UNIVERSITI SAINS MALAYSIA

1st Semester Examination
2010/2011 Academic Session

November 2010

EAS 661/4 – Advanced Structural Mechanics

Duration :   hours

Please check that this examination paper consists of………. printed pages before you begin the examination.

[Instructions: This paper contains **FIVE (5)** questions. Answer **____(   )** questions only.

You must answer the questions in English.

All question **MUST BE** answered on a new sheet.

1. Dr Choong

(20 marks)

2. Dr. Choong

(20 marks)

3. Dr Choong

(20 marks)

(Dr Neeraj) Question 1: a) In continuum mechanics, contravariant and covariant tensor are frequently used, so what is the difference between these two tensors. If a contravariant tensor is defined by S=$a_{\alpha\beta\gamma}\, x^{\alpha}\, x^{\beta}\, x^{\gamma} = 0$, then evaluate $\frac{\partial^3 S}{\partial x^k\, \partial x^l\, \partial x^l}$.

b) A covariant tensor has components a, b, c in rectangular Cartesian co-ordinates, find the components in spherical co-ordinates.

5. (a) Briefly define the difference between a triangular and rectangular finite element in plane elasticity.

(5 marks)

5. (b) Show clearly in a step by step manner the development process of a stiffness matrix, $[K]^e$, for a triangular element in a state of plane stress as shown in Figure 5. Given E = 200 GN/m^2 , ν = 0.3 and t = 1 cm.

(15 marks)

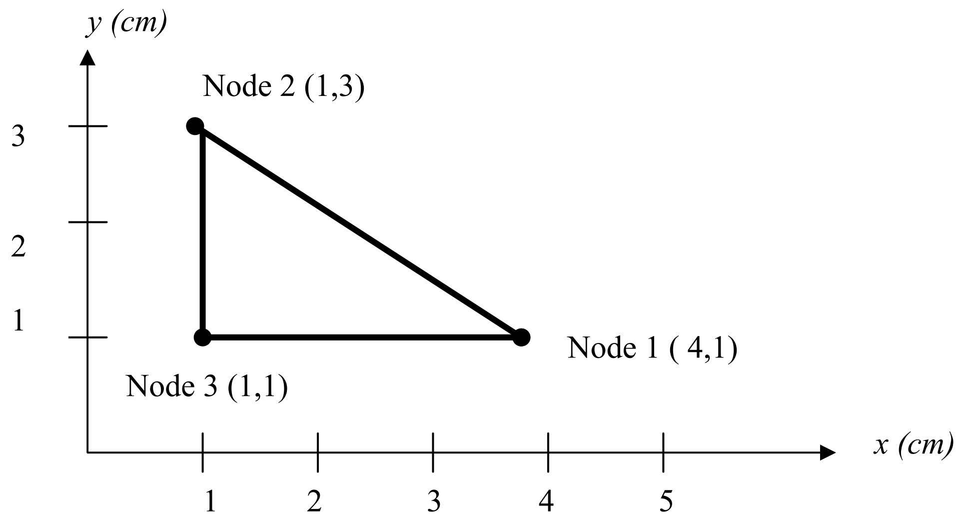

Figure 5

6. (a) Clearly define the difference between a bar and beam in the analysis using finite element Method.

(5 marks)

(c) Figure 6 shows a system of two beams labeled with node 1,2 and 3 and a spring labeled with node 3 and 4 subjected to a nodal forces of P = 50 kN at node 3. The beam is fixed at node 1, simply supported at node 2 and spring support at node 3. The spring system can only displace in axial direction and is supported at node 4. Given the value of k = 200 kN/m, $L_1 = L_2 = 3$m, E = 210GPa and I = $2\text{x}10^{-4}$ m^4 .

i. Obtain the element stiffness matrix for the beam and the spring.
ii. Derive the global stiffness matrix for the system.
iii. Evaluate the deflection v_3 , θ_2 and θ_3 in unit metre and rad respectively.

(15 marks)

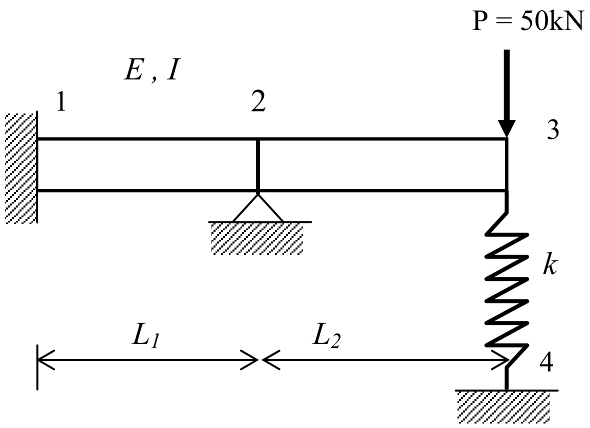

Figure 6

Given the stiffness of the beam element in dimensional space:

$$
k = \frac{EI}{L^3}
\begin{array}{c}
\begin{array}{cccc} v_i & \theta_i & v_j & \theta_j \end{array} \\
\begin{bmatrix}
12 & 6L & -12 & 6L \\
6L & 4L^2 & -6L & 2L^2 \\
-12 & -6L & 12 & -6L \\
6L & 2L^2 & -6L & 4L^2
\end{bmatrix}
\end{array}
\text{ for the beam element}
$$

- ooo OOO ooo -