

UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2014

Module Number: ME5313

Module Name: Computer Aided Design

[Three Hours]

[Answer all questions, each question carries 12 marks]

-
- Q1. a) "Wire frame models are ambiguous." Justify the statement. [2.0 Marks]
- b) Define "geometry" and "topology" with simple examples. [2.0 Marks]
- c) With an example, explain boundary representation method of solid modelling. [2.0 Marks]
- d) I. Explain the Constructive Solid Geometry (CSG) for the representation of solids.
II. Draw the CSG tree for the coffee mug shown in Figure Q1. [3.0 Marks]
- e) I. Describe two sweep representations for solid modelling.
II. How can you generate a sphere using sweeping solid modelling technique? [3.0 Marks]
- Q2. a) 'Nesting of Blanks' is a technique employed by manufacturing process-planning engineers to minimise wastage when producing large quantities of any particular shaped blanks. Figure Q2.(a) shows the blank and a nesting pattern chosen by an engineer. In the process of planning the nest, the engineer first drew blank 1 and then created blanks 2, 3 and 4 using transformations.
I. Describe the transformations necessary to produce, blank 2, blank 3 and blank 4
II. Write the concatenated transformation matrix for each case described in Q2.(a).I.
III. If blank 1 has the co-ordinates as shown in Figure Q2.(a) find the co-ordinates of blank 3, by solving the concatenated transformation matrix. [7.0 Marks]
- b) Figure Q2.(b) shows a cube of length 2 cm. The cube is rotated by an angle $\theta = 30^\circ$ about the z axis. If point B is the mid point of side AD, find the coordinates of points A, B, C and D before and after rotation. [5.0 Marks]
- Q3. a) "Features chosen to represent a part depend on, part type and its application." Explain this statement with a suitable example. [2.0 Marks]
- b) I. Discuss the features shown in Figure Q3.(b) in terms of the definition of a "feature".
II. What is the engineering significance of each feature?

[4.0 Marks]

- c) In parametric techniques working on the basis of geometric models, geometric constraints must be defined on macroscopic level, namely on the basis of parameters of entities such as edges, vertices and faces. Those can be intrinsic or extrinsic constraints. Intrinsic constraints are encoded in feature definitions and inserted automatically in feature instances, hence facilitating the creation of a parametric model. Considering Figure Q3.(c),
- I. Write three intrinsic constraints that can be specified on the slot feature.
 - II. Write any further constraints needed to specify the location and orientation of the slot.

[3.0 Marks]

- d)
 - I. What are stored in the Pro/ENGINEER History tree (or Parts tree)?
 - II. Create a History tree sketch showing the steps you plan to create the model shown in Figure Q3.(d)

[3.0 Marks]

- Q4. a) Describe the steps involved in Finite Element Method (FEM) in stress analysis.

[2.0 Marks]

- b) With the usual notation, show that the stiffness matrix of a Constant Strain Triangular (CST) element is given by,

$$k = \int_v B^T DBdV \quad [3.0 \text{ Marks}]$$

- c) The CST element of thickness $t \text{ mm}$, shown in Figure Q4, is under the plane stress condition. It has a Young's modulus of $E \text{ GPa}$, specific weight $\gamma \text{ kN/m}^3$ and zero Poisson's ratio. Considering plane stress conditions, find the;

- I. Element stiffness matrix for this element.
- II. Equivalent load vector

The following are given.

The elasticity matrix for plane stress condition, $[D] = \frac{E}{1-\nu^2} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix}$

Constant values $a_1 = x_2y_3 - x_3y_2$, $a_2 = x_3y_1 - x_1y_3$, $a_3 = x_1y_2 - x_2y_1$, $b_1 = y_2 - y_3$, $b_2 = y_3 - y_1$, $b_3 = y_1 - y_2$, $c_1 = x_3 - x_2$, $c_2 = x_1 - x_3$, $c_3 = x_2 - x_1$ with usual notation.

[7.0 Marks]

- Q5. a) Show that the element stiffness matrix (in global co-ordinates) of a spring element

located at an angle θ to the horizontal as $k \begin{bmatrix} C^2 & CS & -C^2 & -CS \\ CS & S^2 & -CS & -S^2 \\ -C^2 & -CS & C^2 & CS \\ -CS & -S^2 & CS & S^2 \end{bmatrix}$. Where k , C

and S are stiffness coefficient, $\text{Cos}\theta$ and $\text{Sin}\theta$ respectively.

[5.0 Marks]

- b) The truss shown in Figure Q5 is subjected to a horizontal force F at node 4. Let all the members have the same stiffness EA . Using FEM, find the displacement (in terms of F , E , A and L) at node 4.

[7.0 Marks]

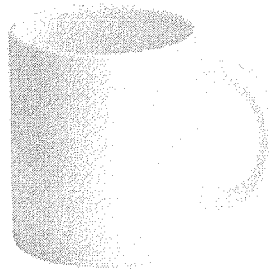


Figure Q1 : Coffee mug

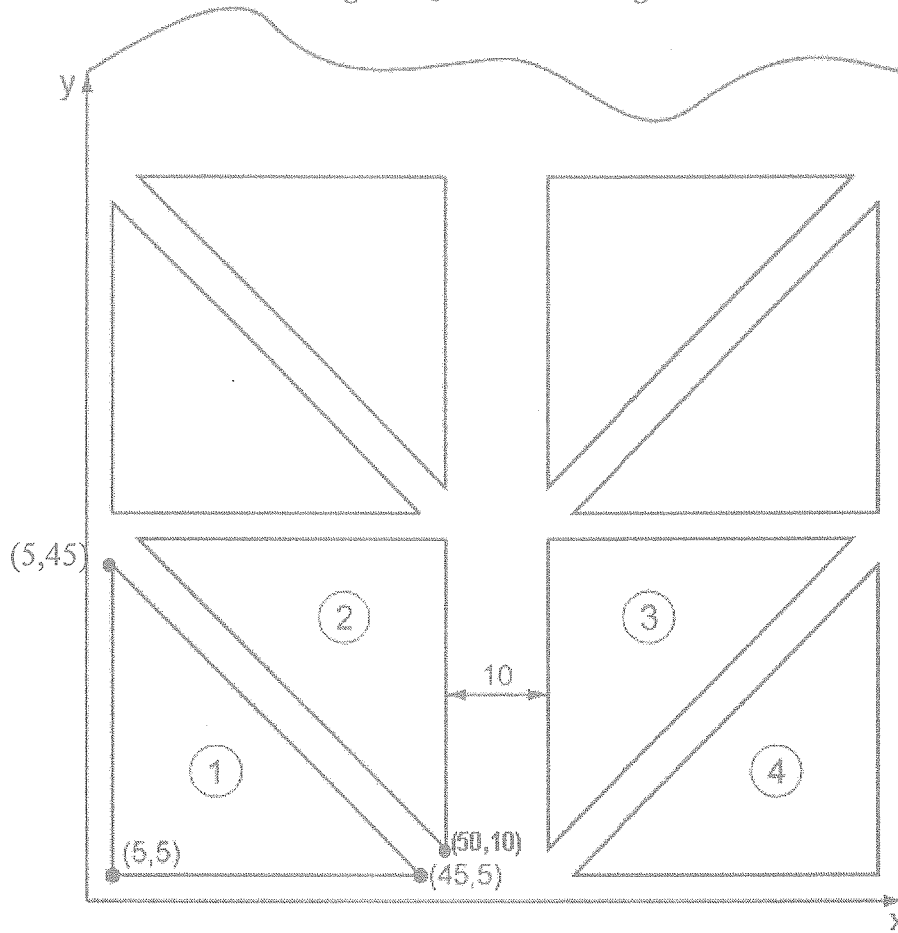


Figure Q2.(a) : Nesting of blanks

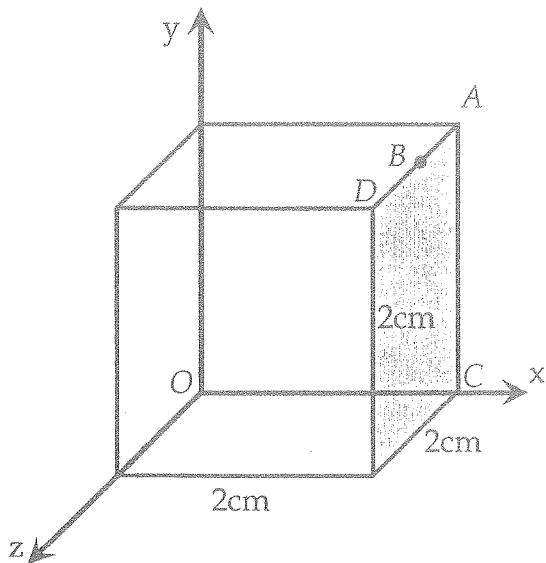


Figure Q2.(b)

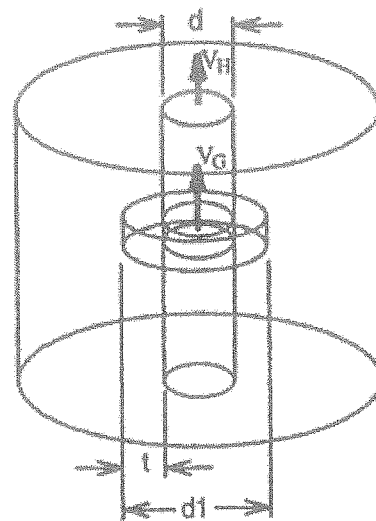


Figure Q3.(b)

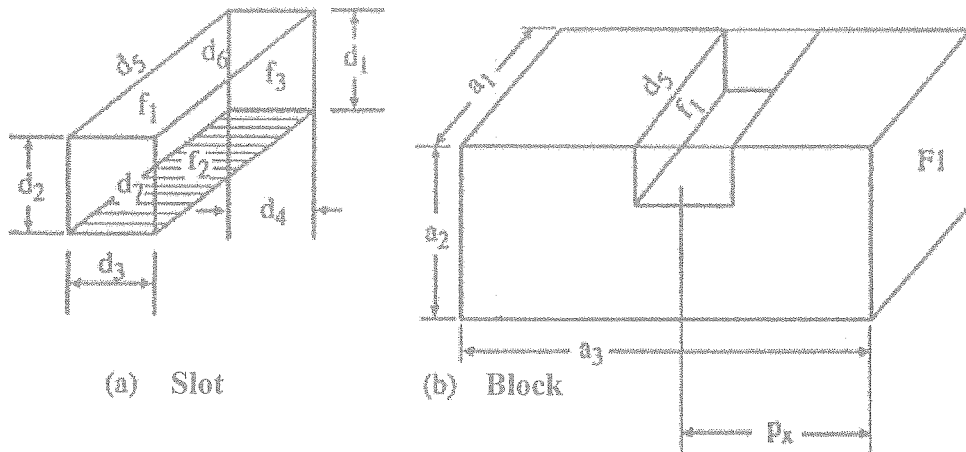


Figure Q3.(c) Positioning of a slot feature

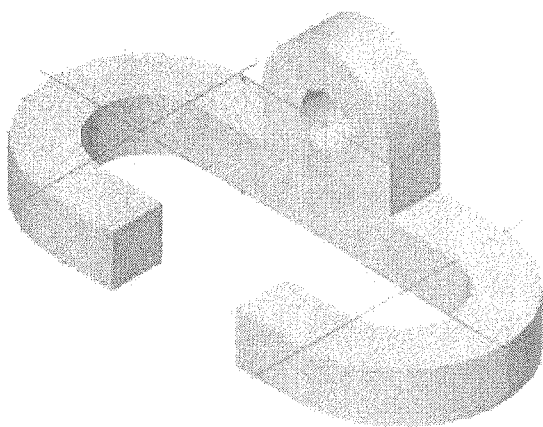


Figure Q3.(d)

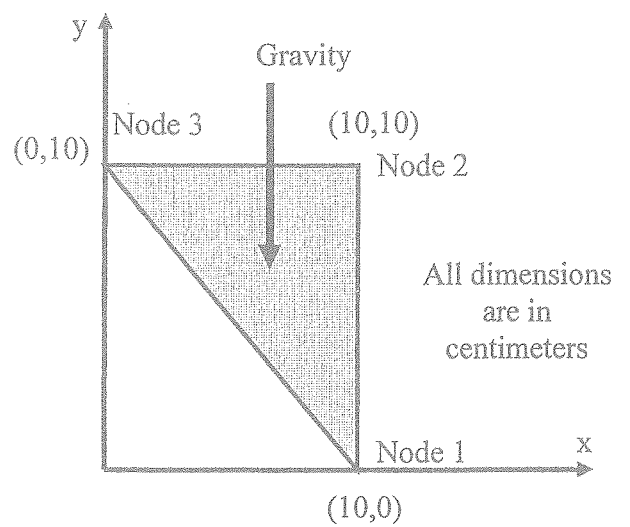


Figure Q4

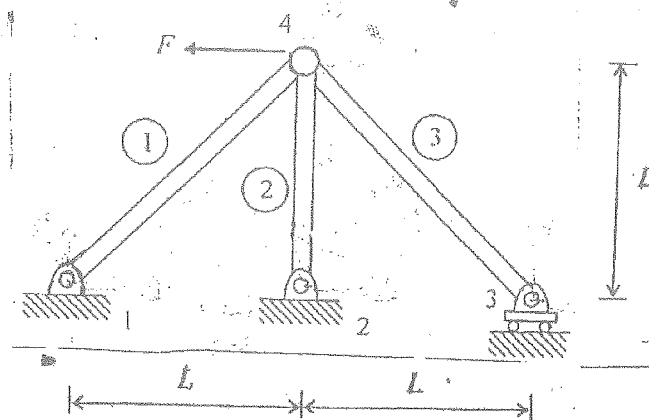


Figure Q5