CAD LAB

LIST OF EXPERIMENTS

Sr No.	Date	Title	Sign
1		OVERVIEW OF COMPUTER AIDED DESIGN	
2		DDA AND BRESENHAM'S ALGORITHMS	
3		2D TRANSFORMATIONS	
4		SOLID MODELLING USING 3D MODLING SOFTWARE	
5		FINITE ELEMENT ANALYSIS	
6		OPTIMIZATION TECHNIQUES AND ITS APPLICATIONS	
7		DESIGN OF MACHINE ELEMENTS USING C-LANGUAGE	

Computer Aided Design (161903)

LAB-1

Title: OVERVIEW OF COMPUTER AIDED DESIGN

Objectives:
1) To define the terminologies CAD/CAM
2) To know the importance and applications of CAD
3) To get acquainted with CAD systems available in CAD lab

Introduction:

Computer Aided Design (CAD) can be defined as the use of computer systems to assist in the creation, modification, analysis or optimization of a design. The computer system consists of hardware and software to perform the specialized design functions required by the particular user firm. The CAD hardware typically includes the computer-one or more graphics display terminals, keyboards and other peripheral equipments. The CAD software consists of computer programs to implement computer graphics on the system plus application programs to facilitate the engineering functions of the user company.

Computer Aided Manufacturing (CAM) can be defined as the use of computer systems to plan, manage and control the operations of a manufacturing plant through either direct or indirect computer interface with plant's production resources.

In this subject, following practicals will be performed as listed below
1) Overview of Computer Aided Design
2) Solid Modeling using Pro/Engineer software
3) DDA and BRESENHAM's Algorithms
4) Programming with C-graphic
5) Finite Element Analysis
6) Generation of SCRIPT files and Introduction to Visual Lisp in AutoCAD
7) Optimization Techniques and its Applications
8) Design of Machine Elements using C-Language
9) Concept of Solid Modeling primitives and generation of DXF file
10) 2D Transformations
11) CAD/CAM Integration

Computer Aided Design (161903)

Exercise

1. List various applications of CAD in the field of Engineering.
2. What do you mean by design for manufacture and assembly? Give suitable examples.
3. Write the hardware specifications of CAD system that you are using in the CAD lab.
4. Enlist various input and output devices used along with CAD system.

References:

1. CAD/CAM Theory and Practice
    - Ibrahim Zeid (McGraw Hil International Edition)
2. Computer Graphics and Design
    - P. Radhakrishnan
    - C.P. Kothandaraman
3. CAD/CAM
    - Groover and Zimmers

LAB-2

Title: DDA and BRESENHAM'S Algorithms
Objectives:
  1) To understand a meaning of Rasterization, scan conversion etc.
  2) To get acquainted with DDA and Bresenham's line algorithms.
 3) To generate circle using various algorithms.

Introduction:
Rasterization: Process of determining which pixels provide the best approximation to a desired line on the screen.
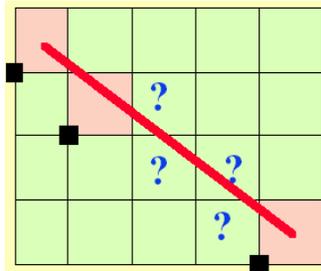

Scan Conversion: Combination of rasterization and generating the picture in scan line order.In other words, the translation of graphic elements to pixel representation.

For horizontal, vertical and 45° lines, the choice of raster elements is obvious. This lines exhibit constant brightness along the length:
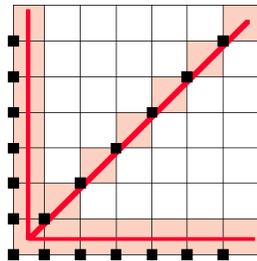
For any other orientation the choice is more difficult:
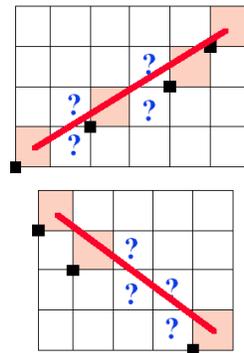
            The general problem of scan conversion is which pixels to turn on.
Basic line algorithms:
Lines must create visually satisfactory images.
  • Lines should appear straight
  • Lines should terminate accurately
  • Lines should have constant density
  • Line density should be independent of line length and angle.
  (a) DDA Algorithm
  (b) Bresenham's Algorithm

Computer Aided Design (161903)

DDA Algorithm:
1. Input the two endpoint pixel positions.
2. Horizontal and vertical differences between end point positions are assigned to parameters dx and dy
3. The difference with greater magnitude determines the value of parameter length.
4. Starting with pixel position (Xa,Ya), we determine offset needed at each step to generate the next pixel position along the line path.
5. We loop through this process length times. If the magnitude of dx>dy.
   a) Xa<Xb – The values of the increments in the x and y directions are 1 and m respectively.
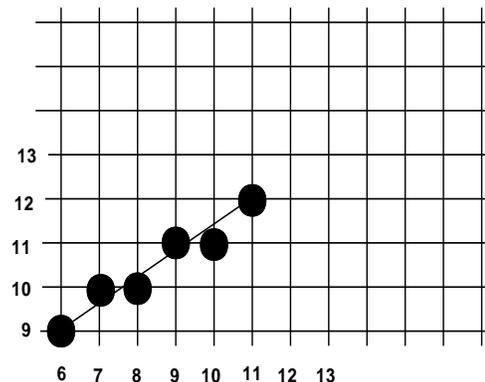   b) Xa>Xb – The decrements -1 and –m are used to generate each new point on the line

Otherwise, we use a unit increment (or decrement) in Y direction and an X increment (or decrement) of 1/m.

Compute which pixels should be turned on to represent the line from (6,9) to (11,12).

Length := Max of (ABS(11-6), ABS(12-9)) = 5
Xinc := 1
Yinc := 0.6

Values computed are:
 (6,9),   (7,9.6),
(8,10.2), (9,10.8),
(10,11.4), (11,12)

Disadvantages:

➢ The DDA algorithm runs rather slowly because it requires realarithmetic.
➢ DDA creates good lines but it is too time consuming due to the round function

Bresenham's line algorithm for |m|<1:
1. Input the two line endpoints and store the left endpoint in (Xo,Yo)
2. Load (Xo,Yo) into the frame buffer; that is plot the first point
3. Calculate constants $\Delta X, \Delta y, 2\Delta Y$ and $2\Delta Y-2\Delta X$ and obtain the starting value for the decision parameter as
$$P_o = 2\Delta Y - \Delta X$$
4. At each Xk along the line, starting at k=0, perform the following test:
   If Pk<0, the next point to plot is (Xk+1,Yk) and
$$P_{k+1} = P_k + 2\Delta Y$$
   Otherwise, the next point to plot is (Xk+1,Yk+1) and
$$P_{k+1} = P_k + 2\Delta Y - 2\Delta X$$
5. Repeat step 4 for ΔX times.

Computer Aided Design (161903)

Advantages:

➢ The Bresenham'sline algorithm uses only integer arithmetic and runs significantly faster.

Basic circle algorithms:

We only need to calculate the values on the border of the circle in the first octant. The other values may be determined by symmetry. Assume a circle of radius r with center at (0,0).

putpixel(a,b);
putpixel(b,a);
putpixel(b,-a);
putpixel(a,-b);
putpixel(-a,-b);
putpixel(-b,-a);
putpixel(-b,a);
putpixel(-a,b)
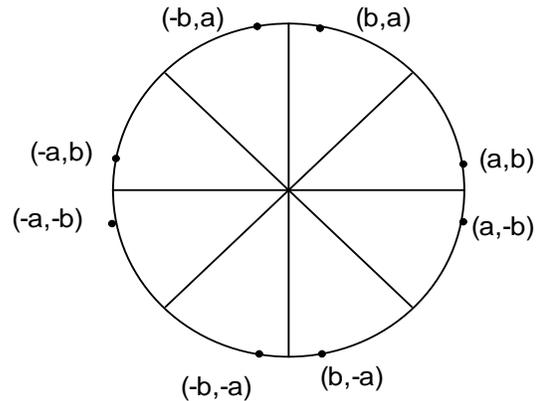
Fast circle generation using Mid point:

Consider only the first octant of a circle of radius r centered on the origin. We begin by plotting point (r,0) and end when x < y.

The decision at each step is whether to choose the pixel directly above the current pixel or the pixel which is above and to the left (8-way stepping).
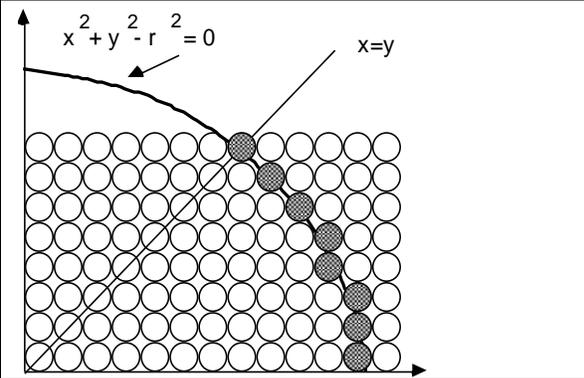
Circle of radius 8

initial pixel ➤ (0,8)
(1,8)
(2,8)
(3,7)
(4,7)
(5,6)
(6,5)
(7,4)
(7,3)
(8,2)
(8,1)
end pixel ➤ (8,0)

Computer Aided Design (161903)
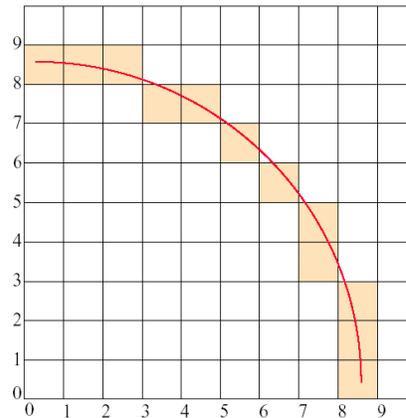
Exercise

1. Using the DDA algorithm sketch the pixels for the line drawn from (4,4) to (15,5) on the graph paper
2. Justify "Line drawn through Bresenham's Algorithm is more accurate than DDA Algorithm"
3. Write a C-program to generate line using Bresenham's Line Algorithm.
4. Sketch the pixels for representing a circle with centre at 200,200 and radius 50 units using rotation method.
5. Write algorithms to draw circle using Bresenham's method

Computer Aided Design (161903)

LAB-3

Title: 2D Transformations
Objectives:

1. To visualize the fundamental 2D geometric operations translation, rotation about the origin, and scale about the origin using C-language
2. To understand the usage of homogeneous coordinates.

Introduction:
Transformations are a fundamental part of computer graphics. Transformations are used to position objects, to shape objects, to change viewing positions, and even to change how something is viewed (e.g. the type of perspective that is used).
There are 3 main types of transformations that one can perform in 2 dimensions:

- translations
- scaling
- rotation

These basic transformations can also be combined to obtain more complex transformations.

Translation
Objective: *Moving an object to a new position by adding to the object x and y coordinates.*

➢ To move a point *p* at (*x*,*y*) to a new position *p'* at (*x'*, *y'*) where
$$x' = x + tx \text{ and } y' = y + ty$$
➢ In matrix form
$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} tx & 0 \\ 0 & ty \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$
➢ The translation can be expressed as.
$$p' = p + T$$
➢ A line or shape can be translated by translating its vertices and redrawing the line or shape.

Scaling
Objective: *Changing the size of the object.*

➢ Scaling refers to rescaling along an axis. A point can be scaled along the x-axis or the y-axis, or both.

$$x' = sx \cdot x \qquad y' = sy \cdot y,$$
➢ In matrix form
$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} sx & 0 \\ 0 & sy \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \qquad \text{or } p' = S \cdot p \qquad \text{where, S= scaling matrix}$$

Computer Aided Design (161903)

➢ A polygon is scaled relative to the fixed point by scaling the distance from each vertex to the fixed point. For a vertex with coordinate (x,y), the scaled coordinates (x',y') are calculated as,

$$x'=x_f+(x-x_f) \cdot sx$$
$$y'=y_f+(y-y_f) \cdot sy$$

➢ It can rewrite as

$$x'=x \cdot sx +(1- sx) \cdot x_f$$
$$y'=y \cdot sy +(1- sy) \cdot y_f$$

where, the additive terms $x_f(1- sx)$ and $y_f(1- sy)$ are constant for all points in the object

Rotation

Objective: *Object is rotated around the origin by a specified angle.*

➢ Rotation about the origin (0,0) is simplest:

x' is some function of *x* and *y*
y' is some other function of *x* and *y*
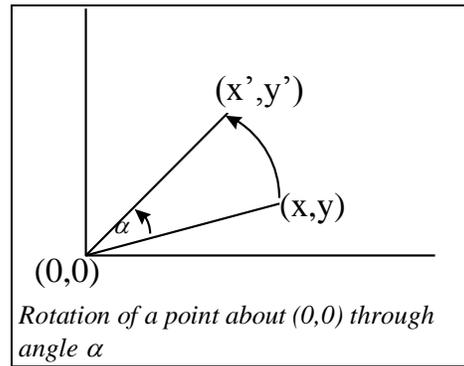
➢ General equations for rotation about (0,0):
$x' = x \cos\alpha - y \sin\alpha$
$y' = x \sin\alpha + y \cos\alpha$

(x',y')

(x,y)

α

(0,0)

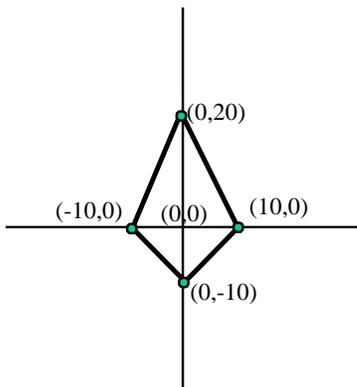*Rotation of a point about (0,0) through angle α*

➢ In matrix form

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

or p'= R • p   where, R= rotation matrix
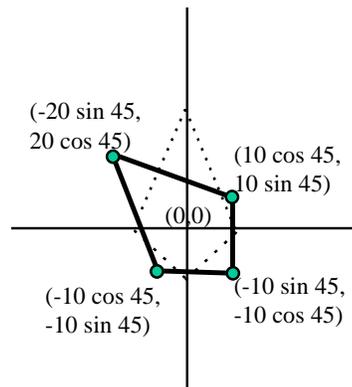
➢ To rotate a line or more complex object, simply apply the equations to the (x,y) co-ordinates of each *vertex*

Original object: Rotated by 45 degrees:

(0,20)

(-10,0)   (0,0)   (10,0)

(0,-10)

(-20 sin 45, 20 cos 45)

(10 cos 45, 10 sin 45)

(0,0)

(-10 cos 45, -10 sin 45)

(-10 sin 45, -10 cos 45)

Computer Aided Design (161903)
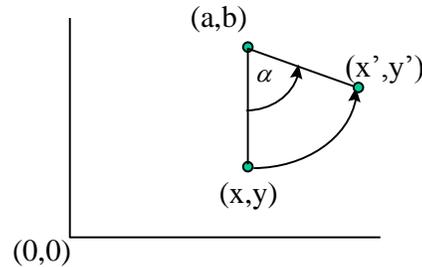
❖ In order to rotate around an arbitrary point *(a,b)*:

now:
$x' - a = (x - a) \cos\alpha - (y - b) \sin\alpha$
$y' - b = (x - a) \sin\alpha + (y - b) \cos\alpha$

i.e:
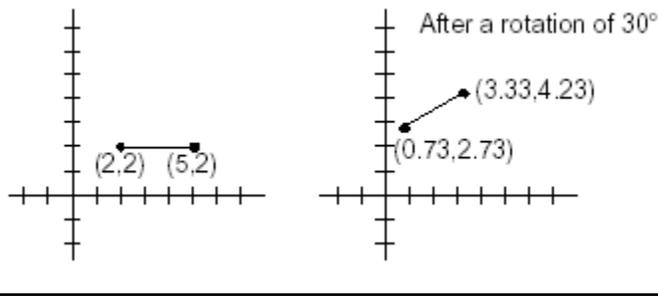$x' = a + (x - a) \cos\alpha - (y - b) \sin\alpha$
$y' = b + (x - a) \sin\alpha + (y - b) \cos\alpha$

Homogeneous coordinates:

> The problem with above approach is that different transformations are handled differently.

$$p' = p + T \qquad p' = S.p \qquad p' = R.p$$

> The solution is to use *homogeneous coordinates*.
> Each point (x, y) is represent as a triple (x, y, W).
>   ▪ Two points are the same is one in a multiple of the other.
> $(1,2,3)$ and $(3,6,9)$ represent the same point.
>   ▪ Each 2D point is now a line in a 3D space.   The $W = 1$ plane is our 2D space and the intersection of the line with this plane gives us the point.
> In a homogeneous coordinate system translation, scaling and rotation are matrix multiplications.

Computer Aided Design (161903)

Exercise

1. Write C-program to scale, translate and rotate the given line about origin.
2. Show matrix representation for scaling, rotation and translation for rectangle having diagonal coordinates (150,150) and (300,300).
3. If scaling of rectangle is to be obtained without changing its apex point (150,150), what procedure to be adopted?
4. Show matrix representation for reflection about xy-plane.
5. Write C-program to translate and rotate rectangle about origin.

References:

1.CAD/CAM and Automation
- FarazakHaideri
2.CAD/CAM Theory and Practice
- Ibrahim Zeid (McGraw Hil International Edition)

LAB-4

Title: SOLID MODELLING USING 3D MODLING SOFTWARE

Objectives:
1) To know different menu available in Pro/E software or inventor.
2) To get acquainted with Extrude, Revolve, Sweep, Blend features of the software.
3) To create solid model of the given objects.

Introduction:

Pro/ENGINEER Part enables you to design models as solids in a progressive three-dimensional *solid modeling* environment. Solid models are geometric models that offer mass properties such as volume, surface area, and inertia. If you manipulate any model, the 3-D model remains solid. Pro/ENGINEERor Inventor provides a progressive environment in which you create and change your models through *direct graphical manipulation*.

There are many kinds of features that you can create on a part. There are solid features and surface features, and features specific to applications. A feature is the smallest building block in a Pro/ENGINEERor Inventor part model.

Following features are used in Pro/E for solid modeling:

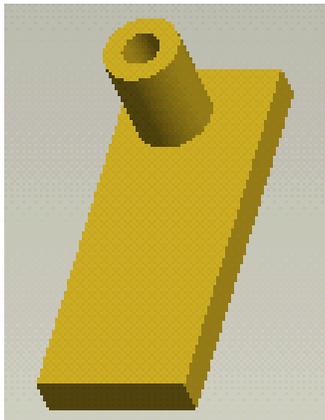**Base features**: Extrude, Revolve, Sweep and Blend

Engineering features: Holes, Ribs, Shells, Draft, Rounds and Chamfers

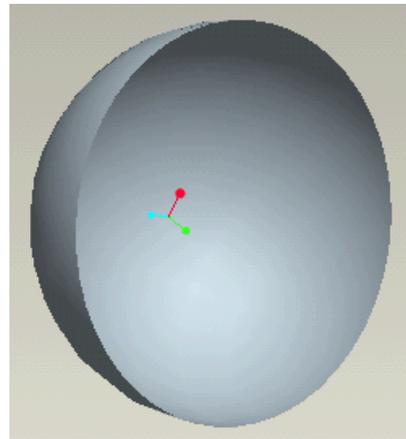**Edit features**: Copy, Mirror, Move, Merge, Trim, Patterns, Extend, Project, Intersect etc.

Advanced Features: Helical sweeps, Boundary blends, Parallel blends, Non-Parallel blends and Swept blends

Tweak Features: Local pushes, Radius domes, Section domes, Toroidal blends etc.

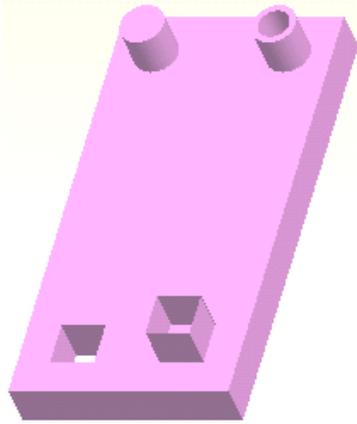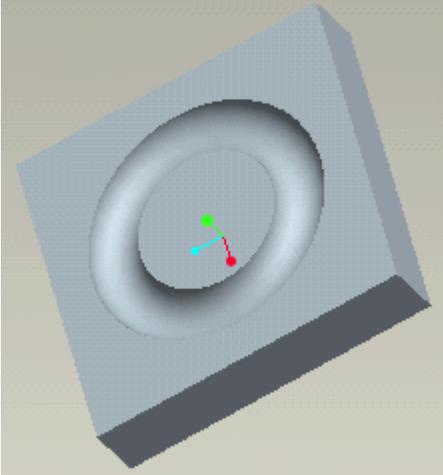|	
Extrude:Extrusion is a method of defining three-dimensional geometry by projecting a two-dimensional section at a specified distance normal to the sketching plane.	*Revolve:* The Revolve tool creates a feature by revolving a sketched section around a centerline.
Sweep: It is used to create a surface by sweeping a section along one or more selected trajectories by controlling the section's orientation, rotation, and	*Blend:* It consists of a series of at least two planar sections that Pro/ENGINEER joins together at their edges with transitional surfaces to form a continuous feature.

Computer Aided Design (161903)

geometry.
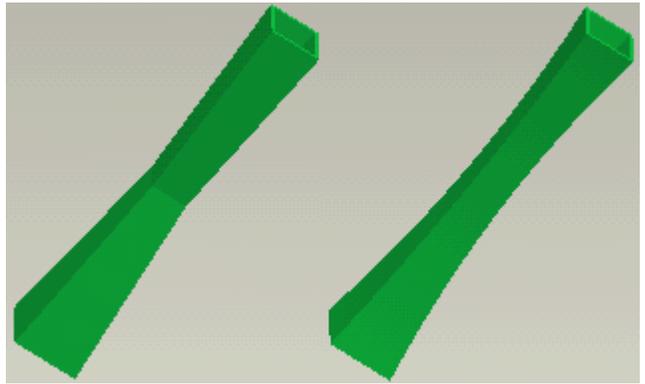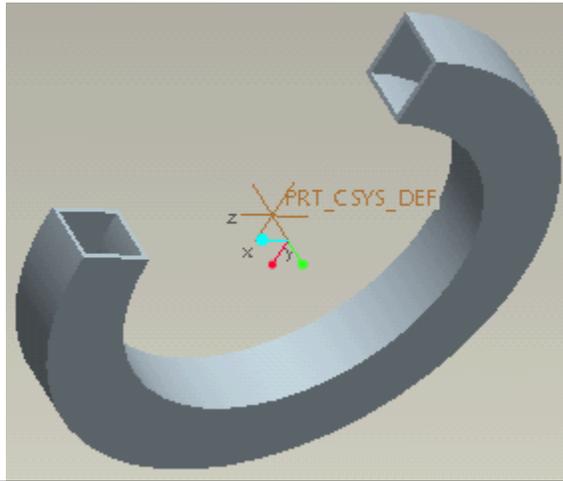
Helical Sweep: Used to sweep section along helical trajectory
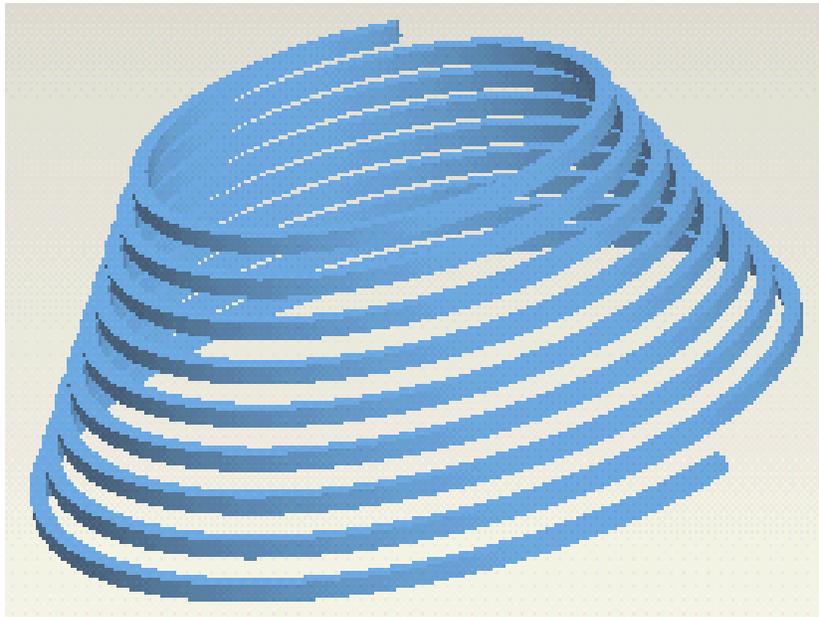
Left Handed (Origin at bottom side)

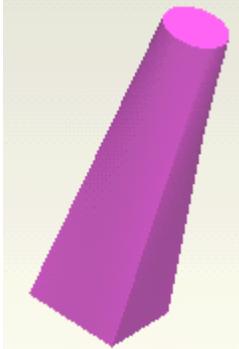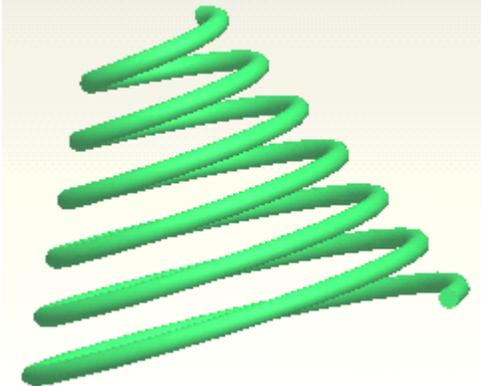Computer Aided Design (161903)

Exercise

1. Differentiate between wireframe modeling, surface modeling and solid modeling.
2. List various solid representation schemes.
3. Create the solid models of following part using PRO/ENGINEER software. Write each step of model creation.

Draw a rectangle of 1000 × 2000 × 200 units. - Create a protrusion of φ200 of 200 unit length and cut of 200 unit square as shown in figure Note: Take a reference of 150 units from both edges for protrusion	Draw a rectangle of 500 × 500 × 100 units. Made a cut of 40-unit radius about the center of the piece.

4. Create the solid model using Blend and Helical sweep feature

Create two section: 1. 350×450 unit rectangle for bottom base 2. Circle of φ 200 for top base **Note**: Add same number of blend vertex to a circle as no of vertices of the rectangle	• Enter Pitch Value say 20unit. • Select type of section say circle of 15 unit.

Computer Aided Design (161903)

LAB-5

Title: FINITE ELEMENT ANALYSIS
Objectives:
1) To know FEM as a tool for analysis.
2) To find out the solution of various problems using FEM.

Introduction:

FEM is powerful numerical technique for analysis. It is used for solid mechanics, fluid mechanics, nuclear reactors etc. It is used for the stress analysis in the area of solid mechanics. The basic concept of the FEM is that a body or a structure may be discretized into smaller elements of finite dimensions called finite elements. The original body or structure is considered as an assemblage of these elements connected at finite number of joints called nodes. The properties of elements are formulated and combined to obtain the solution for the entire body or structure. For a given design problem, the engineer has to idealize the physical system into a finite element model with proper boundary conditions and loads that are acting on the system.

FEM Terminology:

Just as in the truss problem,**u** and **f** are displacement and force vectors respectively. The relation between **u** and **f** is assumed to be of linear and homogeneous. The last assumption means that if **u** vanishes so does **f**. The relation is then expressed by the master stiffness equations:

$$[K]\{u\} = \{f\}$$

K is universally called the *stiffness matrix* even in non-structural applications because no consensus has emerged on different names. The physical significance of the vectors **u** and **f** varies according to the application being modeled, as illustrated in Table 1.

Application Problem	State(DOF) vector u represents	Conjugate vector f represents
Structure and Solid Mechanics	Displacement	Mechanical Force
Heat conduction	Temperature	Heat Flux
Acoustic fluid	Displacement Potential	Particle Velocity
Potential Flows	Pressure	Particle Velocity
General Flows	Velocity	Fluxes
Electrostatics	Electric Potential	Charge Density
Magnetostatics	Magnetic Potential	Magnetic Intensity

Types of Element:

There are different types of elements used for various types of analysis.
Beam Element: The simplest form of element which is used for structure analysis.
Triangular or quadrilateral Element: Plain stress, plain strain or plate bending problems.
Flat or Curved shell Element: For shell structure analysis.
Hexahedral or Tetrahedral Element: 3D analysis.

Computer Aided Design (161903)

Types of Errors:

The finite element analysis is an approximate numerical method to obtain the solution and is not exact. The main types of errors are,

a. Mathematical modeling error.
b. Discretization error.
c. Round off errors.

The first type of error is due to the approximation of the physical system and assumptions and the last error id due to accuracy level possible due to fixed number of digits

Advantages:

The main advantage of FEM is the physical problems, which were so far intractable and complex for any closed bound solution can now be analyzed by this method. The advantages in relation to the complexity of the problem are stated below:

a) The method can be efficiently applied to cater irregular geometry. It can take care of any type of boundary.
b) Material anisotropy and non-homogeneity can be catered without much difficulty.
c) Any type of loading can be handled.

- There are many approximate methods such as weighted residual method, Rayleigh Ritz method, Galerkin's method and others. The FEM stands superior to all of them.
- The formulation of the FEM is that in this method the approximations are confined to relatively small sub domains whereas in other methods the admissible functions satisfy the boundary conditions of the entire domain, which becomes extremely difficult when the domain has irregular shape. In the finite element method, the admissible functions are valid over the simple domain & have nothing to do with the boundary however simple or complex, it may be based on the FEM can be run only in high-speed digital computer.

Disadvantages:

1. One should not form the idea that the FEM is the most efficient for the analysis of any type of structural engineering or physical problem. There are many types of problems where some other method of analysis may prove efficient than the FEM.
2. For vibrations and stability problem in many cases, the cost of analysis by FEM may be prohibitive. It may therefore be a luxury to undertake vibration and stability analysis of simpler structures where applications of even simpler computer methods such as finite strip or other semi analytic methods will lead to more economic solution.

Limitation of FEM:

1. It must be remembered that in whatever sophisticated manner the problem might have been formulated & solved, it has been done so within the framework of its assumptions.
2. Proper engineering judgment, however is to be exercised in interpreting the results.
3. It is not necessary that all conceivable existing complicated problems have been solved by FEM.
4. Due to the requirement of large computer memory and time computer programs based on the FEM can be run only in high speed digital computer.

Computer Aided Design (161903)

5. There are certain categories of problems where other methods are more effective e.g. fluid problems having boundaries at infinity are better treated by the boundary element method.
6. For some problems, there may be considerable amount of input data errors may creep up in their preparation and the results thus obtained may also appear to be acceptable which indicates deceptive state of affairs, it is always desirable to make a visual check of the input data.
7. In FEM, the size of the problem is relatively large, many problems lead to round off errors. A computer works with a limited number of digits solving problem. On the basis of restricted number of digits may not yield the desired degree of accuracy or it may give total erroneous results in some cases. The magnitude of these round off errors varies with the problem, the problem description and computer configuration.

Exercise

1. Derive stiffness equation for a spar element oriented arbitrarily in a 2 dimensional plane.
2. Explain (1) plane stress (2) plane strain (3)Boundary Conditions.
3. A four bar trusses shown in fig.1 assuming that each element cross section area id 400 mm^{2}and modules of elasticity is 200 Gpa, Determine the deflection, reaction forces and stress in each element.
4. A stepped shaft is a shown in fig.2 determine the stress and deflection in each of section assume uniform martial for the complete shaft having a modulus of elasticity as 200 Gpa and axial force as 35KN.
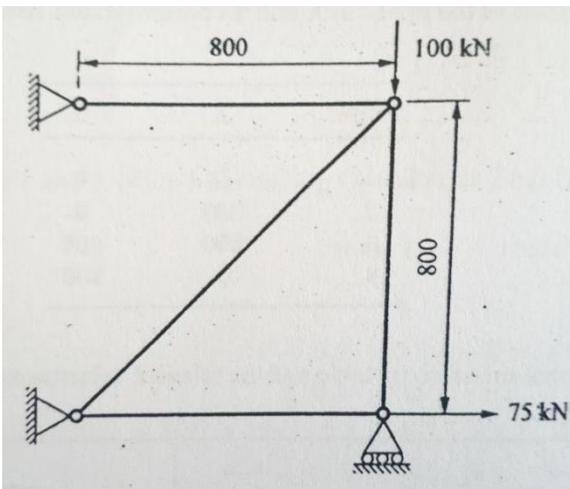5. system of spring as shown in fig.3 determine the overall stiffness matrix and determine deformation of each spring.
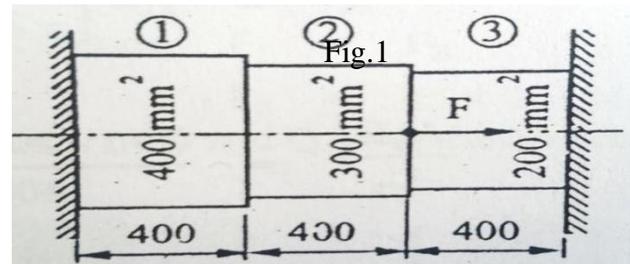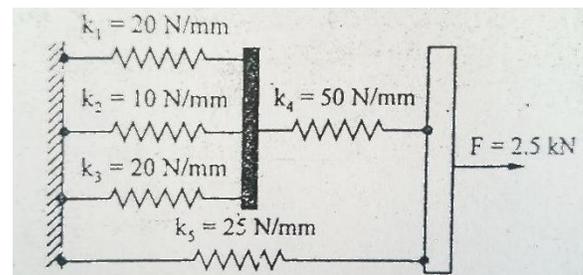

Fig.1

Fig.2

Fig.3

Computer Aided Design (161903)

LAB-6

Title: OPTIMIZATION TECHNIQUES AND ITS APPLICATIONS

Objectives:
3) To get familiar with different optimization techniques.
4) To find out the solution of given problems using optimization techniques.

Introduction:

Optimization techniques, having reached a degree of maturity over the past several years are being used extensively in industries including aerospace, automotive, chemical, electrical and manufacturing. Optimization methods coupled with modern tools of computer aided design are also being used to enhance the creative process of conceptual and detailed design of engineering systems. Optimization helps us to decide which action or combination of actions among all possible (or feasible) ones to optimize an objective function. Optimum design is defined as the best possible design satisfying a specific objective and a set of constraints imposed by the specifications or by design problem itself. The aim of any practical design process is to evolve optimum solution.

Some important application in various engineering field are as below:

1. Design of aircraft and aerospace structures for minimum weight.
2. Finding the optimal trajectories of space vehicle and missile.
3. Design of civil engineering structures like frames, foundations, bridges, towers, chimneys and dams for minimum cost or maximum strength.
4. Minimum weight design of structures for earthquake, wind and other random loading.
5. Design of water resources system for maximum benefits.
6. Optimal plastic design of structures.
7. Optimal design of linkages, cams, gears, machine tools and other mechanical components.
8. Selection of machining conditions in metal cutting processes for the minimum production cost.
9. Design of pumps, turbines and heat transfer equipments for maximum efficiency.
10. Optimum design of electrical equipments like motors, generators and transformers.
11. Optimum design of electrical networks.
12. Inventory control.
13. Optimum design of control systems.

Computer Aided Design (161903)

Exercise

1. Classify optimization problems and explain each in brief.
2. Explain Johnson's Method of Optimum Design.
3. The step-cone pulley shown in figure is to be designedfor transmitting a power of at least 0.75 hp. The speedof input shaft is 350 r.p.m. and the output speedrequirements are 750, 450, 250, and 150 r.p.m. for a fixed center distance between the input and output shaft.The tension on the tight side of the belt is to be kept morethan twice that on the slack side the thickness of the belt is 't'and the coefficient of friction between the belt and the pulleyis μ. Formulate the problem of finding width and diameters ofthe steps for minimum weight.
4. Design a tension bar of length L=200 mm to carry a tension load of 5 KN for a minimum cost out of the following materials.

Material	Mass density Kg/m^3	Material cost Rs./N weight	Yield strength Mpa
Steel	7500	16	130
Al. alloy	3000	32	50
Titanium alloy	4800	480	90
Magnesium alloy	2100	32	20

5. The manufacturing firm produces two machine parts using lathes milling Machine and grinding machines. The different machining time required for each Part the machining time available on different machine and a the profit on each machine part are given in the following table

Types of machine	Machine time required(in mm) 1(x)	2(y)	Maximum time available per week minutes
Lathe	10	5	2500
Milling	4	10	2000
Grinding	1	1.5	450
Profit per unit	Rs.50	Rs.100	

Computer Aided Design (161903)

LAB-7

Title: DESIGN OF MACHINE ELEMENTS USING C-LANGUAGE
Objectives:
1. To know application of a programming language in the design field.
2. To effectively program a given design problem.

Exercise

1. Develop an algorithm for design of helical springs. The design should be quite exhaustive. Write a program in C for helical spring.
2. Prepare computer program using 'C' programming language for the design of shafts on the basis of torsional rigidity. State clearly the inputs and assumptions.
3. Prepare computer program using 'C' programming language for the design of Flange Coupling. State clearly the inputs and assumptions.
4. Prepare computer program using 'C' programming language for the design of a hollow shaft subjected to combined twisting moment and bending moment. State clearly the inputs and assumptions.

References:

1. A text book of Machine Design
   - R.S. Khurmi and J.K.Gupta
2. Programming in C
3. - E. Balaguruswamy.

Computer Aided Design (161903)