Method. Use the tension coefficient technique in computation of internal forces in the frame elements. Table for use is on page 8.



(a) Plan View

Figure Q2

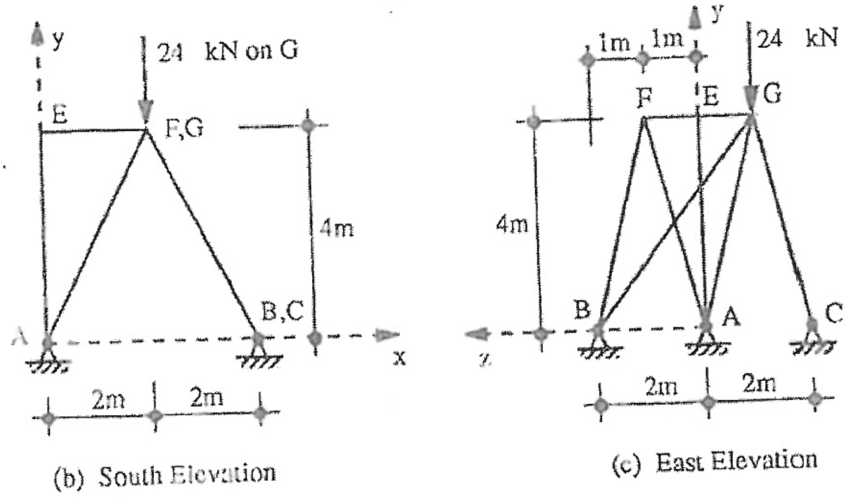


Figure Q2

Total Marks for Question 2 **(25 Marks)**

QUESTION THREE (ARCHES) (25 Marks)

A gymnasium has a two hinged symmetrical parabolic arch which rises 20 m and has clear span of 160 m. Its moment of inertia of the cross section varies with the secant of the slope of the arch rib. Take one of the supports as the origin.

(a) Use integration method to calculate the horizontal reaction at the supports when the arch is carrying an ultimate uniformly distributed load of 50 kN/m on the entire arch.

(b) Hence evaluate the

i. Bending moment at the crown

ii. Radial shear force at the crown and

iii. Radial axial force at the crown.

(c) The Gymnasium Project Architect has decided to introduce a third hinge on the arch to be located at the crown. What is the impact of the architect's decision on your reactions at the supports and bending moment at the crown? Motivate your answer by calculations.

Take

$$H = -\frac{\int \frac{M}{EI} y \, ds}{\int \frac{y^2}{EI} ds}$$

Where

- ***H*** **is the horizontal reaction at the simple supports.**
- ***M*** is the bending moment at any position of the simply supported arch.
- ***y*** is the height of the arch at any position.
- ***I*** is the moment of inertia of the arch section at any point.
- ***ds*** is an incremental length measured along the curve of the arch rib.

Total Marks for Question 3 **(25 Marks)**

QUESTION FOUR (INFLUENCELINES) **(25 Marks)**

Figure Q4 (a) below shows a prismatic continuous two span gantry crane girder ABC with fixed support at A and rests on roller supports at B and C. By using Muller-Breslau's Principle, determine the influence lines for the following responses on the girder:

(a) Vertical reaction at A (9 Marks)

(b) Bending moment at A (9 Marks)

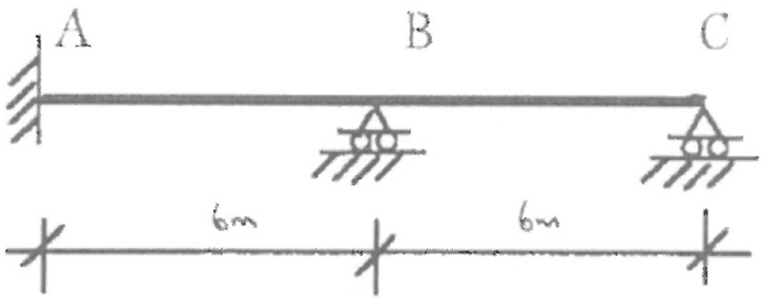


Figure Q4 (a)

The Bridge Design Code (TMH 7), specifies that road structures must be designed to resist **NB-Vehicle** consisting of a train of wheels as indicated in Figure Q4 (b). By using the influence lines obtained in Q4 (a and b) calculate the following actions when the truck is at the centre of the bridge.

(c) Vertical reaction at A (3.5 Marks)

(d) Bending moment at A (3.5 Marks)

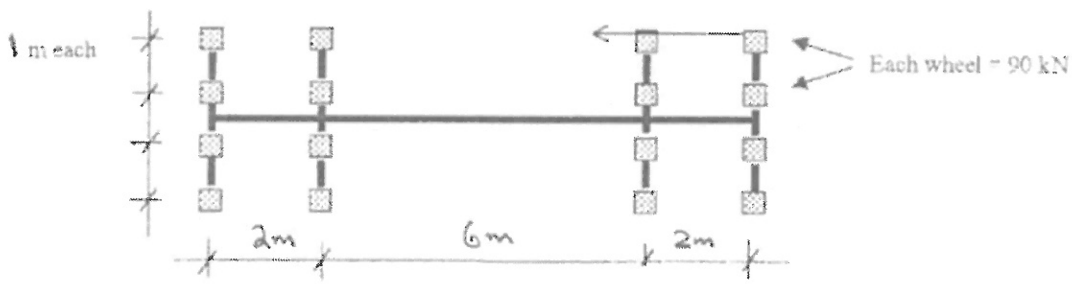


Figure Q4 (b)

Total Marks for Question 4 **(25 Marks)**

QUESTION 5 (BEAM COLUMN ANALOGY) (25 Marks)

Figure Q5 shows a non-prismatic built-in beam ACB with a concentrated load of 90kN and a uniformly distributed load of 3kN/m acting on the entire beam. The section modulus of element AC is I while that of CB is 2I. Calculate the bending moment at the supports by using the Beam Column Analogy method. Take the modulus of elasticity E is constant and the Basic Determinate Structure as a simply supported beam.

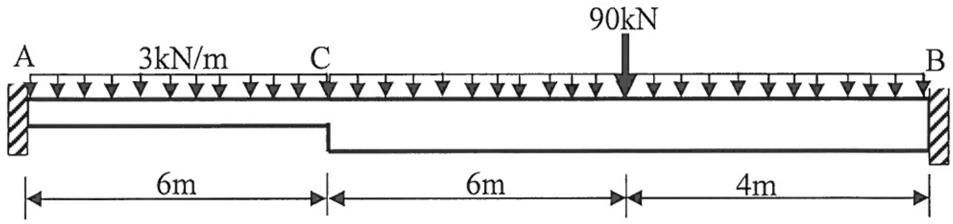
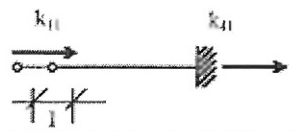
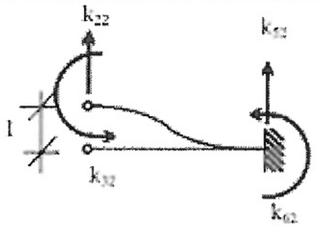
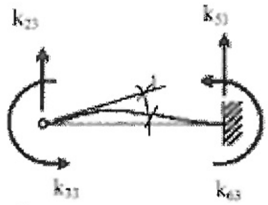
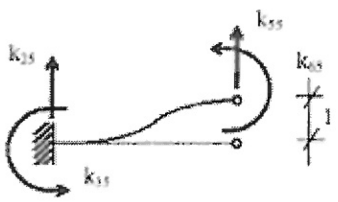
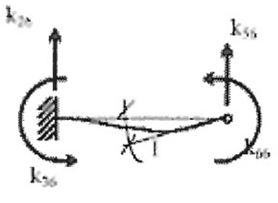


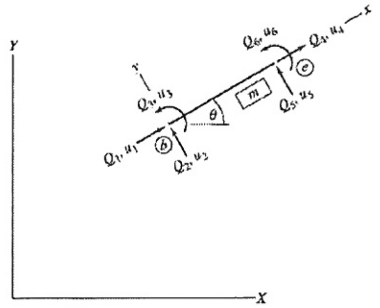
Figure Q5

Total Marks for Question 5 **(25 Marks)**

Total Marks for the examination paper **(100 Marks)**

TABLE 1: Stiffness coefficients

Displacement at degree of freedom 1		$k_{11} = +\frac{EA}{L}$ $\quad k_{41} = -\frac{EA}{L}$
Displacement at degree of freedom 2		$k_{22} = +\frac{12EI}{L^3}$ $\quad k_{52} = -\frac{12EI}{L^3}$ $k_{32} = +\frac{6EI}{L^2}$ $\quad k_{62} = +\frac{6EI}{L^2}$
Displacement (rotation) at degree of freedom 3		$k_{23} = +\frac{6EI}{L^2}$ $\quad k_{53} = -\frac{6EI}{L^2}$ $k_{33} = +\frac{4EI}{L}$ $\quad k_{63} = +\frac{2EI}{L}$
Displacement at degree of freedom 4		$k_{14} = -\frac{EA}{L}$ $\quad k_{44} = +\frac{EA}{L}$
Displacement at degree of freedom 5		$k_{25} = -\frac{12EI}{L^3}$ $\quad k_{55} = +\frac{12EI}{L^3}$ $k_{35} = -\frac{6EI}{L^2}$ $\quad k_{65} = -\frac{6EI}{L^2}$
Displacement (rotation) at degree of freedom 6		$k_{26} = +\frac{6EI}{L^2}$ $\quad k_{56} = -\frac{6EI}{L^2}$ $k_{36} = +\frac{2EI}{L}$ $\quad k_{66} = +\frac{4EI}{L}$



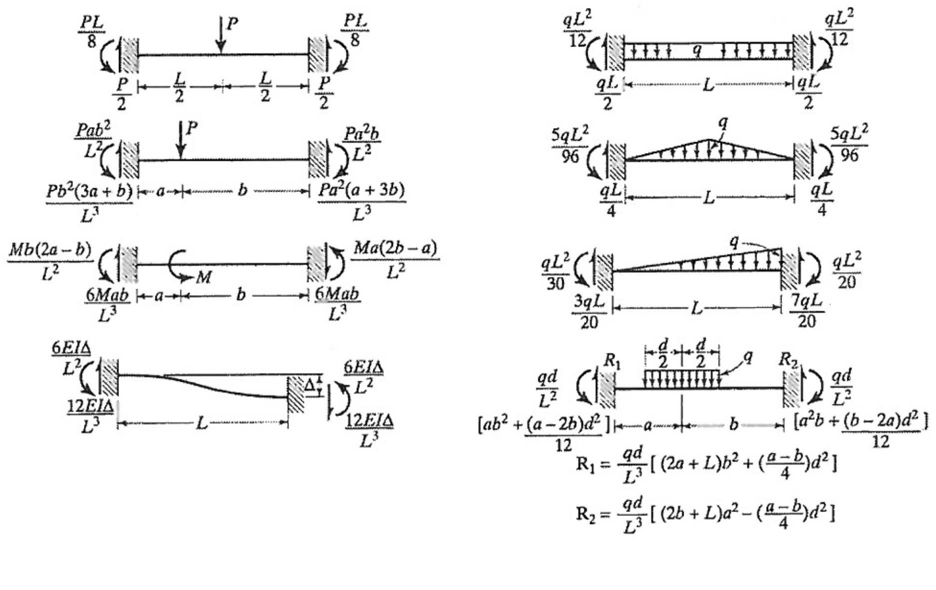
Stiffness Matrix [k]

$$
\left[\begin{array}{ccc|ccc}
EA/L & 0 & 0 & -EA/L & 0 & 0 \\
0 & 12EA/L^3 & 6EI/L^2 & 0 & -12EI/L^3 & 6EI/L^2 \\
0 & 6EI/L^2 & 4EI/L & 0 & -6EI/L^2 & 2EI/L \\
\hline
-EA/L & 0 & 0 & EA/L & 0 & 0 \\
0 & -12EI/L^3 & -6EI/L^2 & 0 & 12EI/L^3 & -6EI/L^2 \\
0 & 6EI/L^2 & 2EI/L & 0 & -6EI/L^2 & 4EI/L
\end{array}\right]
$$

Transformation Matrix [T]

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

Fixed End Moments



JOINT	MEMBER	X	Y	Z	LENGTH L	TENSION COEFFICIENT	REAL FORCE FR	NOMINAL DIAMETER	ACTUAL AREA A	VIRTUAL FORCE FV		
E	EA											
	EF											
	EG											
F	FA											
	FB											
	FE											
	FG											
G	GA											
	GB											
	GC											
	GE											
	GF											