**UNIVERSITY OF TORONTO**
**FACULTY OF APPLIED SCIENCE AND ENGINEERING**
**FINAL EXAMINATION, 26 APRIL 2001**
**MIE 441S - COMPUTER-AIDED DESIGN**
**Examiner: Prof. L. Chen**

- **Closed book exam, no aids permitted**
- **Time allotted: 2.5 hrs**
- **Total mark: 100 points**

**Problem 1 (20 points)**

Answer the following 10 questions pertinent to your hands-on operation of I-DEAS:

a) Will it be a problem in meshing if a part is not a closed solid?

b) Can different elements be generated on the same part?

c) Since each element contains a material property ID that refers to a table of material properties, will it be a problem if one material table is referenced by many elements?

d) When Map Meshing is applied to a part with interior holes, an error message is always given by I-DEAS. How can the part be modified in order to apply Map Meshing?

e) Suppose a higher local meshing density is desired to apply on the entire surface of a part, but the resulting higher local density only appears on a concentrated area of that surface. What seems to be the problem and how can it be fixed?

f) When it is required to fix the perpendicular movement of a surface, but unfortunately the normal vector of that surface is not parallel to any vector of the global coordinate, what should be done?

g) In TMG Thermal Analysis, both shell mesh and solid mesh have been defined to allow heat conduction from surface to volume and vise versa. When the two types of mesh are generated, there is an error message indicating that the two mesh types cannot be merged together. What is most likely the problem in terms of element type?

h) Suppose no result is shown on the beam cross-section when Contour On X Section function is performed in Beam Section Analysis. What is most likely the problem in the solution stage?

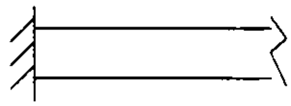
i) What is the main purpose of Coincident Nodes check in TMG Thermal Analysis?

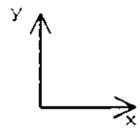
j) Discuss the difference between Element Forces and Element Stresses in Beam Section Analysis?

**Problem 2 (20 points)**

a) Give appropriate FEA constraints and their geometric equivalents to the following classic beam support conditions:

(i)



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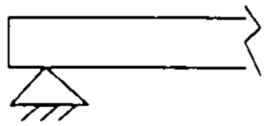

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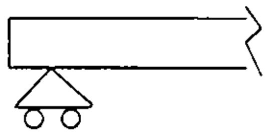
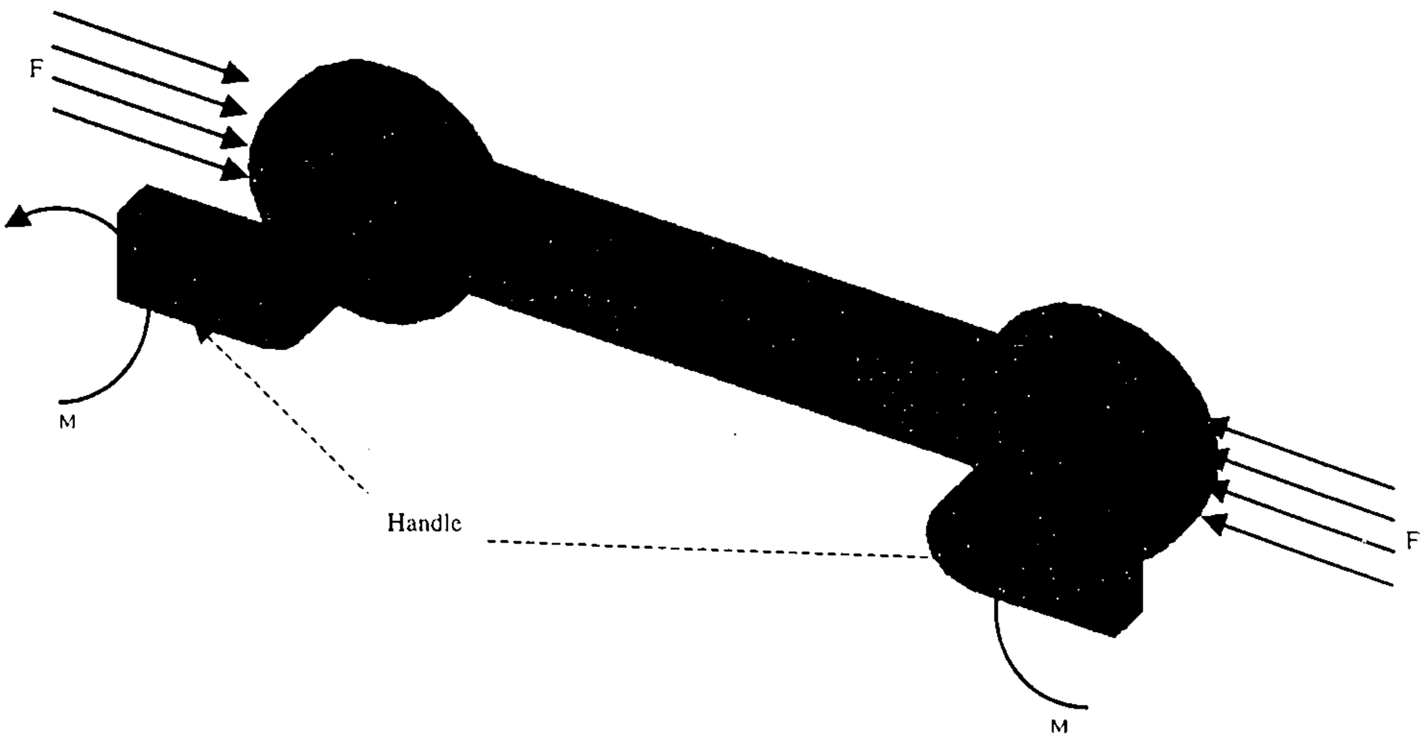


b) Apply appropriate loading and boundary conditions on a simplified geometry for the following part:
   (i) Is the simplified part a plane-stress or plane-strain problem? Justify your choice.
   (ii) Locate, by inspection, where a higher local meshing density should be applied. Provide discussions to support your argument(s).

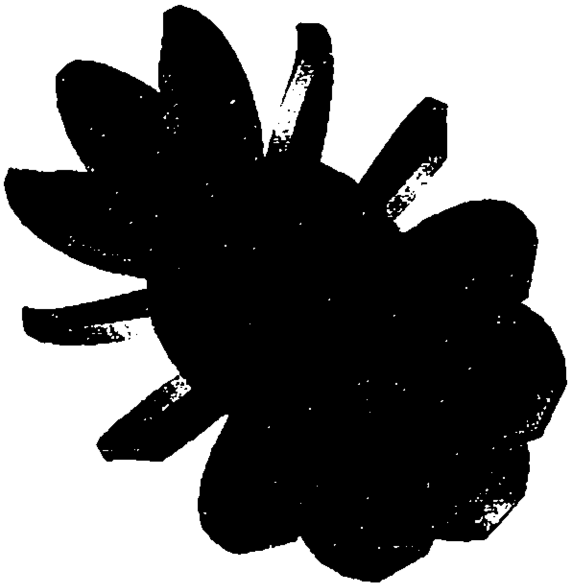


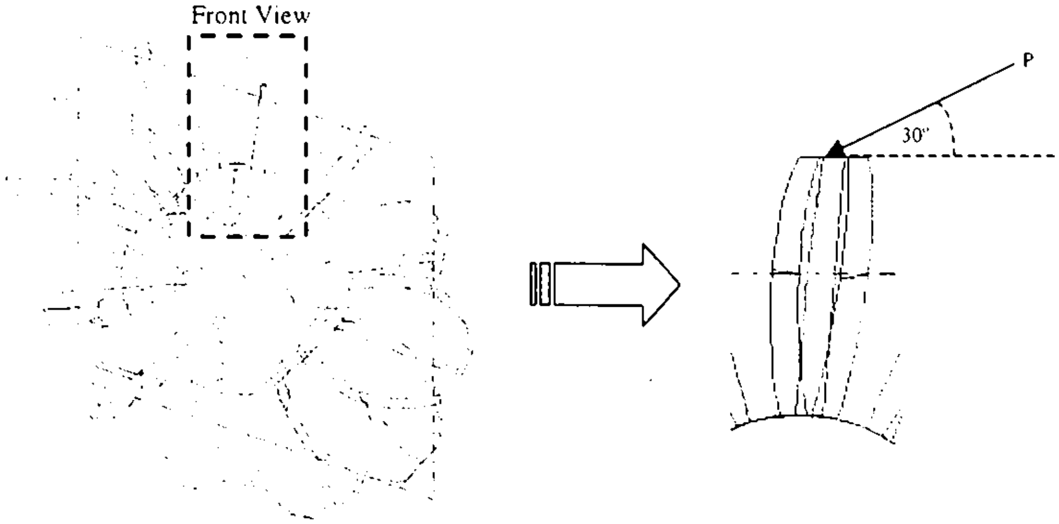
**Problem 3 (20 points)**

a) Elaborate a construction sequence in solid modeling for the following part (see the figure) in the format of a typical I-DEAS history tree.

b) Idealize the given part for FEA according to its symmetry, and apply appropriate boundary conditions so that the simplified one becomes a true representation of the whole part.

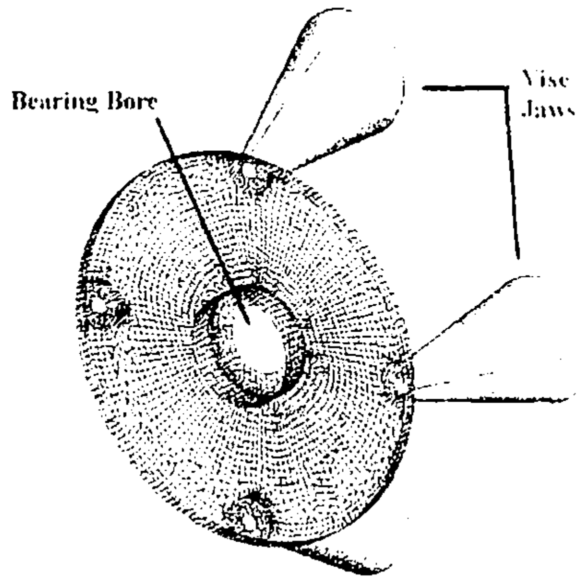
(Note: A total pressure of 15 lbf is applied at the top of the blades parallel to the x-y plane.)





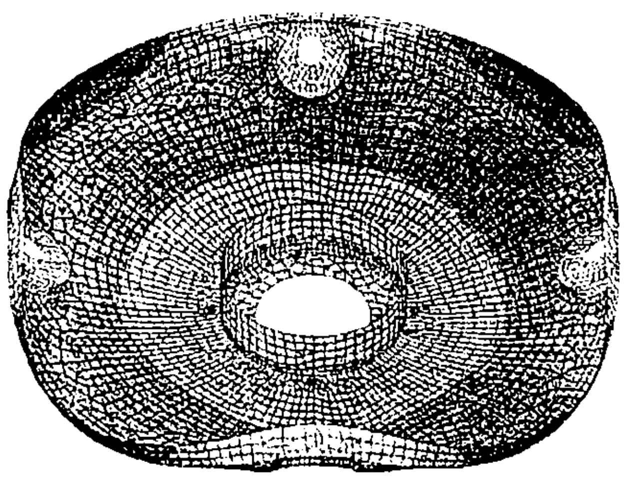
**Problem 4 (20 points)**

a) The motor end cap shown in the following figure was clamped in a four-fingered vise at its mounting holes to turn the bearing bore in production. A high vise pressure caused the bore geometry to collapse elastically so that, after the precise boring operation was complete, the sprung-free part exhibited eccentricity at the bore. The design team wished to use FEA to evaluate the sensitivity of this bore deformation to different loading configurations with a goal of improving roundness after the boring process.



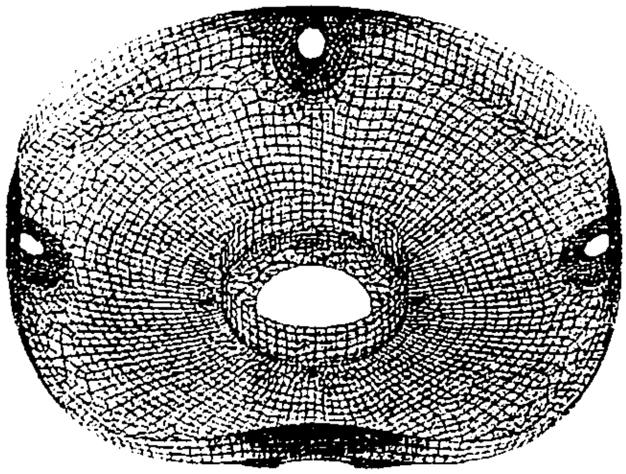

Two modeling approaches were suggested. The first approach was to fix the mounting holes and adjust thermal expansion parameters to produce a reaction force at the fixed mounting holes equal to the known vise loading.

(Note: Higher stress values correspond to darker color in all below stress and deformation plots.)



First Approach

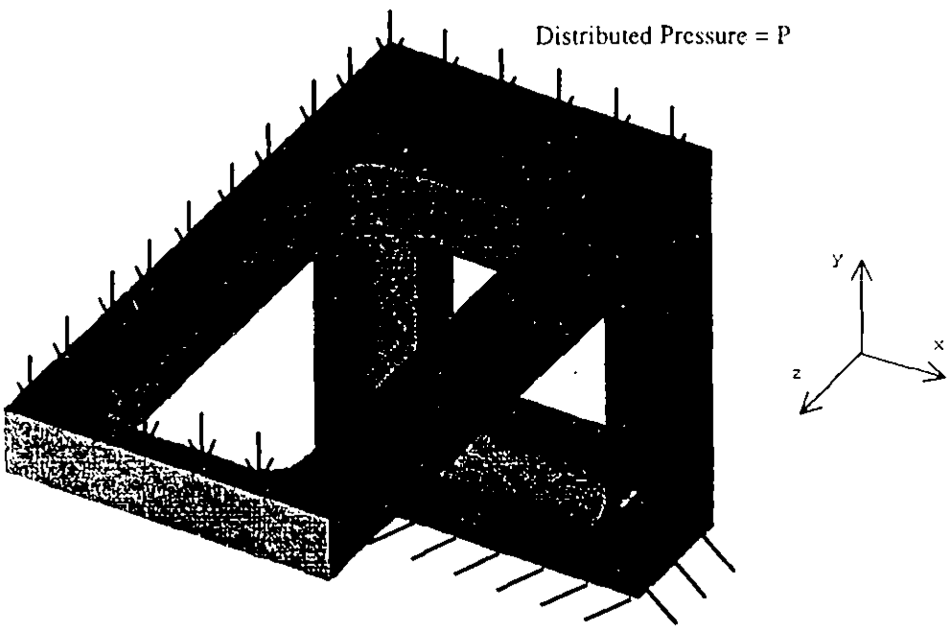
The second approach used a combination of the constraints and radially oriented loads to actually compress the end cap.



Second Approach

Determine and justify which approach could model the loading configuration more accurate based on the given stress and deformation plot with respect to each approach.

b) A bracket is fixed on the ground (see below), where a distributed loading condition is applied vertically over its top surface:
   (i) Draw a free body of the FE model in view of its available symmetry.
   (ii) Specify appropriate boundary conditions on the free body.
   (iii) Determine an element type(s) as used in I-DEAS.
   (iv) Indicate, with the aid of diagram, the locations where adaptive meshing is most appropriate to apply.



**Problem 5 (20 points)**

a) Explain what are r-method, h-method, and p-method in Finite Element Method?

b) What are the major steps in a finite element approach? Describe them in a step-by-step manner.

c) Given the quadrilateral plane element in the following figure:

(i) Define a complete set of notation in the figure for deriving the element stiffness matrix. (Note: OXYZ represents a global coordinate system, and *oxy* a local coordinate system.)

(ii) Describe the derivation procedure for the element stiffness matrix in a step-by-step manner by assuming a linear displacement variation inside the element. In particular, you need to clearly

- state what strategy should be adopted in the derivation,
- express the interpolation model in terms of the nodal shape functions,
- list a general form of the underlying equations necessary for the derivation,
- explain all the variables/parameters to be used in the derivation, and
- specify the size of each matrix/vector to be involved in the derivation.