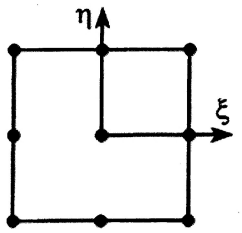
Qualified Examination Spring 2020

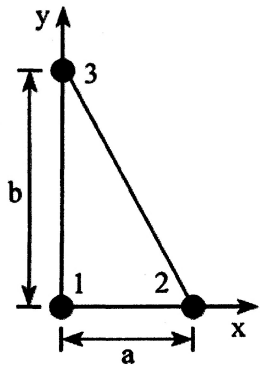
Finite Element Method

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

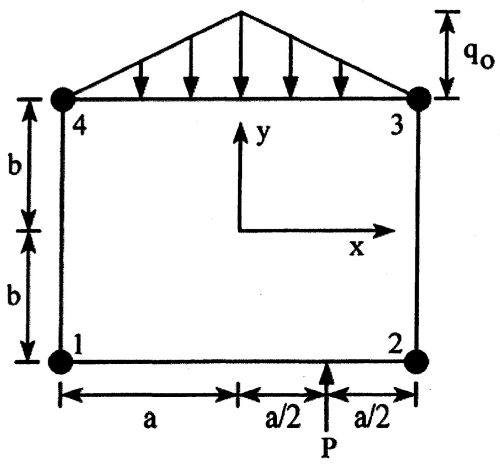
1. (i) Sketch one of the zero energy mode shapes for a 9-node isoparametric plane element with reduced integration rule. (ii) Explain why the strain energy at the reduced integration point is zero? (15%)



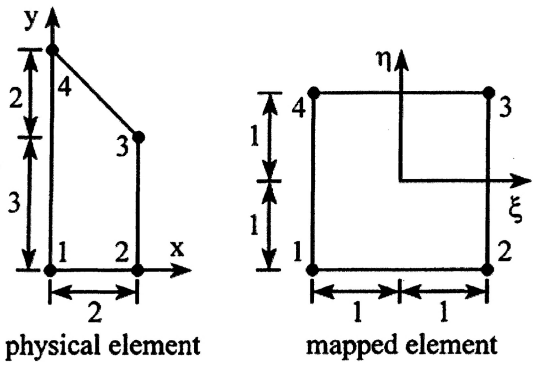
2. The displacement field u of the CST element can be expressed as $u=[N]\{d\}$, where $[N]=[N_1,N_2,N_3]$ and $\{d\}^T=\{u_1,u_2,u_3\}$. Find the expressions for N_1, N_2, N_3 and ε_x. (15%)



3. A Q4 element with constant thickness t is subjected to a distributed load q(x) (unit: force/length) and a concentrated force P as shown. Find the consistent nodal forces in y direction for all the nodes 1, 2, 3 and 4. (20%)



4. Calculate the Jacobian matrix [J] and its determinant J of the 4-node element shown below. (15%)



5. Consider a flat-faced tetrahedron of volume V = 1/6, and the function:

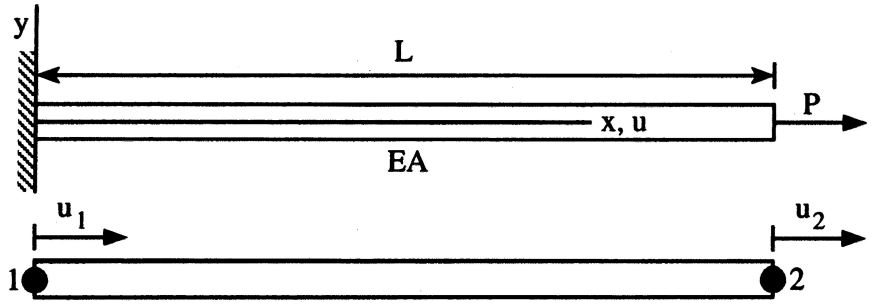
$$\phi = a_1 r + a_2 r^2 + a_3 rs$$

Where the a_i are constants. (a) obtain the exact integral $I = \int \phi dV$ over the volume V. (b) Approximate I by use of the 4-point integration rule. (15%)

TABLE 7.4-2 SELECTED FORMULAS FOR NUMERICAL INTEGRATION OVER A TETRAHEDRAL VOLUME, EQ. 7.4-2 [7.11]

No. of points	Degree of precision	Coordinates (r_i, s_i, t_i)	Weights W_i
1	1	$\left(\frac{1}{4},\frac{1}{4},\frac{1}{4}\right)$	1.0
4	2	$(a,b,b),(b,b,b),(b,b,a),(b,a,b)$	$\frac{1}{4}$
		where $a = \frac{5+3\sqrt{5}}{20}$, $b = \frac{5-\sqrt{5}}{20}$	

6. 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%)



Pavement Analysis

National Cheng Kung University

Qualification Exam for Ph.D. Students

27 March, 2020

1.

Define precisely the difference between pavement serviceability and performance. (20 points)

2.

Design a flexible pavement with the design characteristics listed below using the 1993 AASHTO Pavement Design Guide. Round the asphalt depth to the nearest ½" and other depths to the nearest 1". (40 points)

- Rural local road
- Lifetime 20 years
- ESALs = 1,300,000
- 75% reliability
- Standard Deviation (S_0) = 0.50
- $\Delta PSI = 2.0$
- $P_t = 4.0$, $P_i = 2.0$
- Asphalt Elastic Modulus = 300,000 psi
- Granular base Resilient Modulus = 25,000 psi
- Subgrade Resilient Modulus = 10,000 psi
- The pavement is exposed to saturation moisture levels >25% of the time.
- The drainage quality of the pavement is Good.
- Be sure and check your depths against the AASHTO minimum thicknesses.

3.

A new runway is proposed at an airfield. The airport manager is requiring the use of the FAA procedure for designing the flexible airfield pavements. The potential aircraft, gross weight and projected number of annual departures for the new runway for a 20-year period are listed as follows: (40 points)

Aircraft	Gross weight (lb)	Tire pressure (psi)	Annual Departures
B737-200	175,000	160	3,000
A300-B84	325,000	195	1,200
B757	225,000	180	6,000

Soil tests have already been completed. CBR tests showed the average strength value of the silt clay is 6 with a standard deviation of 1. The unconfined compressive strength of the soil is 25 psi. The following material properties should be used for any mechanistic analysis of the flexible pavement: elastic modulus of the AC of 500 ksi with a Poisson's ratio of 0.35, P-209 crushed stone modulus of 30 ksi with a Poisson's ratio of 0.35, P-154 granular subbase modulus of 15 ksi with a Poisson's Ratio of 0.35, and the silt clay subgrade modulus of 5 ksi with a Poisson's ratio of 0.40.

Using the FAA standard design procedure for flexible pavements, without using layer equivalencies unless specified, answer the following the questions:

(a) What is the required pavement design for only the B727-200?
(b) What is the required pavement design for only the A300-B4?
(c) What is the required pavement design for only the B757?
(d) What is the conventional flexible pavement design (AC, base, subbase)?
(e) What is the pavement design if the subbase is replaced with P-209 and the base is replaced with a stabilized bituminous material (P-401)?
(f) What is the pavement design for full-depth AC (P-401)?

108 學年度第二學期博士學位候選人資格考試

高等瀝青材料學 (20% for each question)

1. Explain and comment the following paragraph.
   Empirical tests are used less frequently now because they are not able to predict performance for conditions that are different than those under which the tests were developed. These tests were never good at predicting performance and have become less reliable in prediction performance as axle loads and tire pressures have continued to increase.

2. Briefly describe the asphalt cement grading system. (including PEN, AC, AR, and SHRP)

3. Briefly describe the properties of an ideal pavement binder.

4. Briefly describe the major superpave asphalt binder testing equipment and purpose.

5. Briefly describe the procedures of the Marshall mix design and superpave mix design method.

108 學年度第二學期博士學位候選人資格考試

考試科目: 高等鋼結構

考試方式: Closed Book
考試時間: 100 分鐘

1. [15%] Please list the important processes in modern steel making (or steel production).

2. [15%] What is the difference between *first-order structural analysis* and *second-order structural analysis*? What is the objective of *second-order structural analysis*?

3. [15%] Please describe the theories of *Tresca yield criterion* and *von Mises yield criterion*, and draw the 2-D diagrams of principal stresses (σ_1 and σ_2) for the two yield criteria.

4. [15%] What are *isotropic hardening* and *kinematic hardening* phenomena for metals under cyclic loading? Please draw the stress-strain diagrams for the two hardening phenomena and describe them.

5. [20%] Please derive the theoretical effective lengths (KL) for the following two elastic columns (Column A & Column B) with the same length L and the same EI under their compressive axial forces as shown in Fig. 1. Then, draw the sketchy buckling shapes of Column A and Column B, and show their effective lengths on the buckling shapes respectively.

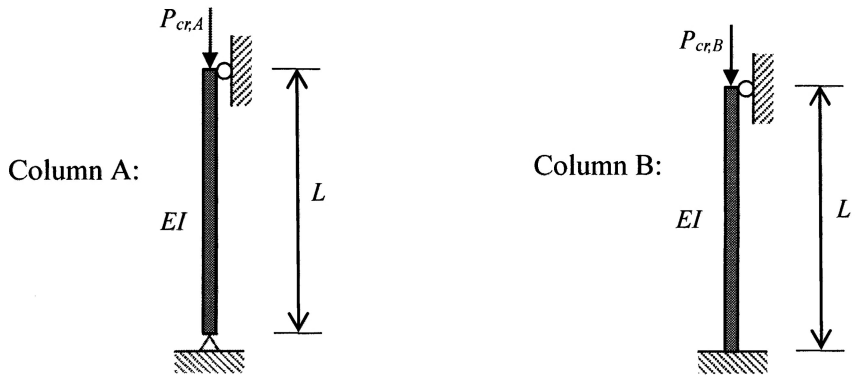


Fig. 1

6. [20%] The load Q is applied to the following beam first. Then, the load P is applied to the same beam as shown in Fig. 2. The plastic moment M_p of the beam is 3000 in-kip:
   (a) If Q = 0 kip, please compute the plastic limit load of P and draw the corresponding failure mechanism.
   (b) If Q = 60 kips, please compute the plastic limit load of P and draw the corresponding failure mechanism.
   (Note: No need to consider lateral torsional buckling & local bucking for this problem.)

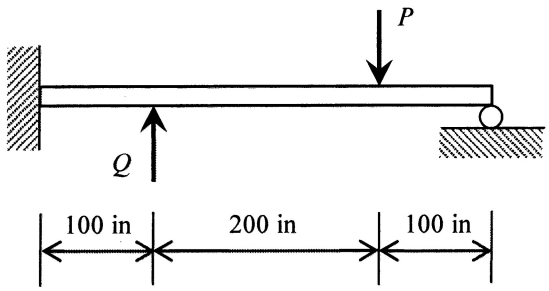


Fig. 2

Plastic Moment of the Beam:

M_p = 3000 in-kip

(in = inch; 1 kip=1000 lb)

Qualification CMIS 2020

1. James must decide which courses to register for this semester. He has a part-time job, and he is waiting to find out how many hours per week he will be working during the semester. If he works 10 hours or less per week, he will register for three classes, but if he works more than 10 hours per week, he will register for only two classes. If he registers for two classes, he will take one class in his major area and one elective. If he registers for three classes, he will take two classes in his major area and one elective.
   1.1. Use structured English to represent this logic. (10%)
   1.2. Use decision table to represent this logic. (10%)

2. Describe what total specialization, partial specialization, disjoint, and overlap rules are. Give an example for each of them. (15%)

3. What are update anomalies, addition anomalies, and deletion anomalies within the data redundancy? (15%)

4. What are the differences between Structured Query Language and Query By Example? (10%)

5. Use the following dependencies to normalize Table 1 to 3rd normal tables. (15%)
   (A, B) → C, D, E, F, G
   B→D, E, F
   C→B
   E→F

Table 1

A	B	C	D	E	F	G

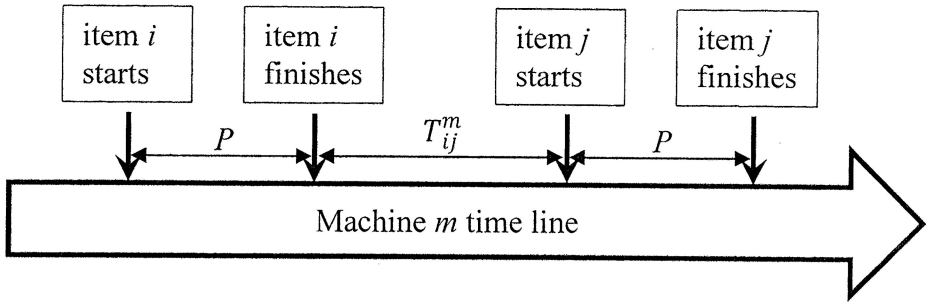
6. Use the following business rules to answer the questions:
   a. A department employs many employees, but each employee is employed by one department.
   b. Some employees, know as "Rover," are not assigned to any department.
   c. A division operates many departments, but each department is operated by one division.
   d. An employee may be assigned to many projects and a project may have many employees assigned to it.
   e. A project must have at least one employee assigned to it.
   f. One of the employees manages each department.
   g. One of the employees runs each division.

   6.1. Develop an appreciate E-R diagram (15%)
   6.2. Write all the cardinalities into the model.(5%)
   6.3. Modify the E-R model by splitting the M:N relationship into two 1:M relationships that are connected through a composite entity. Then rewrite the connectivities and cardinalities to match the changes you have made.(5%)

Please answer in English or Chinese. Answer all the questions concisely.

Consider a production line where there are a total of N items (numbered 1 to N) waiting to be processed in M machines (numbered 1 to M). The dispatching rule is as follows.

1. Each item needs to be processed by exactly one machine.
2. Each machine can process no more than one item at any time.
3. All the machines are identical.
4. The *processing time* of each item is a given constant P, which is identical among items and machines.
5. If items i and j are both processed in the machine m, and item j is processed immediately after item i, then the *cleaning time* between them is a given constant T_{ij}^{m}. During the cleaning time the machine cannot process any item. The time line can be illustrated with the following figure.



6. The optimization goal is to:
   (1) Minimize the total machine working time, which is the sum of total *processing time* and total *processing time*.
   (2) Minimize the completion time, which is the time duration between the start time and the time all the items are processed.

Please answer the following questions.

1. Propose a mixed linear integer program (MLIP) that, when solved, is able to yield the optimum assignment of items to machines, as well as the order the items are processed in the machines. Please define your decision variables clearly.
   (1) (10%) What are the decision variables of your MLIP? Please define them clearly.
   (2) (40%) Write the constraints of your MLIP.
   (3) (20%) Write the objective function for optimization goal (1).
   (4) (20%) Write the objective function for optimization goal (2).
2. (10%) Comment on the complexity of this problem, and propose a method to solve your MLIP.