CAD/ CAM

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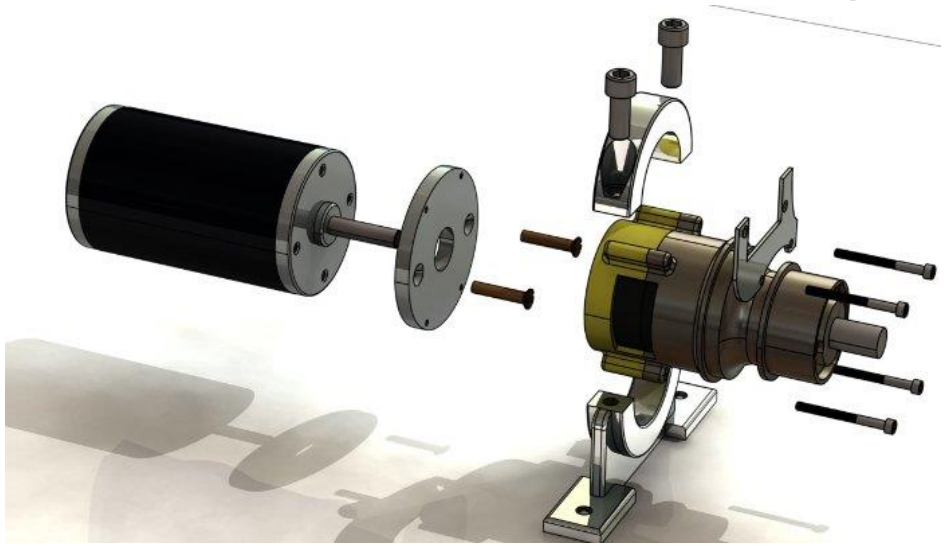

INTRODUCTION:

- **CAD/CAM**: is a term which means computer aided design and manufacturing it is the technology concerned with the use of digital computer to perform certain function in design of production.
- **CAD CAM** has spread down the market, and down the price seals to the point at which it is both a feasible and an affordable technology for a wide range of small and medium sized companies in varies areas such as: general engineering industries, plastic molding ,and consumable electronics.

Some typical applications of CAD/CAM

- Programing for NC and CNC and industrial robots
- Designing for dies and molds for casting
- Designing for tools and fixtures and EDMs electrodes.
- Quality control and inspections
- Process planning and scheduling


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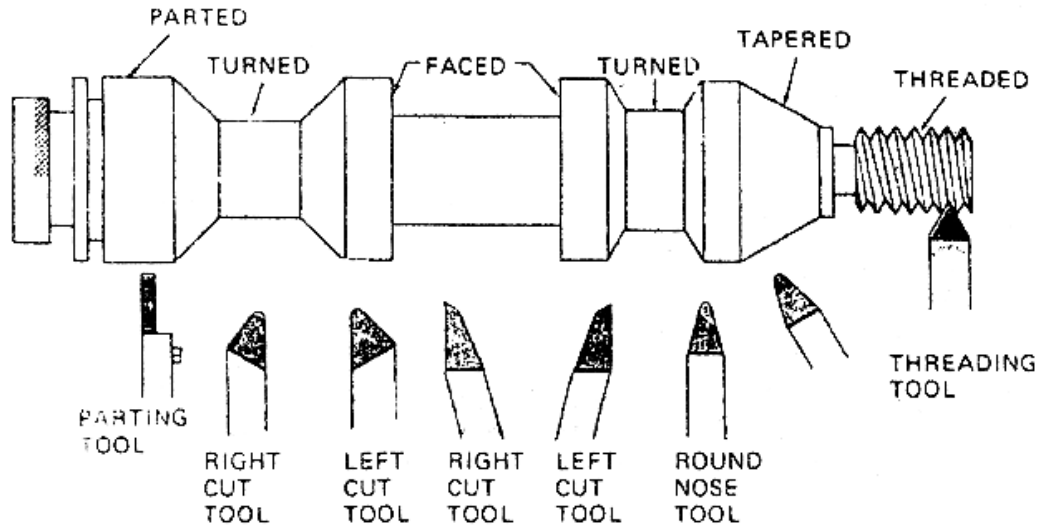
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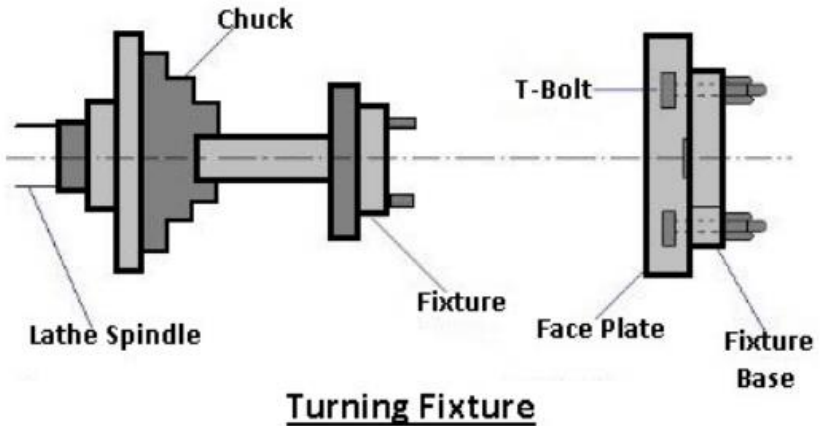
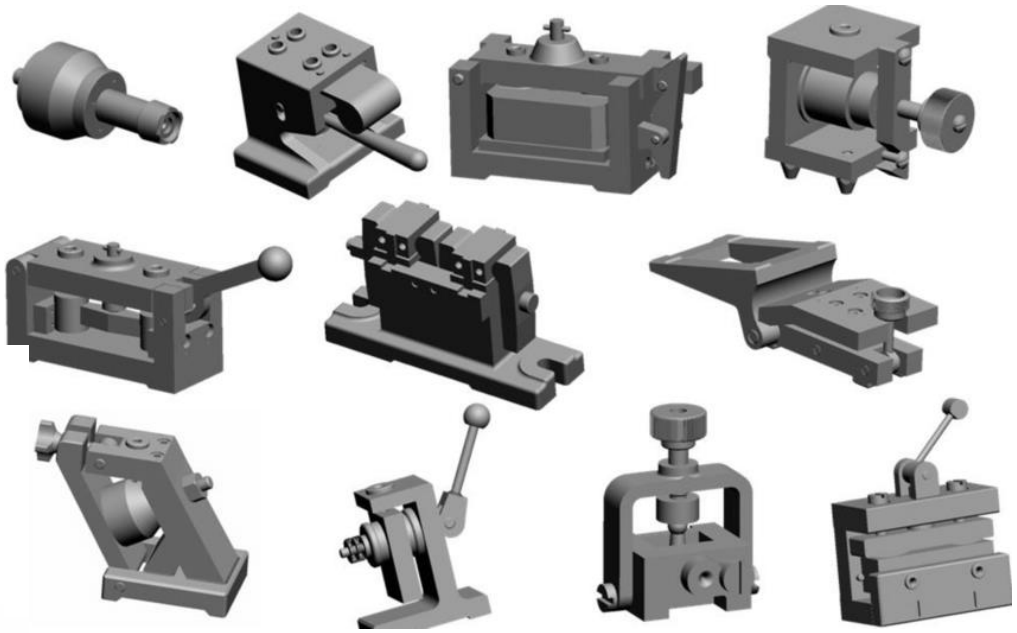
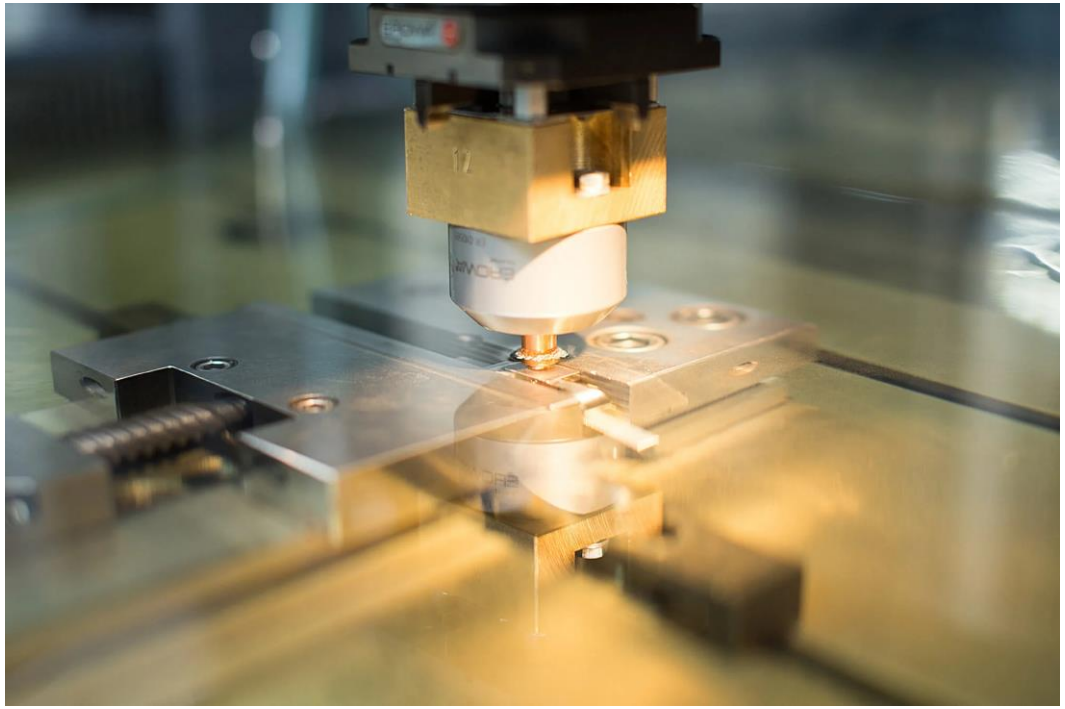
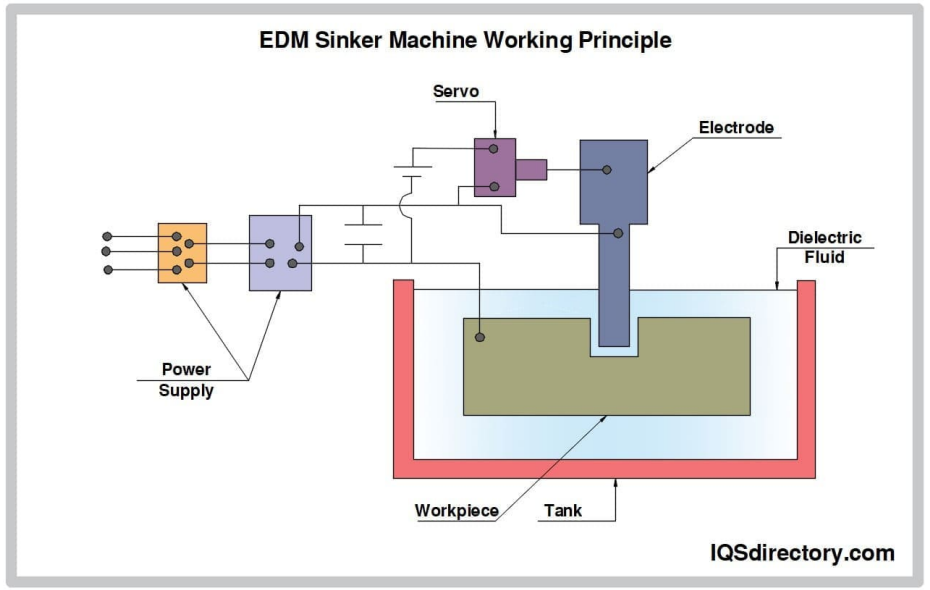


Turning Fixture



EDM’s :electro discharge machines

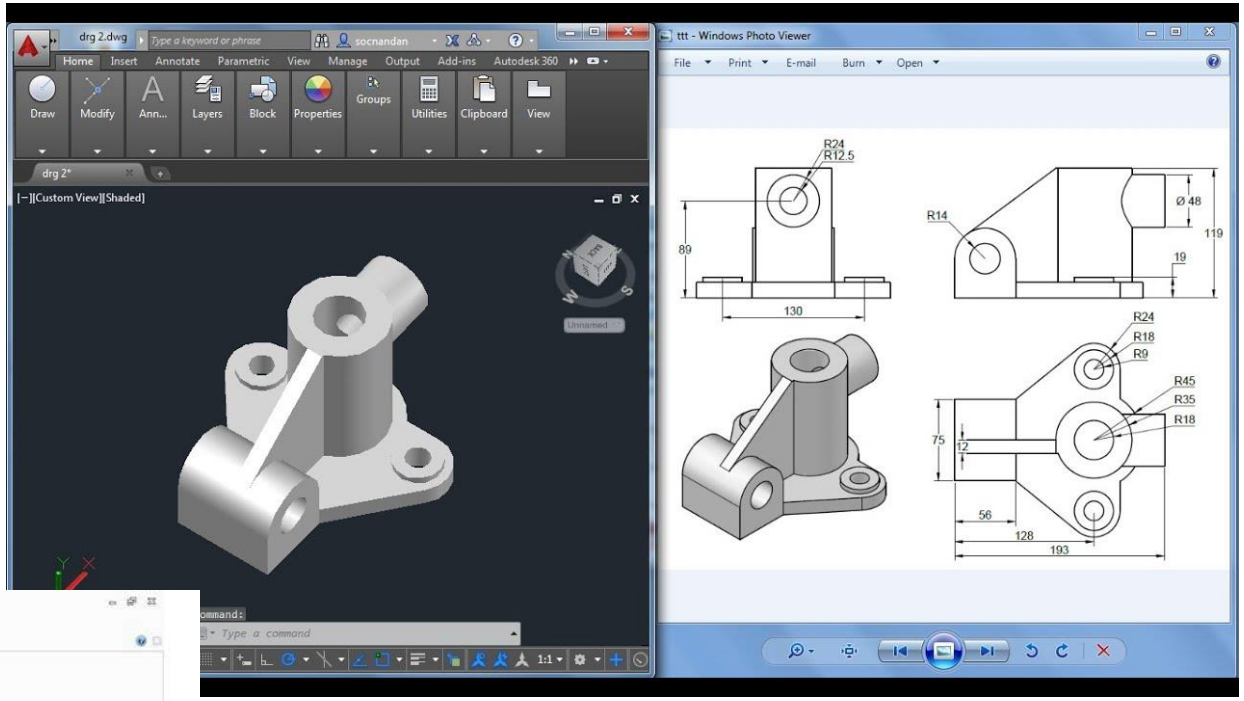




Computer aided design (CAD):

- Computer aided design (CAD) is the use of computer systems to assist in the creation. modification. analysis or optimizations of a design
  - Computer systems consist of the hardware and software to perform the specialized design functions
  - The CAD hardware typically includes input and output devices and CPU the computer keyboard and mouse for data input and display terminals for outputs.
  - The cad software consist of the programs to implement computer graphics of the system plus application programs to facilitate the engineering functions
  - Examples of application programs includes: stress-strain analysis ,dynamic response of mechanisms, heat transfer calculations and NC part programing

- CAD systems can be classified in several ways:
  - BY the system hardware Mainframe, Minicomputer, Engineering workstation, Microcomputer
  - By the application area: Mechanical engineering ,circuit design, and board layout, Architectural design ,and construction engineering, Cartography.
  - By the modeling method: 2-D drafting, 3-D drafting ,sculptured surface, 3-D solid modeling.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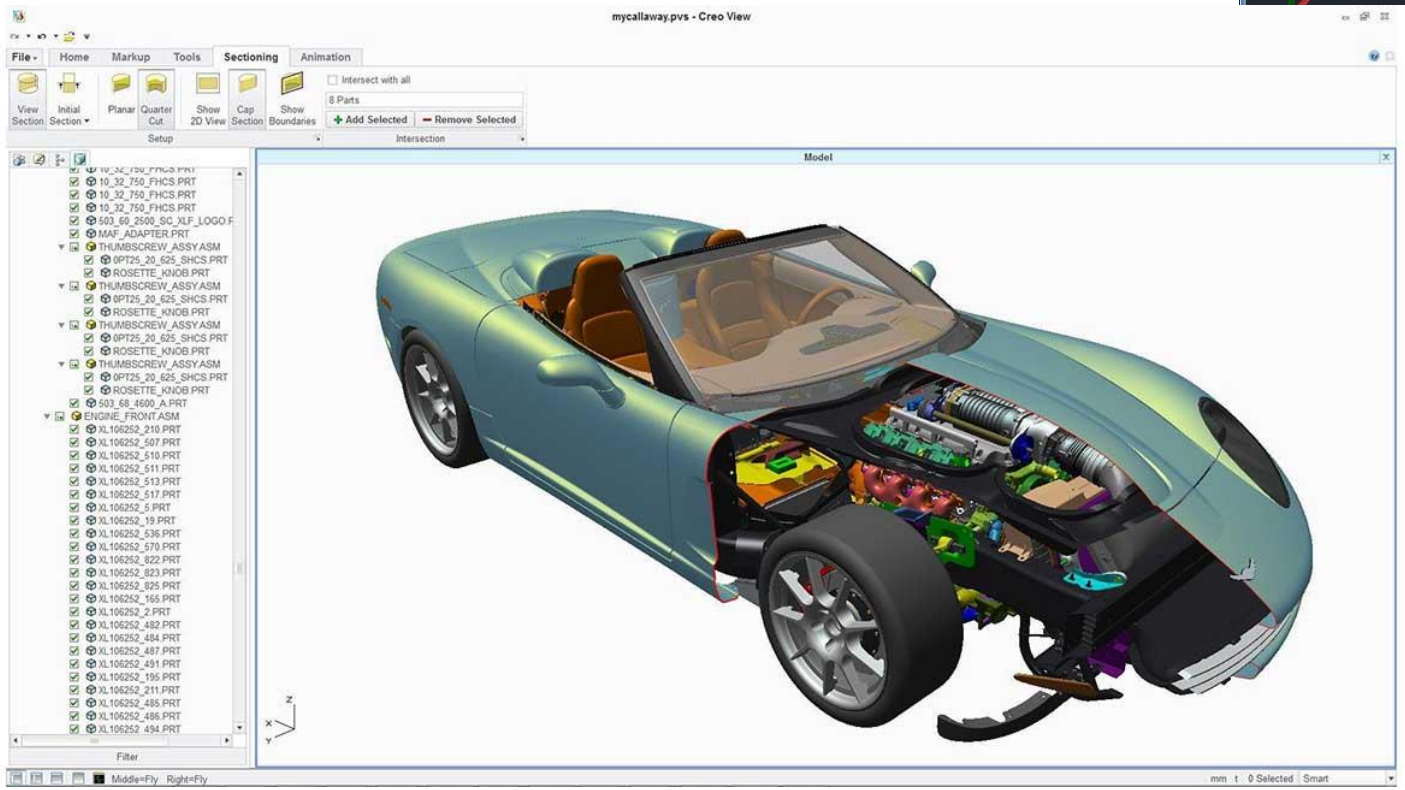
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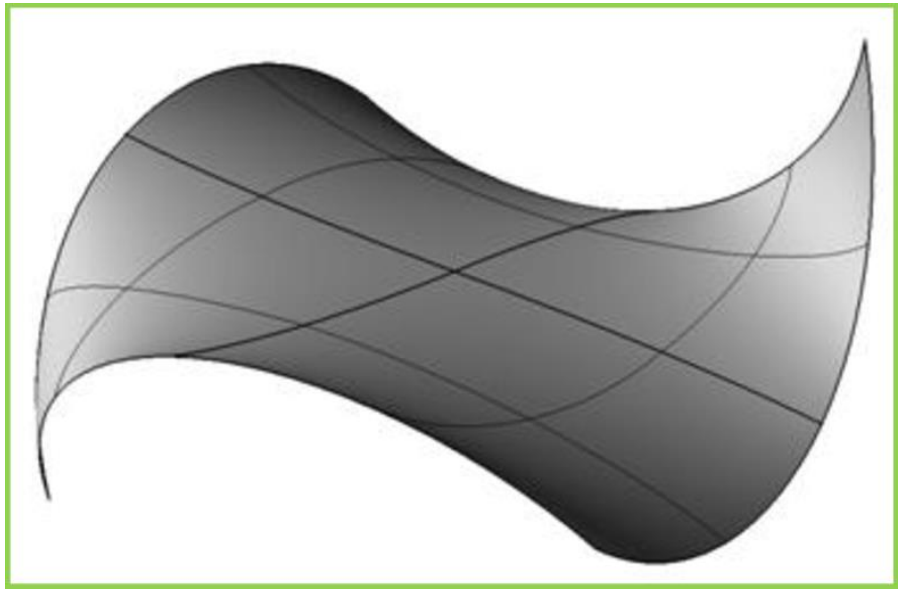


Advantages of Programing CAD:

- Can be used directly to general cutting data for CNC machines
- Flexibility in in model design.
- Faster to produce programs with less labor required
- Multiple copies can be stored printed and shared
- More accurate than hand drawings
- Accurate 3D models can be visualized and tested before production.

Disadvantages of CAD:

- Power cuts and viruses can be problematic
- Users may need expensive training in order to use the software
- Software requires continuous updates
- Expensive software
- Traditional drafting well be lost

Computer aided manufacturing(CAM):

- **Computer aided manufacturing (CAM)**: is the use of computer systems to plan, manage, and control the operations of a manufacturing plant through direct or indirect computer interface with production resources.
- **Advantages of CAM:**
  - - Manufacturing can take place with minimum supervision and after hours.
  - - The process is less labor-intensive and thus saves employment cost.
  - - Accurate manufacture and can be repeated several times.
  - - Continuous working hours with less errors.
  - -Ability to fabricate quick prototypes prior design finalizing

Computer aided manufacturing(CAM):

- **Disadvantages of CAM:**
  - - Maintenance cost is very high.
  - - Initial and startup cost are very high.
  - - Requires less labor and thus increase the number of unemployed skills.
  - - Requires highly trained technicians.

Computer aided manufacturing(CAM):

- The applications of CAM fall into two categories:

  1-Computer monitoring and control

  - These are the direct applications in which the computer is connected directly to the manufacturing process for the purpose of monitoring or controlling the process.

  2- Manufacturing support applications

  - These are the indirect application in which the computer is used in support of the production operations in the plant, but there is no direct interface between the computer and manufacturing process.

The applications of CAM fall into two categories:

1- Direct computer process interface

Computer process **monitoring** involves a direct computer interface with the manufacturing process for the purpose of observing the process and associated equipment and collecting data from the process.

Computer process **control** is not only observing the process, but also controlling it based on the observations.

Figure 1: (A)computer monitoring and (B) computer control

The applications of CAM fall into two categories:

Table 1.1: Comparison between computer monitoring and computer control

Computer monitoring	Computer control
The flow of data between the process and the computer is in one direction only from the process to the computer.	The computer interface allows for a two-way flow of data. Signals are transmitted from the process to the computer and the computer issues command signals directly to the manufacturing process based on control algorithms continued in the software.

The applications of CAM fall into two categories:

2- Indirect computer process interface

In support applications the relationship between the computer and the process is presented as follows:

-Dashed lines are used to indicate that the communication and control link is an offline connection and human is often required to operate the process.

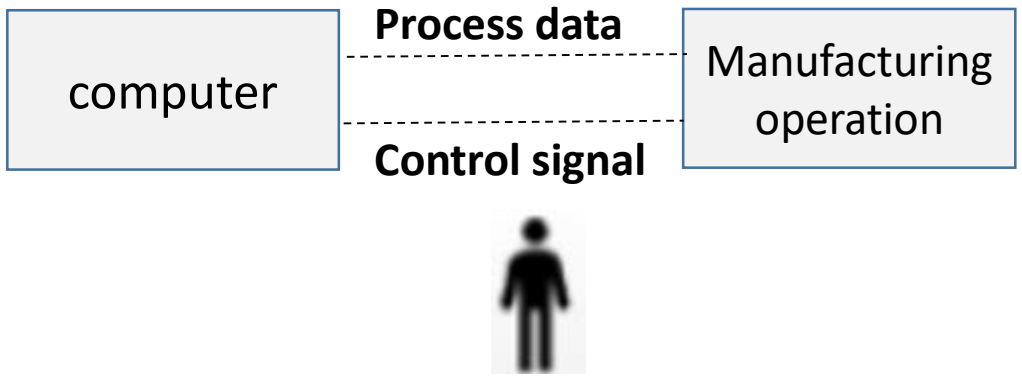


Figure 1.2: CAM for manufacturing support

The applications of CAM fall into two categories:

- Some examples of CAM for manufacturing support include:

  - Numerical control part programming: control programs are prepared for automated machine tools.
  - Computer-automated process planning: the computer prepares a listing of the operation sequence required to process a particular product or component.(i.e. ball bearing and stepped shaft)
  - Computer-generated work standards: the computer determines the time standard for a particular production operation.
  - Production scheduling: the computer determines an appropriate schedule for meeting production requirements.

The applications of CAM fall into two categories:

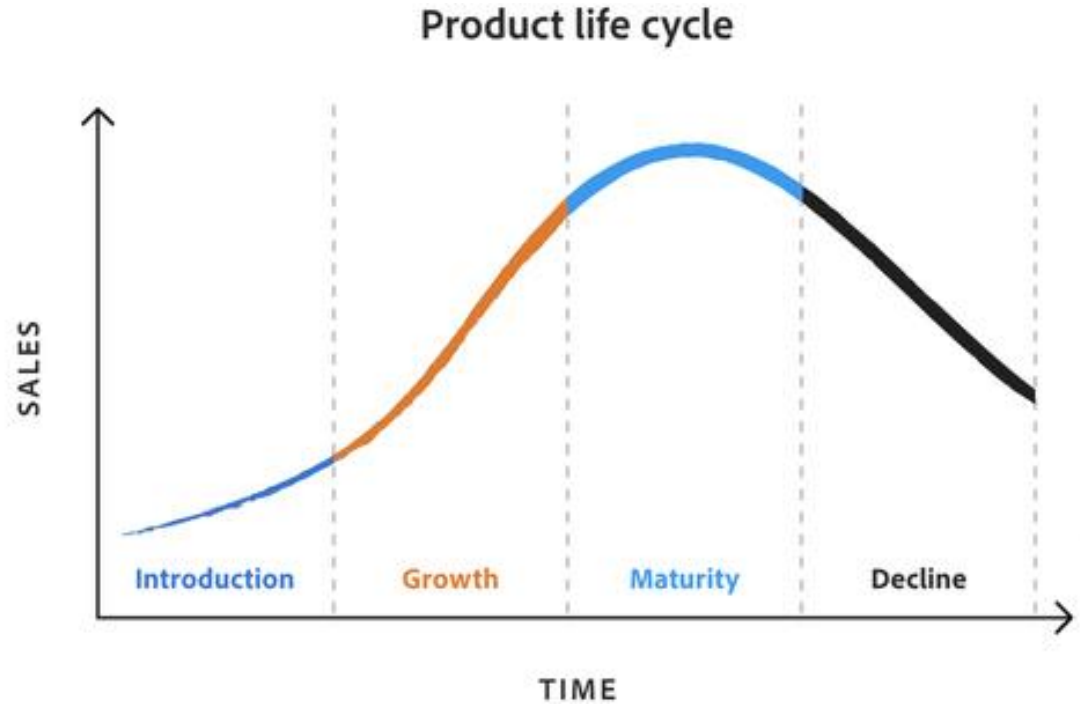
- Material requirement planning: the computer is used to determine when to order raw materials and purchased component and how many should be ordered to achieve the production scheduling.
- Shop floor control: in this cam application data are collected from the factory to determine the progress of the various production shop orders.

*Human beings are presently required in the application either to provide input to computer programmers or to interrupt the computer outputs and implement the required action.

The product cycle and CAD/CAM

- **Product cycle**: The various activities and functions that must be accomplished in the design and manufacturing of a product.

  - The product life cycle has 4 very clearly defined stages, each with its own characteristics that mean different things for business that are trying to manage the life cycle of their particular products.



The product life cycle

- **Introduction Stage** - This stage of the cycle could be the most expensive for a company launching a new product. The size of the market for the product is small, which means sales are low, although they will be increasing. On the other hand, the cost of things like research and development, consumer testing, and the marketing needed to launch the product can be very high, especially if it's a competitive sector.

- **Growth Stage** - The growth stage is typically characterized by a strong growth in sales and profits, and because the company can start to benefit from economies of scale in production, the profit margins, as well as the overall amount of profit, will increase. This makes it possible for businesses to invest more money in the promotional activity to maximize the potential of this growth stage.

The product life cycle

- **Maturity Stage**-During the maturity stage, the product is established and the aim for the manufacturer is now to maintain the market share they have built up. This is probably the most competitive time for most products and businesses need to invest wisely in any marketing they undertake. They also need to consider any product modifications or improvements to the production process which might give them a competitive advantage.

- **Decline Stage**-Eventually, the market for a product will start to shrink, and this is what's known as the decline stage. This shrinkage could be due to the market becoming saturated (ie. all the customers who will buy the product have already purchased it), or because the consumers are switching to a different type of product. While this decline may be inevitable, it may still be possible for companies to make some profit by switching to less-expensive production methods and cheaper markets.

The product life cycle

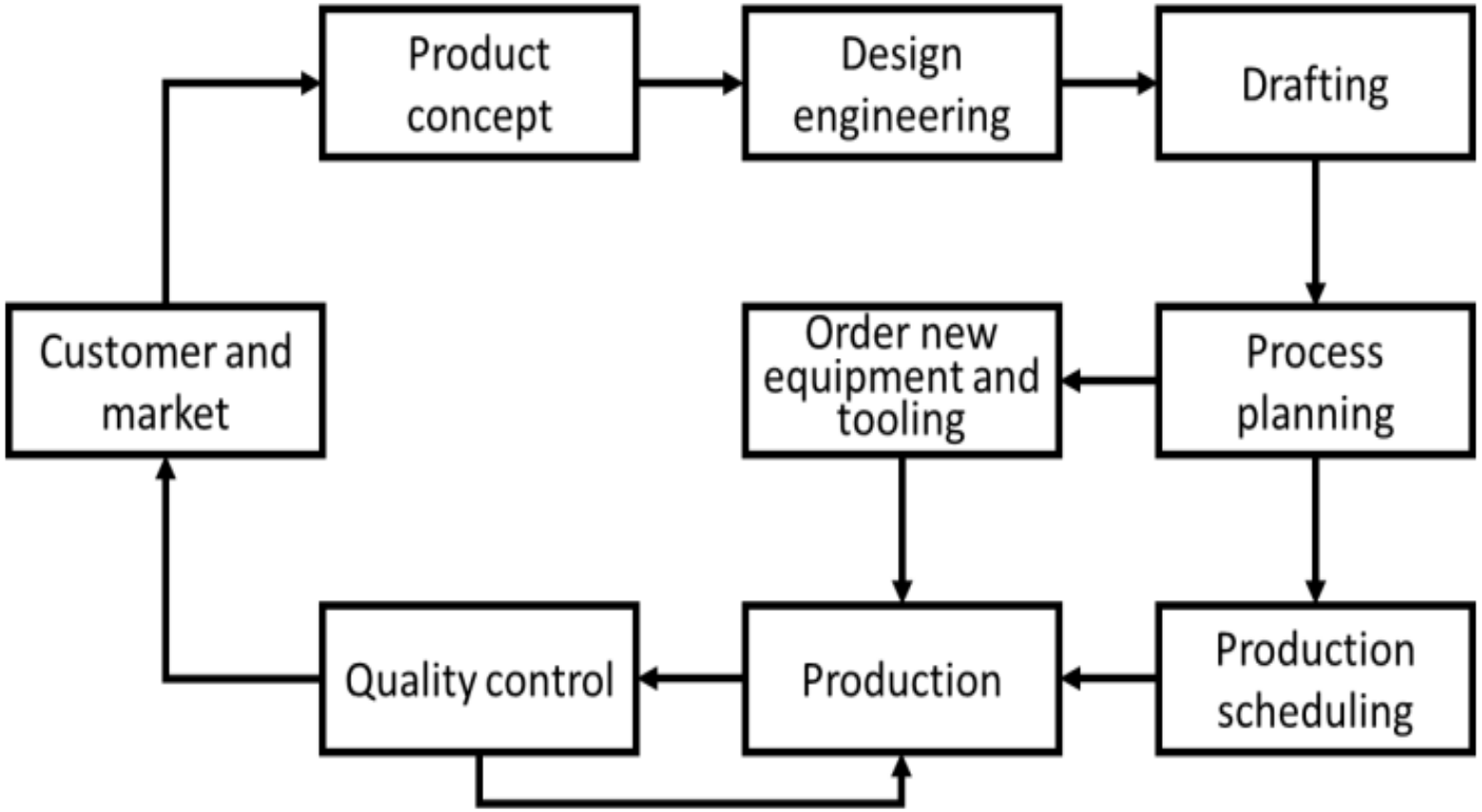


Figure 1.4: Product life cycle (design and manufacturing)

The product life cycle

- The cycle is driven by the customers and markets which demand the product.
- -The cycle begins with the concept, an idea for a product
- This concept is grown, refined, analyzed, improved and translated into a plan for the product
- through the design engineering process.
- The plan is documented by drafting a set of engineering drawings showing how the product is made.
- The next activities involve the manufacture of the product → the process plan specifies the sequence of production operations.
- New equipment and tools must sometimes be acquired to produce the new product.
- Scheduling provides a plan that commits the company to the manufacture of certain quantities of the product by certain dates.
- The product then goes into production followed by quality testing and delivery to the customer.

The impact of CAD/CAM on the product cycle:

1- The computer aided design and automated drafting are utilized in the conceptualization, design and documentation of the product

2- Computers are used in process planning and scheduling to perform these functions more effectively

The product life cycle with CAD/CAM

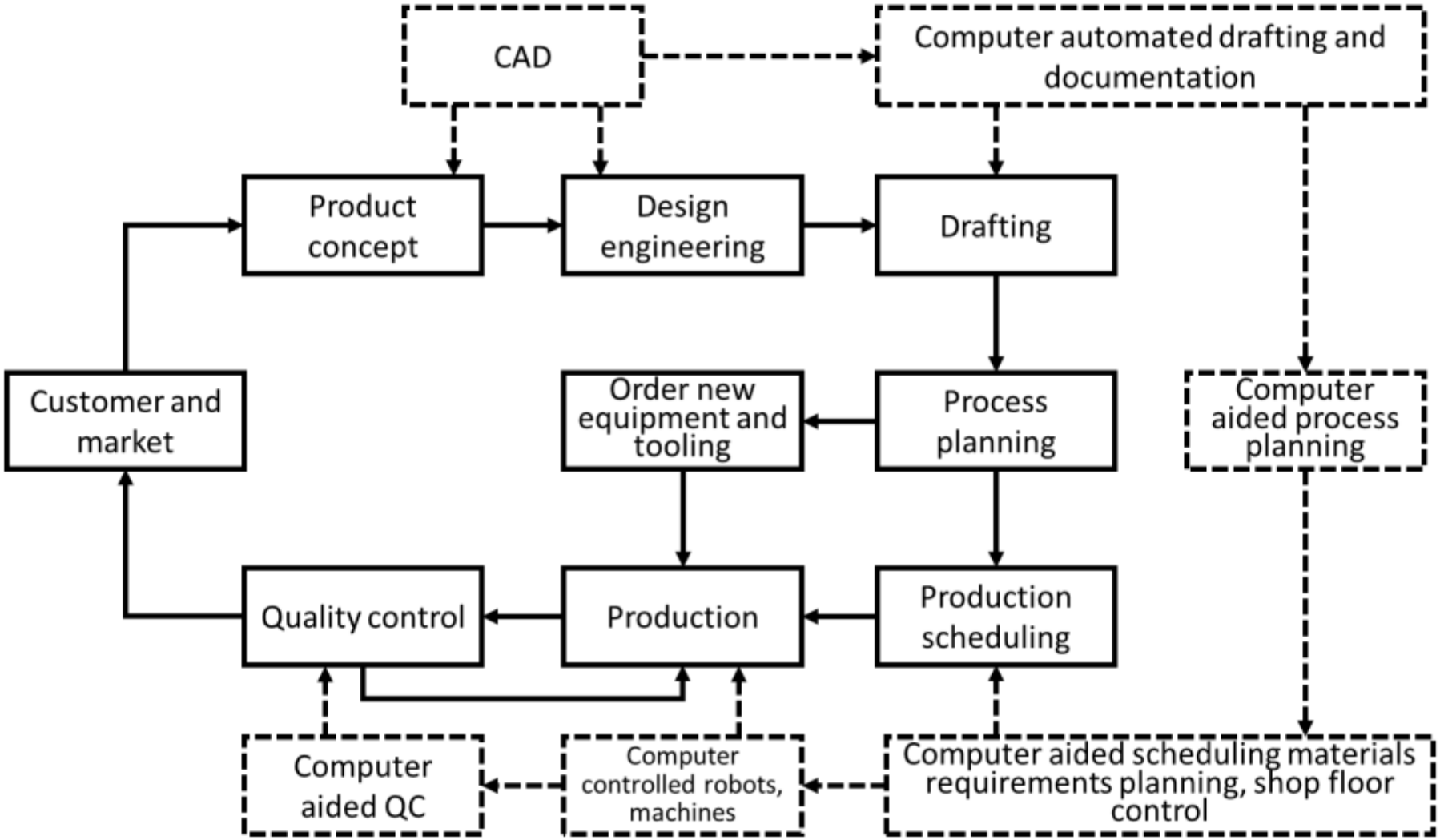


Figure 1.5: Product cycle revised with CAD/CAM overlaid

The Design Process

- The design process is the sequence of operations which links a concept the idea of a thing existing only inside someone's head, to a description, the complete design of that thing which specifies it with sufficient accuracy and in sufficient detail for someone to go away and actually make one of them. It can, roughly speaking, be broken down into the following phases:

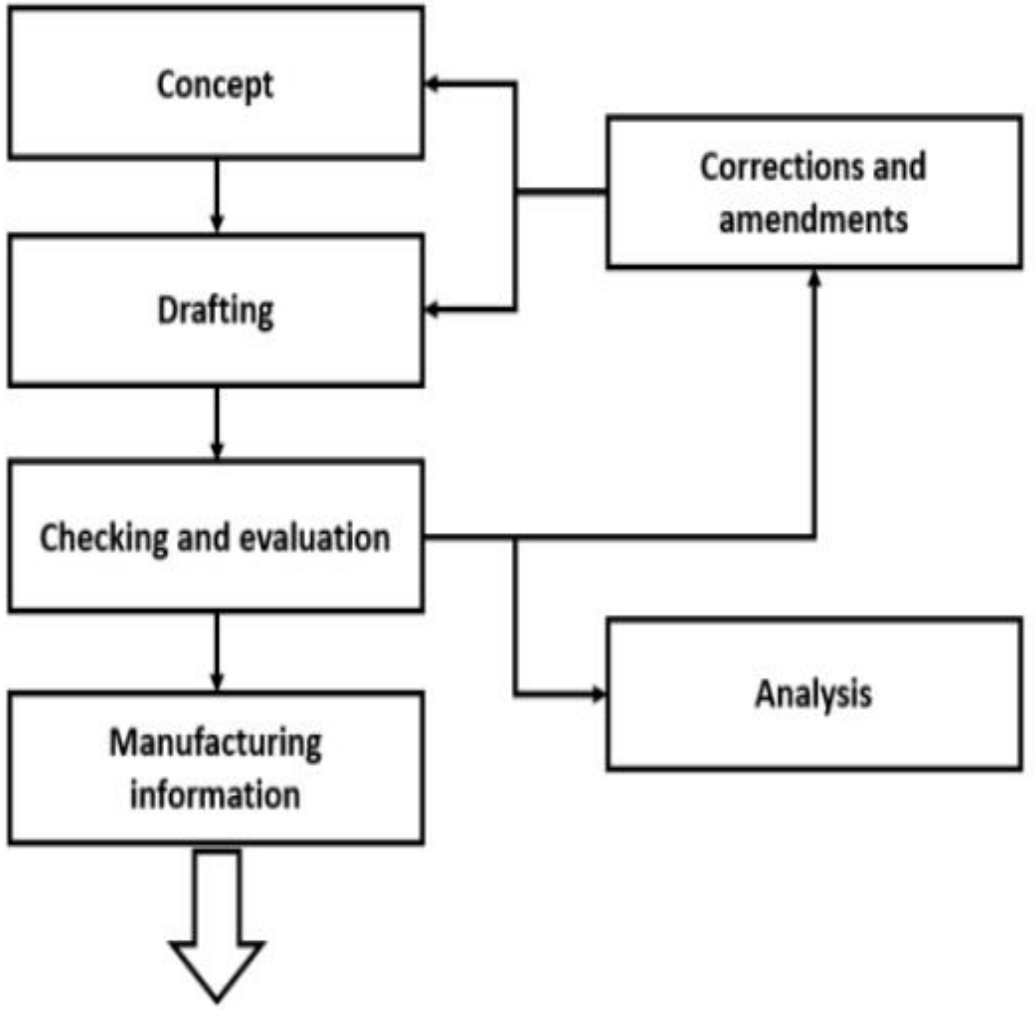


Figure 1.6: Description of the design process

The Design Process

- Drafting
  - Creating the various geometrical elements -lines, arcs, surfaces etc. which together make up the graphical description of an object.
- Checking and evaluation
  - Checking and evaluating progress is essential. Periodically, the designer must step back to ensure that the evolving depiction aligns with the initial concept and meets predetermined criteria. This includes verifying compliance with specifications, adherence to established constraints, feasibility of construction, and fulfillment of functional requirements.
- Correction and amendment
  - As and when errors are detected, or the designer decides to try a different solution or to modify some part of the description in order to improve it, it will be necessary to delete and redraft some elements - or, in some cases, to start all over again from scratch.

The Design Process

- Analysis
  - Once the description has reached a stage where the designer is reasonably content with it, further analysis is typically required. If the object in question is intended to be integrated into a larger mechanism or structure, assembly drawings might be necessary to ensure proper fit and prevent interference between components. Additionally, assessing the object's durability against physical or thermal stress may be essential. If this evaluation involves finite element analysis techniques, it often constitutes the most time-consuming and labor-intensive phase of the entire process.
- Manufacturing information
  - Finally, it will be necessary to make sure that the description contains all the information - dimensions, tolerances, etc - needed at the manufacturing stage. This may well require the production of additional, supplementary descriptions - alternative views of the object, or cutaway or exploded drawings of an assembly, etc.

Components of CAD/CAM/CAE systems

- Computer aided engineering (CAE): is a technology concerned with the use of computer systems to analyze CAD geometry, allowing the designer to simulate and study how the product will behave for product optimization.

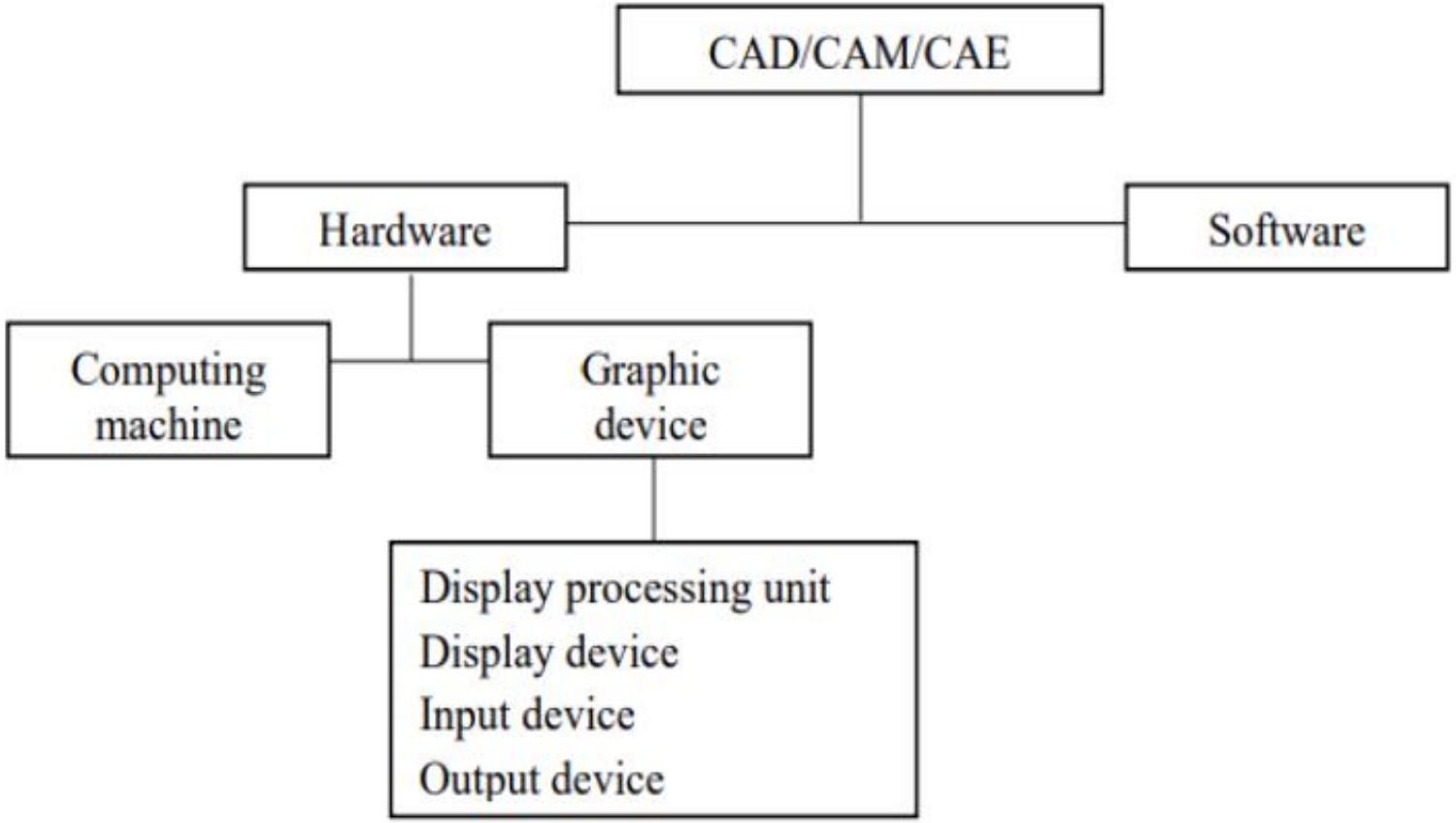


Figure 3.1: Components of CAD/CAM/CAE systems

Components of CAD/CAM/CAE systems

Hardware Components

1. the CAD system components are divided into input devices and output devices as illustrated in Figure 3.2.

Input Devices

- Input devices are tools that users employ to communicate with computer systems

- The input devices used depends on the type of information that is to be fed to the system

- The possible types of information include text (keyboard), graphics (digitizers, location devices and image input devices), and sound (microphone). - Input devices are classified into:

- Absolute (Mouse) relative (Trackball)
- Direct (Touch screen) or indirect (Tablet)
- Discrete (Cursor-control keys) or continuous (Joystick

Components of CAD/CAM/CAE systems

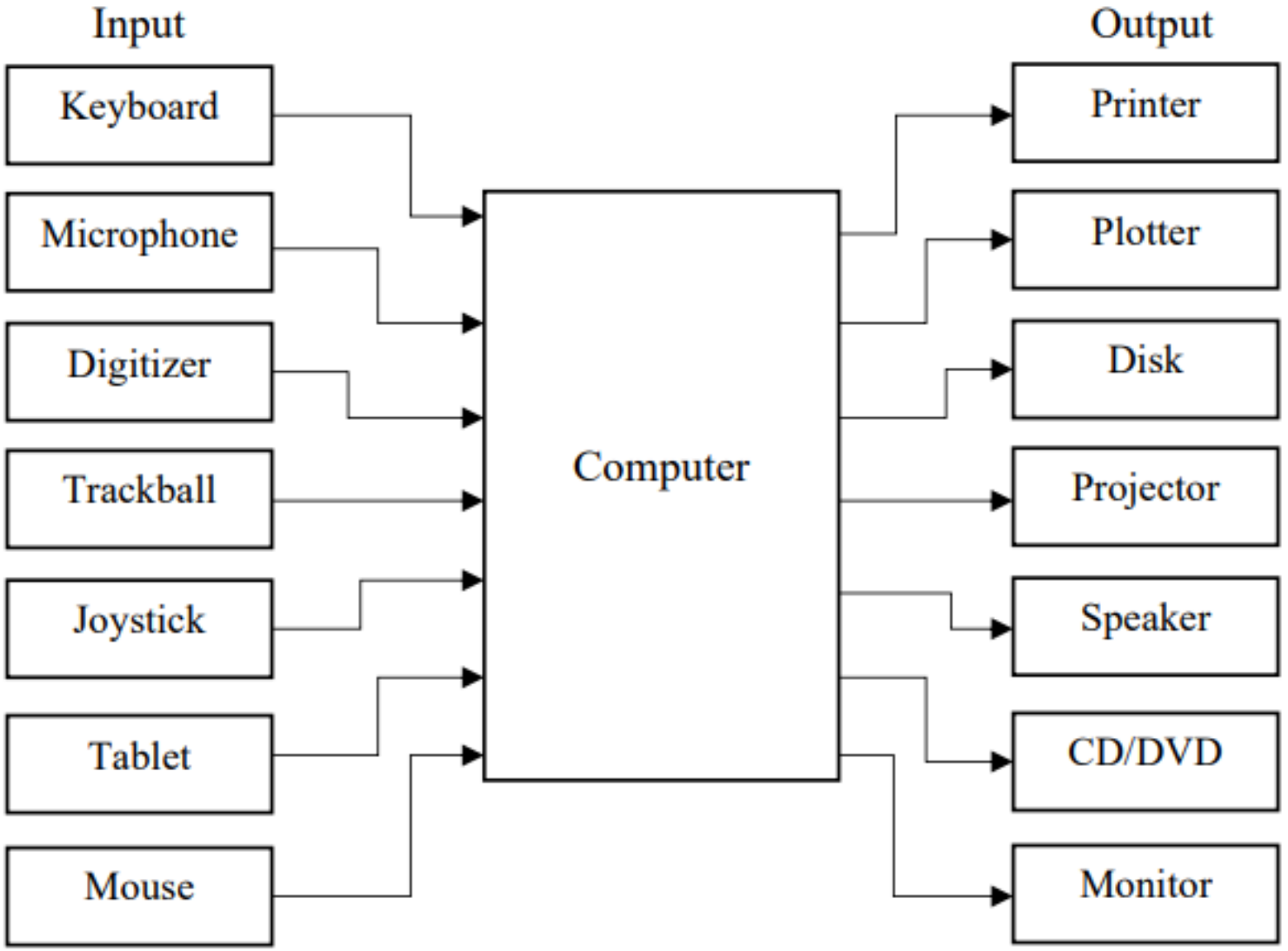


Figure 3.2: Input and output devices

Components of CAD/CAM/CAE systems

Output Devices

Output devices are classified into soft-type and hard-type devices

Soft-type devices are those show graphics or text on the monitor screen but not permanently

- - Examples of soft-type devices: cathode ray tube (CRT), liquid crystal display (LCD), the light emitting diode (LED) and plasm displays.

Hard-type devices are those used to produce hard copies that can be stored permanently such as paper printout

- - Examples of hard-type devices: plotters and printers

Components of CAD/CAM/CAE systems

- Software components

1. The CAD software allows the designer to create and manipulate a shape interactivity on the monitor and store it in a database.
    - Any software that can facilitate the design process can, in a sense, be classified as CAD software.

    - For example, a customized application program for automating the design of a specific part or mechanism is also considered to be CAD software. Figure 3.3 shows a mechanical drawing generated by computer aided drafting, a typical CAD software.

CAD software

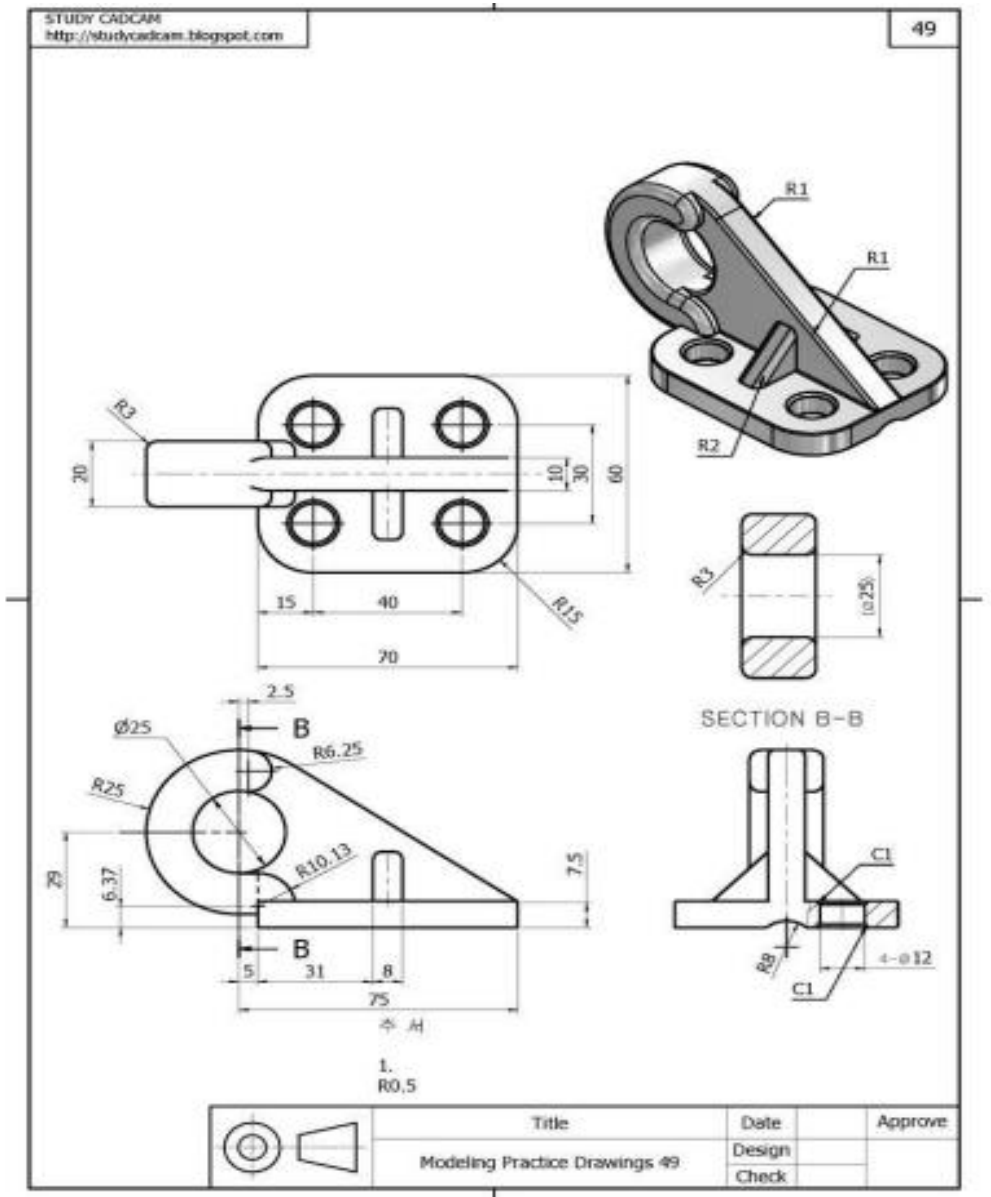


Figure 3.3: Example outputs of computer-aided drafting system for a mechanical drawing

Components of CAD/CAM/CAE systems

2. The CAM software is used to facilitate the manufacturing process of the product cycle

   Any software related to planning, managing and controlling the operations of a manufacturing plant through either direct or indirect computer interface with the plant's production resources can be considered as CAM software.

   For example, software that generates a process plan to manufacture a part is typical CAM software.

   Another example is the software that generates a part program, simulates the tool motion, and drives an NC machine tool to machine the external surfaces of a part.

CAM software

- Figure 3.4 illustrates the simulation of the tool path of an NC milling machine generated by CAM software after the part geometry has been already created by the use of CAD software

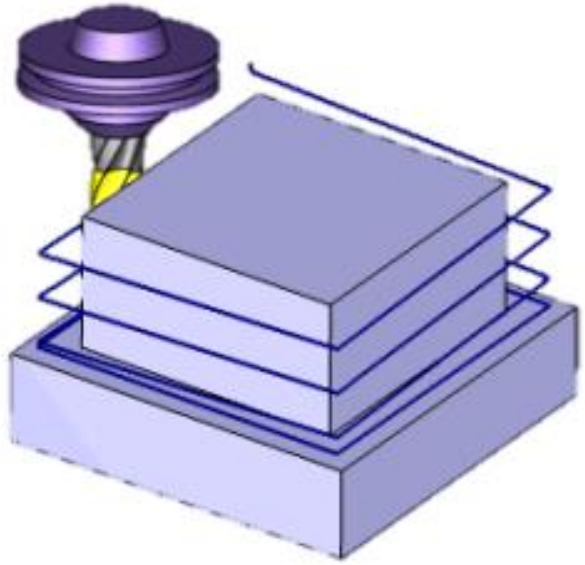


Figure 3.4: Example output of the tool path simulation

CAM software

- The CAE software is used to analyze design geometry, allowing the designer to simulate and study how the product will behave. Thus the design can be refined and optimized.
  - o A typical example of CAE software is a finite-element (FE) program used to calculate factors such as the stress, deformation, and heat transfer on a part of an assembly
  - Figure 3.5 illustrates the contour plots of stress on a part under load.

The CAE software

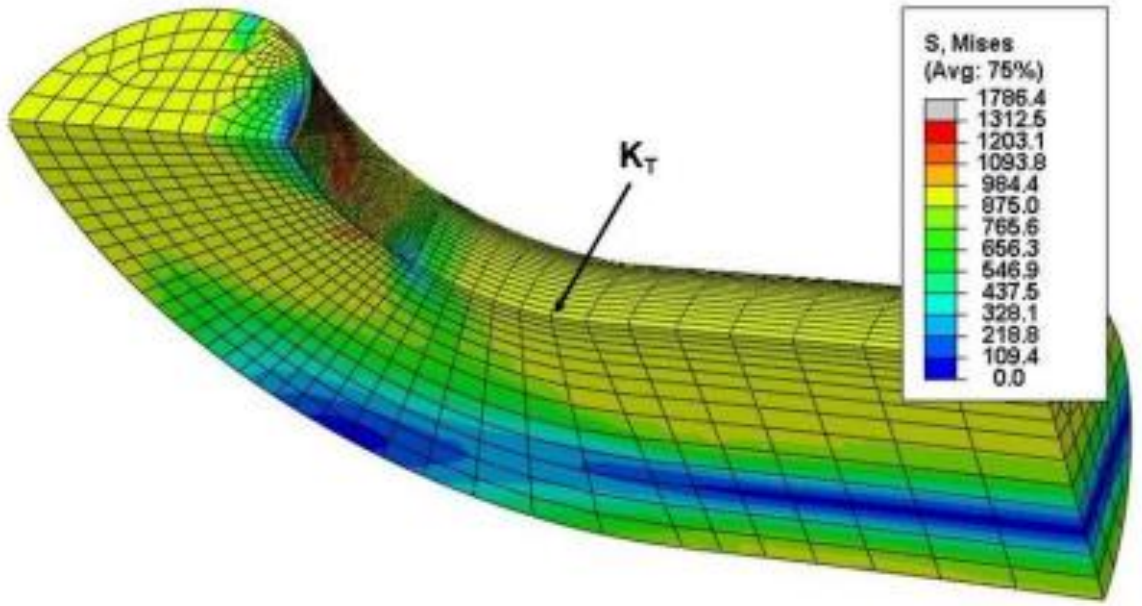


Figure 3.5: Von Mises stress contour plot when the proof load is applied

Graphics programming

- Graphics programming: The term computer programming used to mean writing a composition by using some computer commands in compliance with a predetermined grammar.
- The activity that includes graphics as input and output is called graphics programming, and the field related to it is called computer graphics
- Graphics Library (GL): Is a set of subroutines, each of which has a specific purpose
  - 1- Each subroutine is created by using a supporting set of device driver command
  - 2- Graphic library is needed to be independent from incompatible display of graphic device
- Most popular Graphic libraries:
  - Standard: CORE graphic systems, Graphic Kernal system was developed by ISO and then extended to GKS-3D and PHIGS → X(PEX)
  - Commercial: Open GL→ Drives both engineering workstations and PCs

Computer aided drafting systems

- ## Computer aided drafting systems

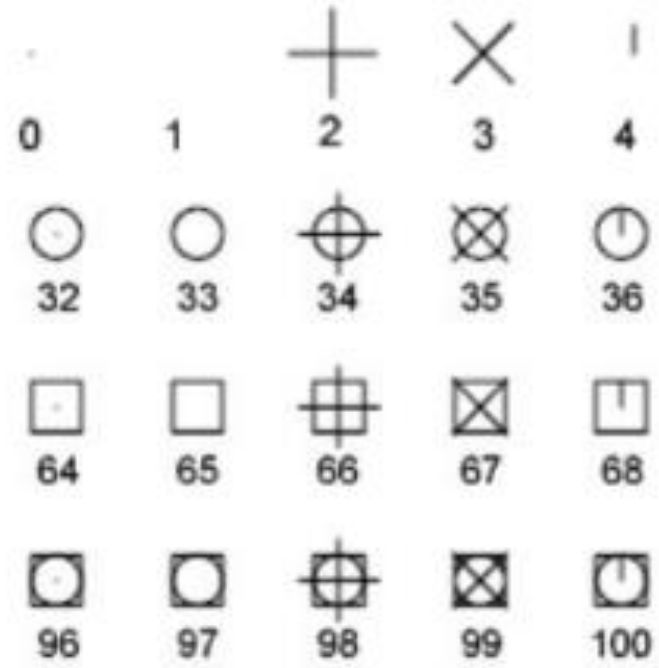
  Computer-aided drafting system is a software product that enables the creation and modification of various types of drawings according to the designer's interactive input.

- ## Characteristics of the computer-aided drafting software:

  1. This software updates a database by storing the resulting drawings and modifications to them
  2. The output is a drawing instead of a document
  3. The modifications can be made from an existing drawing

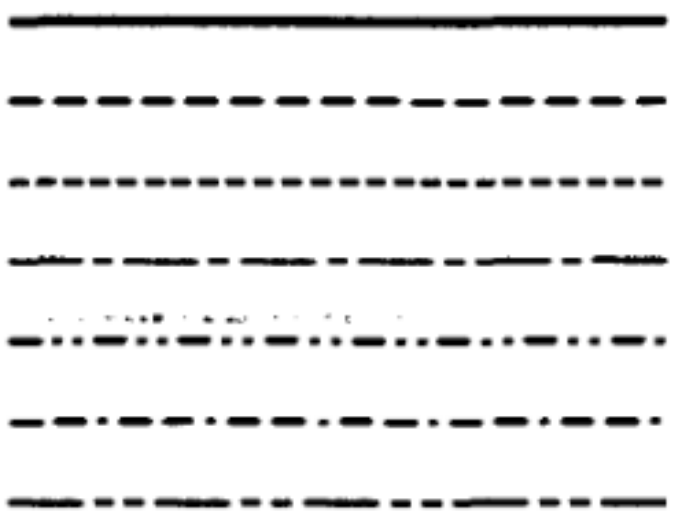
Basic drawing functions

- Drawing a point: point is the smallest unit accepted in a single pixel, which has (X, Y) coordinates. Thus, picture contains hundreds of pixels.
  - Point command is generally used to differentiate data points in a graph For example: the graphics library in AutoCAD contains 20 points markers
  - AutoCAD command: PEDIT → point number → POINT → (X, Y)



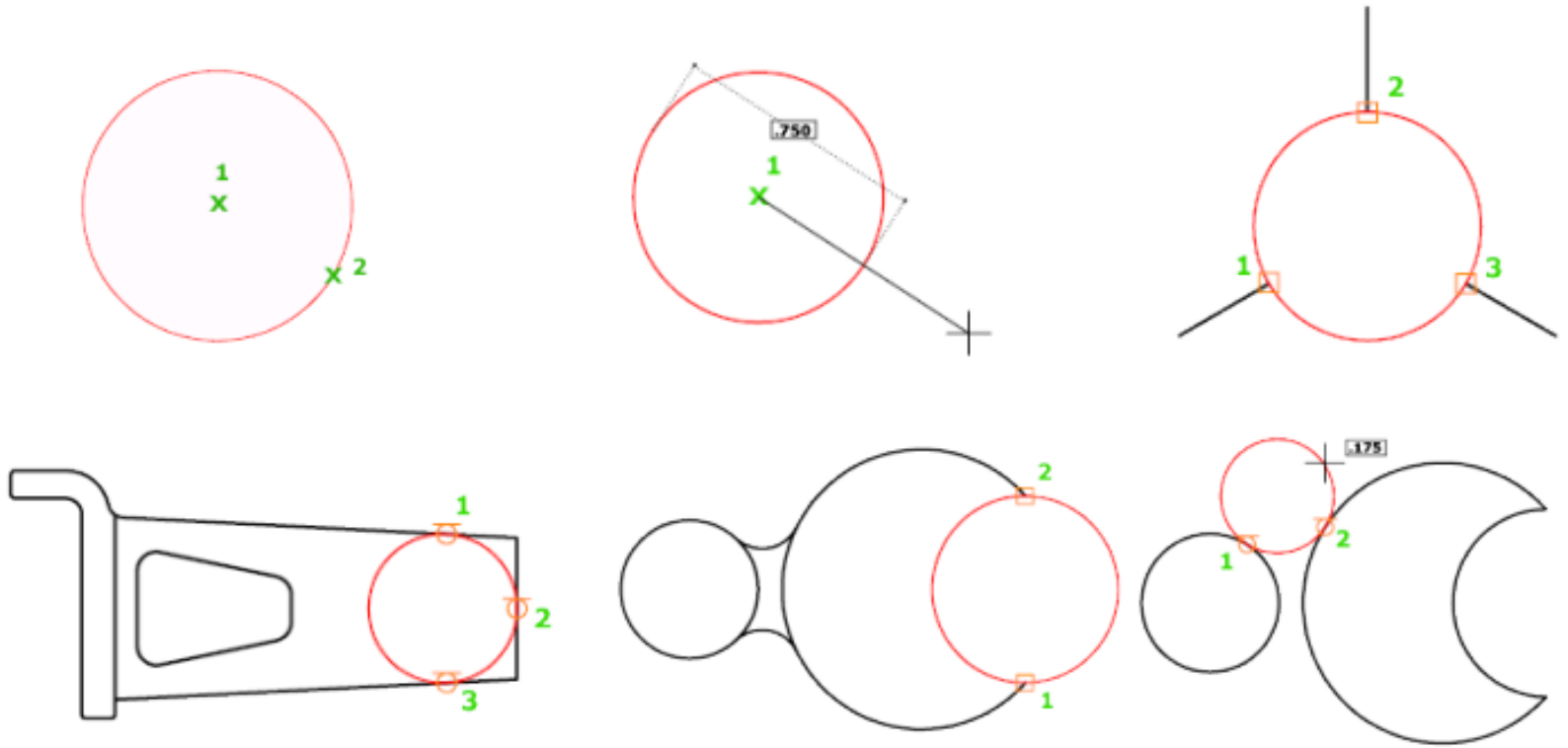
Basic drawing functions

- Straight line: The straight line is defined as the shortest distance between two points. There are many ways of drawing a straight line in computer-aided drafting system.
  - The most popular one is by specifying the two ends of the line
  - Another way is by drawing a tangent line on an existing curve from a specified point
  - Drawing a straight line in AutoCAD involves the following forms using the command LINE.
  - lines should appear straight
  - lines should terminate accurately
  - lines should have constant density
  - line should be drawn rapidly



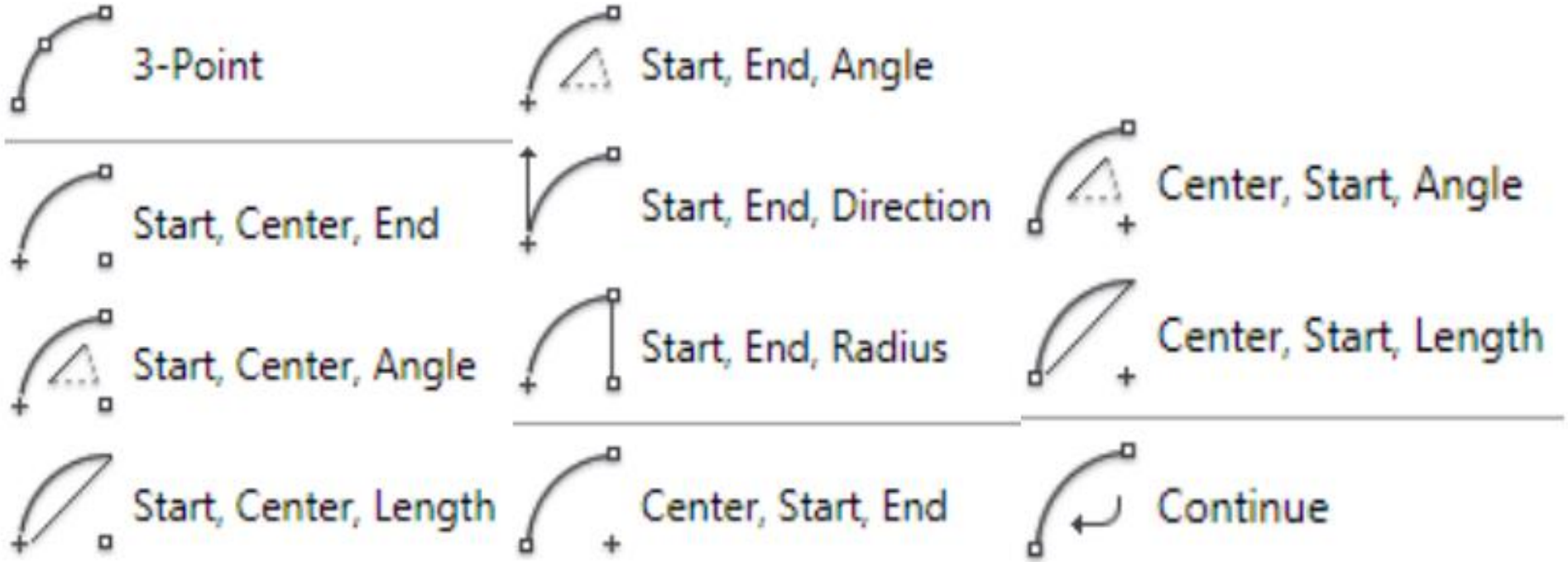
Basic drawing functions

- Plotting circle and circular arc: There are many methods to generate circles and circular arcs using CAD systems
  - To draw a circle in AutoCAD use command: CIRCLE → Center and radius/ Center and diameter/ 3P/ TTT/ 2P and TTR.



Basic drawing functions

- To draw a circular arc in AutoCAD use command: ARC → 3P/ start, Center, End/ Start, Center, Angle/Start, Center, Length/Start, End, Angle/ Start, End, Direction/ Start, End, Radius/ Center, Start, End/ Center, Start, Angle/ Center, Start, Length/ Continuous



Basic drawing functions

- Plotting a polygon: A polygon is any 2D shape formed with straight lines.
  - Triangles, quadrilaterals, pentagons, and hexagons are all examples of polygons.
  - The name tells you how many sides the shape has. For example, a triangle has three sides, and a quadrilateral has four sides.
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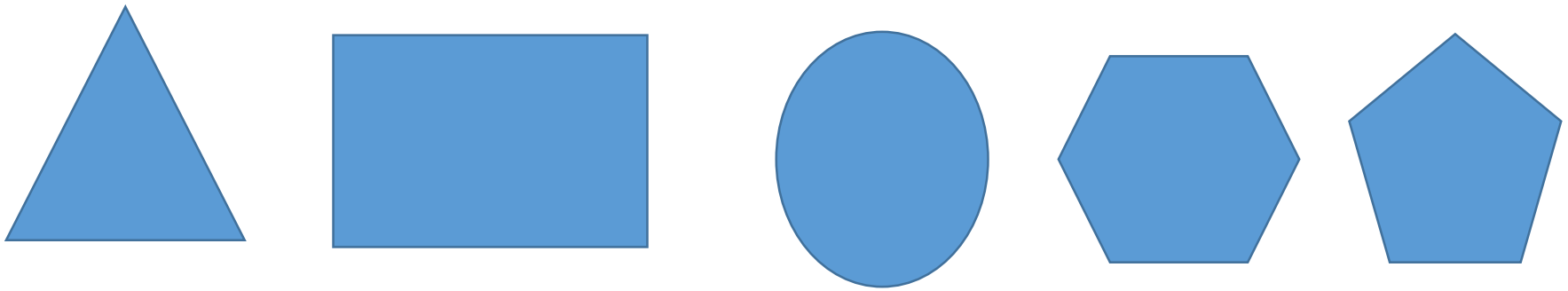
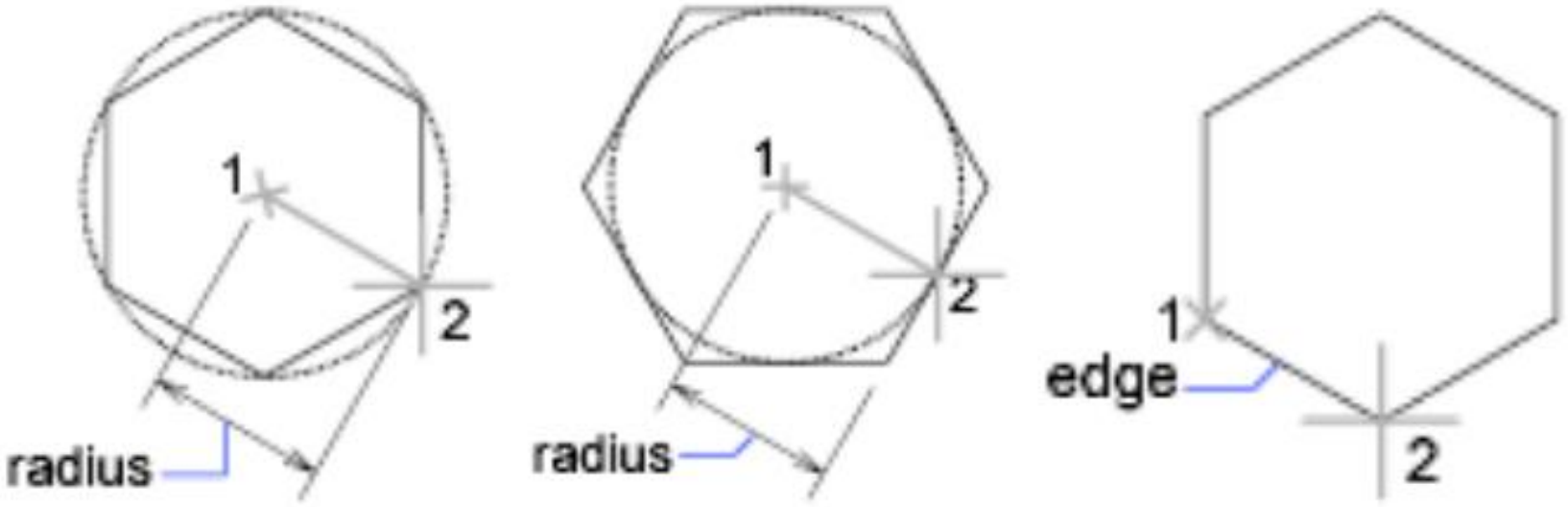


Basic drawing functions

- The POLYGON can be generated by three methods:

  Circumscribed about circle (outside a circle), inscribed in a circle (inside a circle) and Edge length



Basic drawing functions

Editing Geometry

- **Move**: moving objects at a specified distance and direction from the originals
- **Copy**: creating duplicates of objects at a specified distance and direction from the originals
- **Rotate**: rotating objects in the drawing around a specified base point
- **Stretch**: Moving and stretching objects a specified distance in a specified direction relative to the base point specified by the action
- **Scale**: Enlarging or reducing the selected objects keeping the same proportion between objects after scaling
- **Scale**: Enlarging or reducing the selected objects keeping the same proportion between objects after scaling
- **Offset**: Offsetting an object to create a new object whose shape parallels the shape of the original object
- **Mirror**: Flipping objects about a specified axis to create a symmetrical mirror image

Basic drawing functions

Editing Geometry

- **Trim**: Shortening objects to meet the edges of other objects
- **Erase**: Deleting objects from the drawing and cleaning up the display
- **Explode**: Breaking a compound object into its components objects
- **Array**: Copying and arraying objects in a pattern
- **Fillet**: Connecting two objects with an arc that is tangent to the objects and has a specified radius
- **Chamfer**: Connecting two objects to meet in a flattened or beveled corner