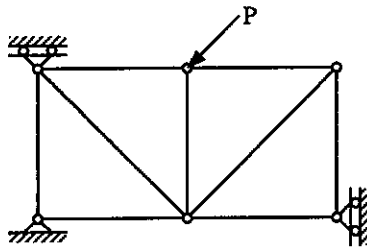


# Finite Element Method

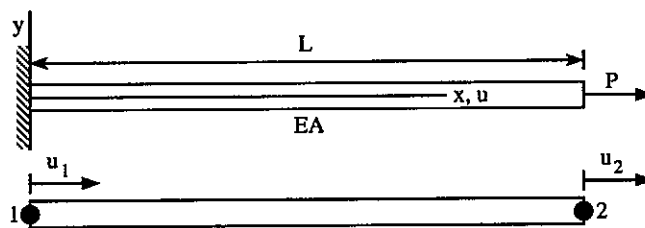
(Close book, 100 minutes, 60% to pass)

1. The following True-False questions refer to finite elements based on assumed displacements. Answer True or False for each problem. (15%)

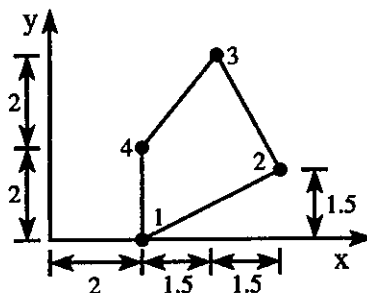
- ( ) A. Finite element solutions always satisfy the compatibility and boundary conditions but not the equilibrium conditions at every material point.
- ( ) B. CST and Q4 elements work well in bending condition.
- ( ) C. Variation methods provide more general finite element approximations for physical problems where virtual work does not exist such as heat conduction.
- ( ) D. The potential energy of a physical problem is called a “strong form” and the differential equation of the same physical problem is called a “weak form”.
- ( ) E. The stiffness matrix  $[K]$  of the following truss is not singular, i.e.  $|[K]| \neq 0$



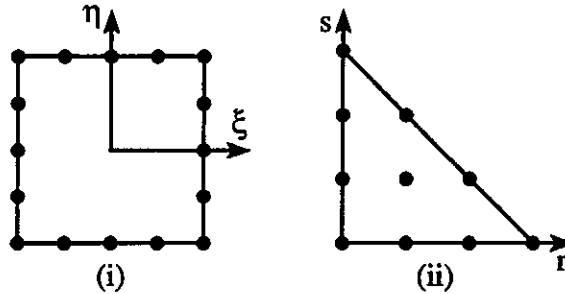
2. A cantilever bar is subjected to a concentrated force  $P$  at the free end. The governing differential equation of the bar is  $EAu_{,xx} = 0$ . Let the bar be modeled by a two-node element as shown. The approximated axial displacement  $\tilde{u}$  within the element is assumed to be  $\tilde{u} = [N]\{d\}$ , where  $[N] = [N_1, N_2]$ ,  $\{d\} = \{u_1, u_2\}^T$ . Use the Galerkin method to derive the finite element expression  $[K]\{D\} = \{R\}$  for the cantilever bar and find the displacement of the bar at the free end. (20%)



3. A 4-node isoparametric element is shown below. Assume the thickness of the element is  $t = 0.5$ . Compute the Jacobian matrix  $[J]$  and its determinant  $|J|$  at the centroid of the element. (15%)

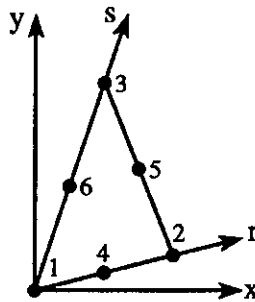


4. Indicate the polynomial terms in the Pascal triangle that should be used for the 16-node Serendipity element and the 10-node triangle element shown below. (15%)



5. A triangular element of constant thickness  $t$  is subjected to a body force  $p$  (force/volume) in the  $x$  direction. Let  $A$  be the area of the triangle. Use the area coordinates  $(\xi_1, \xi_2, \xi_3)$  to calculate the consistent nodal load forces  $Q_{2X}$  and  $Q_{5X}$  at nodes 2 and 5. (15%)

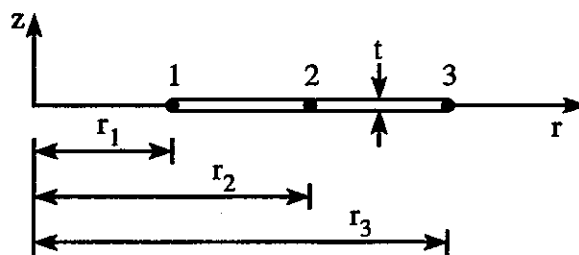
Hint:  $Q_{iX} = \int p N_i dV$ .



6. The sketch shows the cross section of an axisymmetric element of uniform thickness  $t$ . Degrees of freedom of the element are radial displacements  $u_1, u_2$  and  $u_3$  at nodes 1, 2 and 3. Let  $u = N_1 u_1 + N_2 u_2 + N_3 u_3$  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%)



## 高等瀝青材料學

(博士學位候選人資格考試)

1. Read and translate the following paragraph.

Many engineers and technicians from all sectors of the asphalt industry who entered the work force during the major construction years of the interstate system have retired. Also the QC/QA system that many state DOTs have been using for a number of years makes it much more difficult to train young engineers leading to a lack of adequate numbers of qualified staff within the DOTs. These retired professionals must be replaced and the younger staff must be adequately trained to provide engineers and technicians the knowledge needed to successfully maintain and continue to build quality hot mix asphalt pavements.

2. Describe the asphalt cement grading system.
3. Describe the Superpave asphalt binder testing equipment and purpose.
4. Describe the objectives of mix design for hot mix asphalt.
5. Describe the two principal types of HMA mixing facilities in use today.
6. What are the purposes of using additives and modifiers in HMA?

## Engineering Management Information System, Qualification (2012)

- 1 Represent the decision logic in the decision table of Figure 1 in Structured English. (25%)

Conditions/ Courses of Action	Rules			
	1	2	3	4
Employee type	S	H	H	H
Hours worked	=	<40	40	>40
Pay base salary	X			
Calculate hourly wage		X	X	X
Calculate overtime				X
Produce Absence Report		X		

Figure 1

- 2 A company has the following business rules. Each product is (described by Product\_No, Description, and Cost.) composed of at least three components (described by Components\_No, Description, and Unit of measure.) and components are used to make one or many products (must be used in at least one product). In addition, assume that components are used to make other components and that raw materials are also considered to be components. In both cases of components being used to make products and components being used to make other components, we need to keep track of how many components go into making something else. Draw an E-R diagram for this situation and place minimum and maximum cardinalities on the diagram. (25%)

**Note: You need to add necessary attributes to keep track of how many components go into making products and components.**

- 3 Describe what total specialization, partial specialization, disjoint, and overlap rules are. Give an example for each of them (25%)
- 4 What is the data warehouse? What is the data mining? What kind type of the database structure is best suited for data warehousing, why? Assuming that you are a construction material supplier and wish to build up an OLAP system of the material management, please develop a systematic (input, output, control, process, feedback) framework, which includes the hardware, software, technology, data, people, and networks. You have to explain the design process in detail. (25%)