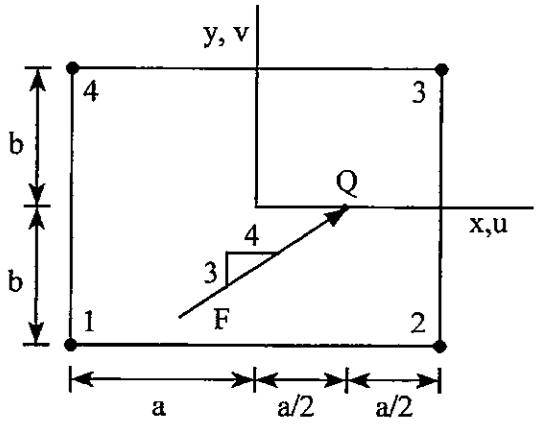
Qualified Examination Spring 2022

Finite Element Method

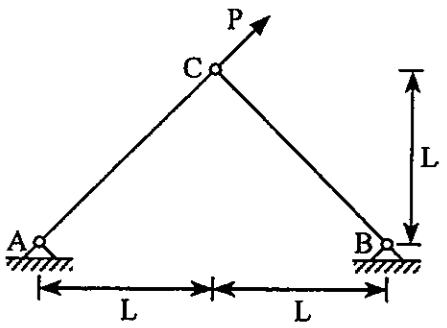
(Close book, 100 minutes, 70% to pass)

1. The following True-False questions refer to finite elements based on assumed displacements. (15%)
   ( ) A. For FE solutions, the calculated stresses are more accurate than the calculated displacements.
   ( ) B. The diagonal coefficients of a structural stiffness matrix [K] may be less than or equal to zero.
   ( ) C. The stiffness matrix [K] of an unsupported structure is singular, i.e. $|[K]| = 0$.
   ( ) D. The elements should be able to display rigid body motion and constant strain states.
   ( ) E. The potential energy Π_p of a structure in equilibrium is stationary (i.e. $d\Pi_p = 0$) and at its maximum value.

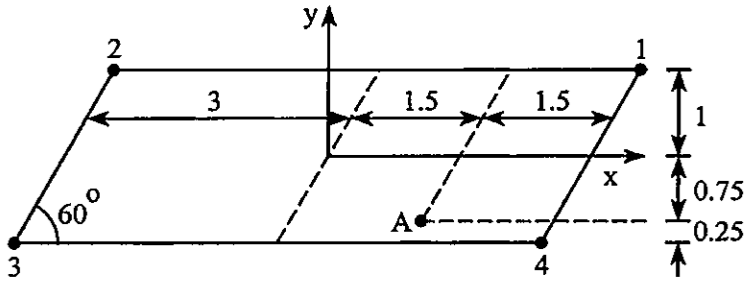
2. A force F = 10 N acts at point Q in the Q4 element shown. Determine the load vector $\{r_e\}^T = \{F_{x1}, F_{y1}, F_{x2}, F_{y2}, F_{x3}, F_{y3}, F_{x4}, F_{y4}\}$. (15%)



3. A 2-bar truss is subjected to a concentrated force P as shown. Assume both bars have the same cross section area A and the same modulus of elasticity E. Use the finite element method to calculate the displacements at node C, the reactions at nodes A and B, and the axial forces in both bars. (15%)



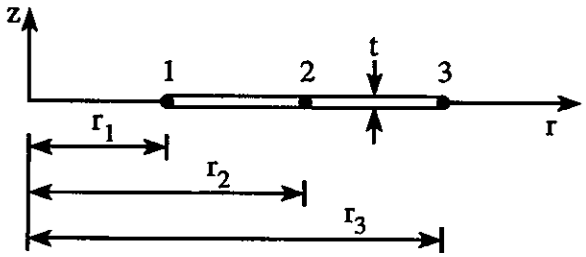
4. A 4-node isoparametric element is shown below. Compute the Jacobian matrix [J] at point A. (15%)



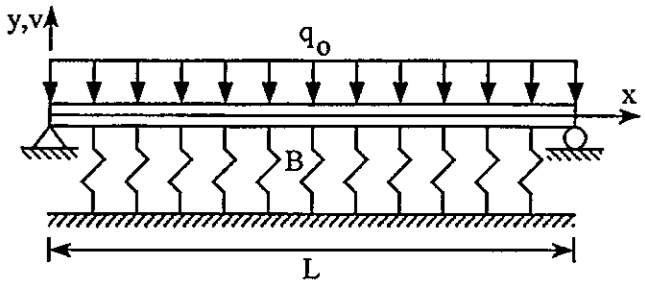
5. The sketch shows the cross section of an axisymmetric element of uniform thickness t. Degrees of freedoms of the element are radial displacements u_1, u_2 and u_3 at nodes 1, 2 and 3. Let $u = N_1u_1 + N_2u_2 + N_3u_3$ and N_1, N_2, N_3 are the shape functions of nodes 1 and 2. If the strain-displacement relation of the element is

$$\begin{Bmatrix}\varepsilon_r\\ \varepsilon_\theta\end{Bmatrix} = \begin{Bmatrix}\frac{\partial}{\partial r}\\ \frac{1}{r}\end{Bmatrix} u = [B]\begin{Bmatrix}u_1\\ u_2\\ u_3\end{Bmatrix} = [B]\{d\}$$

Determine the $[B]_{2\times 3}$ matrix for the element. (20%)



6. A simply supported beam rested on elastic foundation (with foundation modulus B) is shown below. The beam is subjected to a uniformly distributed lateral load q_o. The differential equation of the beam can be written as: $EIv_{,xxxx} + q_o + Bv = 0$. Assume the approximate deflection of the beam is $\tilde{v}(x) = \alpha x(L-x)$. Use the Galerkin method to find the generalized d.o.f. α in the approximate deflection. (20%)



110學年度第二學期成大土木系博士學位候選人資格考試

Qualifying Examination

結構動力學(Structural Dynamics)

及格分數：60分　考試時間：100分鐘

1. For an undamped single-degree-of-freedom system with mass m and stiffness k under harmonic excitation tests, the response tends to increase without bound at an excitation frequency of 3 Hz. Determine the resonance frequency for **displacement amplitude** of a single-degree-of-freedom system with mass $2m$, and stiffness $3k$, and damping ratio 5%. (10%)

2. For an undamped single-degree-of-freedom system with mass m, stiffness k, and quiescent initial conditions subjected to an applied force $a\sin\omega t + b\cos\omega t$, where a, b, and ω are constants, find the **displacement response**. (20%)

3. Plot a **ground acceleration time history**, its **Fourier amplitude spectrum**, and the induced **response spectra** for two different damping ratios, all schematically. Describe the characteristics of those plots and their relationship, qualitatively and/or numerically. (30%)

4. Give a procedure to approximate a multi-degree-of-freedom system to a **generalized single-degree-of-freedom** system, and stress the key points to obtain accurate response. (20%)

5. Compare **response history analysis** and **response spectrum analysis** for a multi-degree-of-freedom system, and stress the key points to obtain accurate response in response spectrum analysis. (20%)

Spring 2022

Ph.D. Qualifying Exam for 'Deformation Mechanisms of Materials'
Department of Civil Engineering
National Cheng Kung University

1. Please discuss strengthening mechanisms in steel materials. (25%)

2. Please discuss dislocation-based mechanisms in the creep and fatigue behavior of metal. (25%)

3. Please solve the stress field between two straight edge dislocations arranged in parallel, and discuss how to remove the stress singularity. (25%)

4. Please discuss damping mechanisms in metal and polymer. (25%)

1. Use theories or equations to elaborate the mechanism of temperature affect pavement stress in flexible pavement and rigid pavement. (20%)

2. According to EALF tables for asphalt pavement and rigid pavement in the textbook "Pavement Analysis and Design", how would you evaluate the excess damage caused by overloaded trucks on two types of pavement ? (20%)

3. Please explain the deference between Elastic modulus and resilient modulus. (20%)

4. Please describe the application of fatigue models of HMA and Portland cement concrete on pavement design respectively. (20%)

5. Please explain the differences of backcalculation algorithm between layered system and dense-liquid model. (20%)