Mp3005

1(a)

a) Locator device: to indicate a position or orientation
   Ex, mouse, the cursor of the mouse can indicate a position in a computer
b) Keyboard device: to input a character string
   Ex, keyboard, used in typing a sequence of string
c) Valuator device: to input a real number
   Ex, dials box, dial the number on the box to input a real number
d) Choice device: to select from a set of possible actions or choices
   Ex, function keys, Type a function key which performs a button function

1(b)

Rapid prototyping is that a model or component is modeled using a CAD system, which must represent a closed volume, i.e. a solid. A model is built layer by layer using an RP system. When the shape of the model is very complex, less time is needed, and good resolution is not required, Rapid prototyping is chosen over NC machining.

1(c)

a) Request mode: The application program initiates data entry. Input values are request and processing is suspended until the required data is received.
   Ex: when you logon the MSN, the program will request the user to input the valid username and password. During this process, the "request" mode is used.
b) Sample mode: the application program and input devices operate independently. New input values from the input devices are collected, at predetermined time interval, replacing previously input data values. When the program requires new data, it samples the current values from the input devices.
c) Event-driven mode: the input device initiate data input to the application program. The application program and input devices operate independently but the input devices deliver data to an input queue. All input data are saved. When the program requires new data, it goes to the data queue.

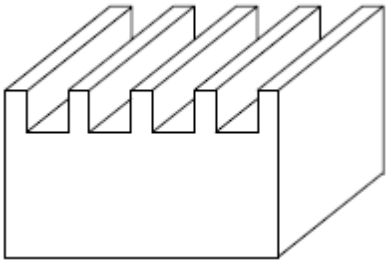
1(d)

Off-screen memory is a non-visible memory, which is a data structure that store an image as a 2D array of pixels plus control information, uses a local Cartesian coordinate system, and able to save and restore pieces of the screen as they are overlaid by other images.
In the pull down menu system, the off-screen memory can store the information of the image which is overlaid. When the user clicks the menu bar, the information stored will be active.

1(e)

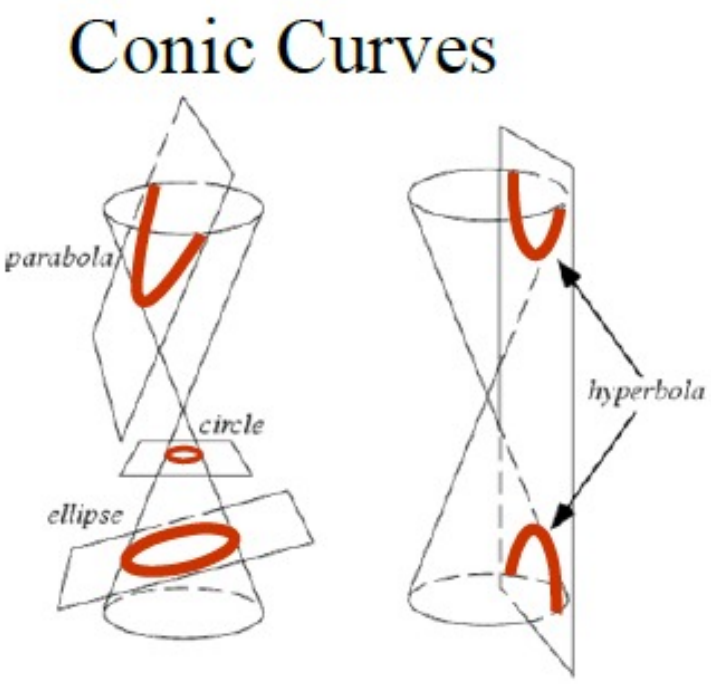
Feature recognition is the process of identifying a feature within a solid model.
Even with feature-based design systems, feature recognition is still necessary because of feature transmutation, the situation in which a feature gives rise to another, often ambiguous, feature. Feature transmutation means that model created using slot features can be

interpreted to have fins as features, which may be the desired feature type for a particular application. Hence, it is necessary to recognize the existence of the fins (refer to the figure below).



It is very difficult to identify a slot as a slot.

1(f)



1(g)

S(u, v) = f(x(u, v), y(u, v), z(u, v))

Tangent in the u direction: $\frac{\partial S}{\partial u} = [\frac{\partial x}{\partial u}, \frac{\partial y}{\partial u}, \frac{\partial z}{\partial u}]$

Tangent in the v direction: $\frac{\partial S}{\partial v} = [\frac{\partial x}{\partial v}, \frac{\partial y}{\partial v}, \frac{\partial z}{\partial v}]$

Surface normal = $\frac{\partial S}{\partial u} \times \frac{\partial S}{\partial v}$

1(h)

The constraint in constraint-based design is referred to largely geometric, which specifies the relationship between different parts of a component, or the way two components are to be assembled together. There are two types: dimensional constraint and relational constraint

The constraints in dynamic simulation specify how the parts are attached to each other and

how they may move against each other, which are idealized. There are three types: joints, e.g. revolute joints, spherical joints; joint primitives, e.g. a point on a part coincident to a plane; cams.

2(a)

a) Flexibility: easy to control and describe shapes with intuitive to use.
b) Continuity: continuous smooth curve preferred. But also need to represent discontinuity where desired.
   - C0 continuity - only joining at end points.
   - C1 continuity - C0 plus equal tangents (1st derivative).
   - C2 continuity - C1 plus equal curvature (2nd derivative).
   - G1 continuity - equal tangent directions but unequal magnitudes. “G” stands for “geometric”.
c) Fast to Compute

2(b)

A circular arc is the intersection graph of a set of arcs on the circle. It has one vertex for each arc in the set, and an edge between every pair of vertices corresponding to arcs that intersect.

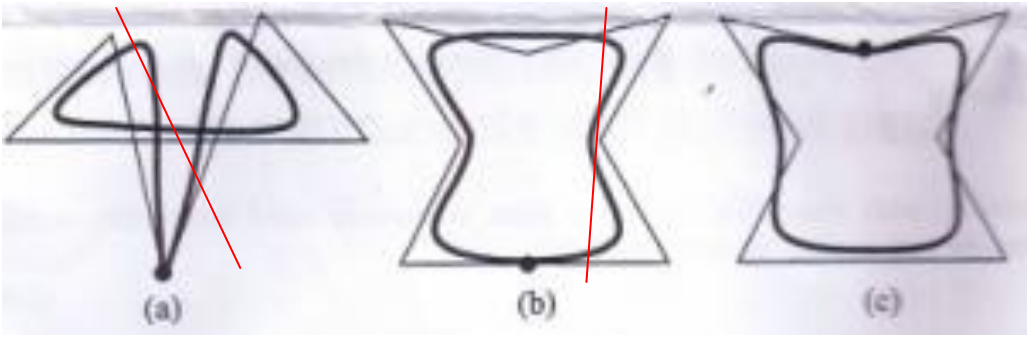
A Bezier curve is a parametric curve, which is control by the control polygons.

Flexibility: Both are very easy to control, Circular arc can be control through changing the radius of the arc and the interval, while Bezier curve has control polygon. However, Bezier curve can describe very complex shapes. Bezier curve is more flexible.

Continuity: Both are very continuous smooth curve and also can represent discontinuity where desired.

Fast to compute: Both have mathematical formula, which is very easy and fast to compute.

2(c)



(a) is not a Bezier curves. Draw a red straight line as shown above. We can see the curve oscillates about the red line 4 times, while the control polygon oscillates only two times. One properties of Bezier curve is that the curve does not oscillate about any straight line more than the control polygon. (a) does not follow this property.

(b) is also not a Bezier curves. Same reasons as (a)

(c) is Bezier curves, which strictly follows all the properties of Bezier curves

3(a)

CSG constructs complex solids by combining simpler ones using set operators, the simplest of which are called primitives. Primitives generally include rectangular blocks, cylinders, cones, spheres and tori. Set operators are not closed over the 2D space. Modified set operators that

produce results only of the same space as the operands by discarding all non-regular results. The complex solids can be represented by CSG tree, which is a binary tree. In the CSG tree, primitives are at terminal nodes, operators are at non-terminal nodes. The final object is at the root of the tree.

3(b)

b-rep is the representation of a solid via its bounding faces. It has a hierarchical structure: solid – shells – faces – loops – edges – vertices. All the entities are represented and stored explicitly.

The role of winged-edge structure is that it links the entities together to form a valid solid, allows navigation through the solid starting from any edge, and enables fast traversal of the entities without heavy computation.

3(c)

Solidworks use feature based modeling

That is because that feature based modeling has following advantages.

a) Generally provide the mechanism for addressing a functional group of faces as a unit, instead of a loose collection.
b) Allow the user to interact with the system in a more natural way -holes as holes, slots as slots, and not as blocks or cylinders.
c) Therefore, features provide a new level of interaction in modeling.
d) Provide a "handle" to associate non-geometric data, such as manufacturing information: "drill and tap", "black hole".
e) Features can be "turned on and off", thus removing design details from applications that do not need them.
f) Enables a program to more intelligently "reason" with a model.

3(d)

The model accepted by CosmosMotion is solid model.

Solidworks and CosmosMotion may have different methods to represent this model. However, they have a “common language”, Application programming interface (API). API can translate the programming language used by Solidworks to the language which can be accepted by the CosmosMotion.

4(a)

For mechanical engineering applications, these application models are 3D sold model.

For other applications, such as in garment design, they may be soft surface model.

4(b)

Planning: project planning, QFD

Concept development: industrial design, visualization and animation

System-level design: industrial design, visualization and animation, CA design and drafting, CA simulations, CA engineering

Detail design: CA design and drafting, CA simulations, CA engineering

Testing and refinement: CA design and drafting, RP, CA manufacturing, CA simulations

Production ramp-up: RP, CA manufacturing, CA simulations

4(c)

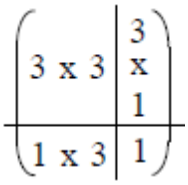
i. Concept development
ii. System level design and detail design
iii. System level design, detail design, and testing and refinement

Computer aided design system also includes the dynamic simulation system. Dynamic simulation system allows engineers to build and test machines on the computer, without having to build a physical prototype, which is expensive to test their functions and performances.

5(a)

A homogeneous coordinate system is a coordinate system in which there is an extra dimension, used most commonly in computer science to specify whether the given coordinates represent a vector (if the last coordinate is zero) or a point (if the last coordinate is non-zero).

In homogeneous coordinates, a 3D vector has four elements: v = (x, y, z, w). Homogeneous coordinate system can be used to form the transformation matrix, which can represent pure rotation and translation moving an object rigidly in space.



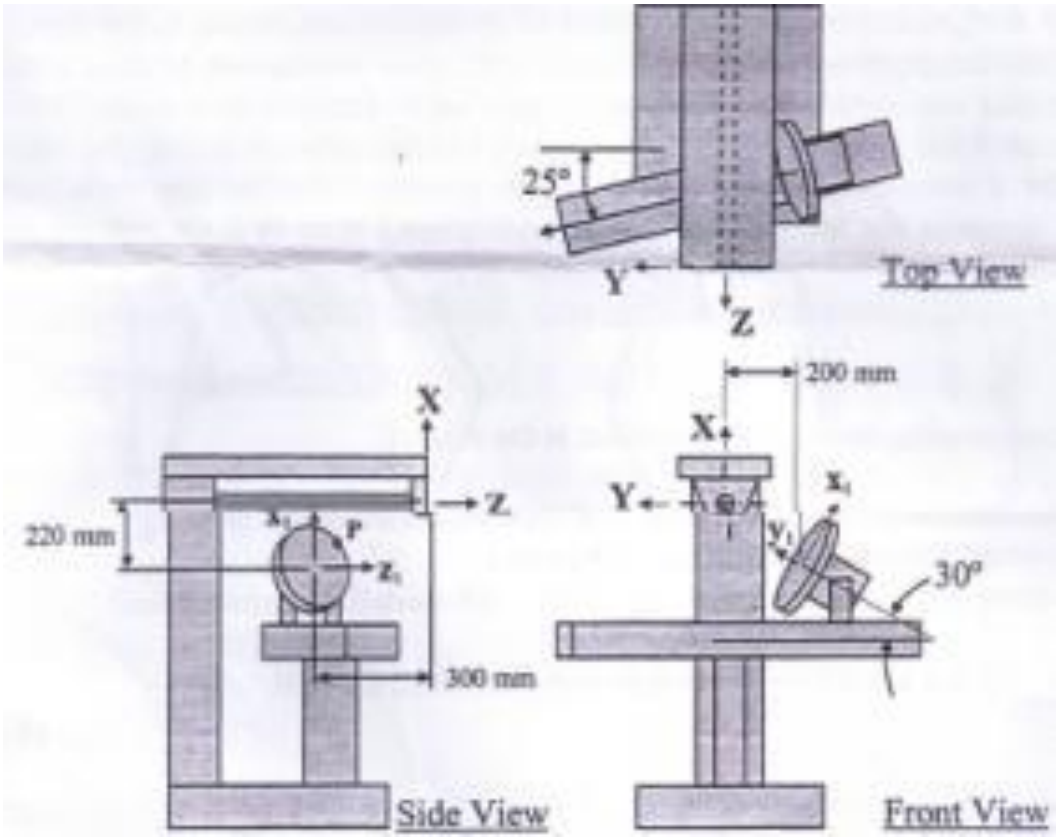
The top left 3x3 forms the rotation component if it has a determinant of 1, otherwise it can be used for shearing and scaling in the individual x, y z directions, or a combination of all three. The top right 3x1 component is for translation, the bottom 1x3 is for skewing (or perspective transformation) and the single bottom right element is for overall scaling. We shall not delve into the details here.

5(b)

Advantage: Homogeneous coordinates system allows all affine transformations to be represented by a matrix operation. Homogeneous coordinates can be used to translate and rotate a point. Any number of transformations can be combined, in the correct order, to form one matrix before applying them to the vector. This is more efficient because we often want to apply the same set of transformations to a number of points.

Disadvantage: Homogeneous coordinates system translates the geometric transformation to pure matrix computation, which is very complicated. It costs lots of time if manual computation. It need be solved with aid of computer.

5(c)



5(c)

i. Translate the origin of LCS to the origin of GCS

$$[T] = \begin{bmatrix} 1 & 0 & 0 & 220 \\ 0 & 1 & 0 & 200 \\ 0 & 0 & 1 & 300 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. Rotate about X-axis into X-Y plane (CW)

$$[R_x] = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(-25^\circ) & -\sin(-25^\circ) & 0 \\ 0 & \sin(-25^\circ) & \cos(-25^\circ) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3. Rotate about Z-axis into Y-axis (CCW)

$$[R_z] = \begin{bmatrix} \cos 30^\circ & -\sin 30^\circ & 0 & 0 \\ \sin 30^\circ & \cos 30^\circ & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. Actual Rotate about Y-axis by -35°

$$[R_y] = \begin{bmatrix} \cos(-35^\circ) & 0 & \sin(-35^\circ) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(-35^\circ) & 0 & \cos(-35^\circ) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$[P'] = [T]^{-1}[R_x]^{-1}[R_z]^{-1}[R_y][R_z][R_x][T][P].$$

So the transformation matrices is

$$[T]^{-1}[R_x]^{-1}[R_z]^{-1}[R_y][R_z][R_x][T].$$