Syllabus Module 2

- **Mechanization and Automation:** Mechanization and automation, product cycle, hard Vs flexible automation, Capital- intensive Vs low cost automation
- Types of systems- mechanical, electrical, hydraulic, pneumatic and hybrid systems
- Automation using CAMS, Geneva mechanisms, gears etc.
- Assembly line Automation: automated assembly systems, transfer systems, vibratory bowl
- feeders, non-vibratory feeders, part orienting, feed track, part placing & part escapement systems
- Introduction to Material storage/ handling and transport systems, and its automation using AS/RS, AGVS and conveyors etc.

Basic Concepts in Evaluating Automation Effects

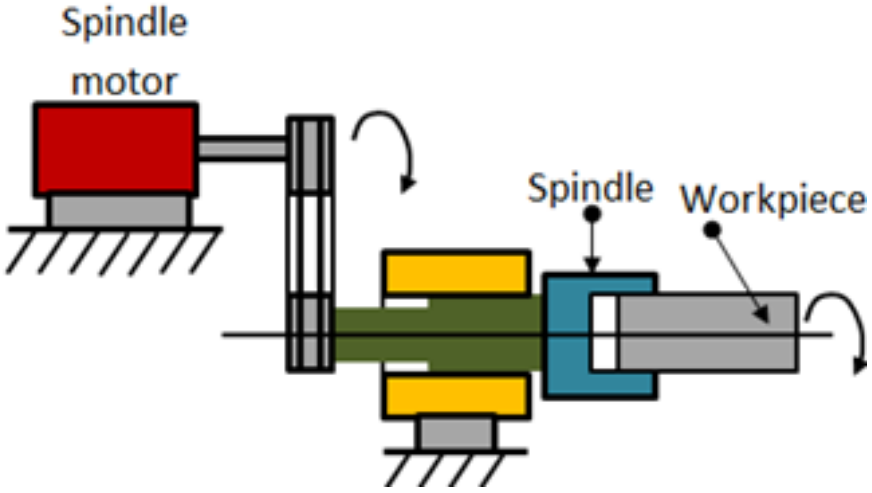
- Robotizing
  - automation of manufacturing operations
  - Effects on the process : Operation speed
  - Effects on personnel : Work reduction
- Flexibilitization
  - flexibility through automation, by automating setup and supply
  - Effects on the process : Response time to demand
  - Higher skills
- Monitorizing
  - Effects on the process : monitoring automation through automating measures and operations control.
  - Effects on personnel : Process accuracy and product quality

Elements of CNC Machine Tools

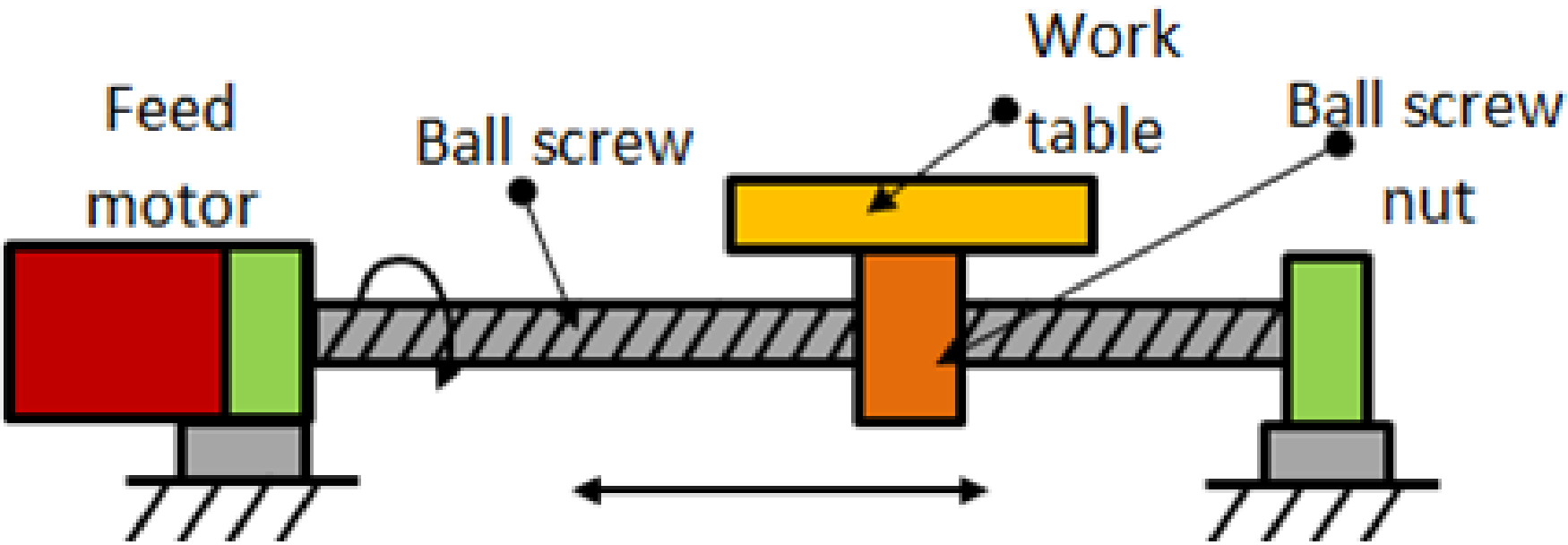
- **Drives**
- **Power drives**
  - **Electrical drives**
    - These are direct current (DC) or alternating current (AC) servo motors. They are small in size and are easy to control.
  - **Hydraulic drives**
    - These drives have large power to size ratio and provide step less motion with great accuracy.
    - Difficult to maintain and are bulky.
    - Generally they employ petroleum based hydraulic oil which may have fire hazards at upper level of working temperatures.
    - Also hydraulic elements need special treatment to protect them against corrosion.
  - **Pneumatic drives**
    - This drives use air as working medium which is available in abundant and is fire proof.
    - Simple in construction and are cheaper.
    - Generate low power, have less positioning accuracy and are noisy.

Spindle drives

- The spindle drives are used to provide angular motion to the work piece or a cutting tool.
- drives are essentially required to maintain the speed accurately within a power band which will enable machining of a variety of materials with variations in material hardness.
- The speed ranges can be from 10 to 20,000 rpm.
- The machine tools mostly employ DC spindle drives.
- High overload capacity is also needed for unintended overloads on the spindle due to an inappropriate feed.
- It is desirous to have a compact drive with highly smooth operation.



Feed Drives

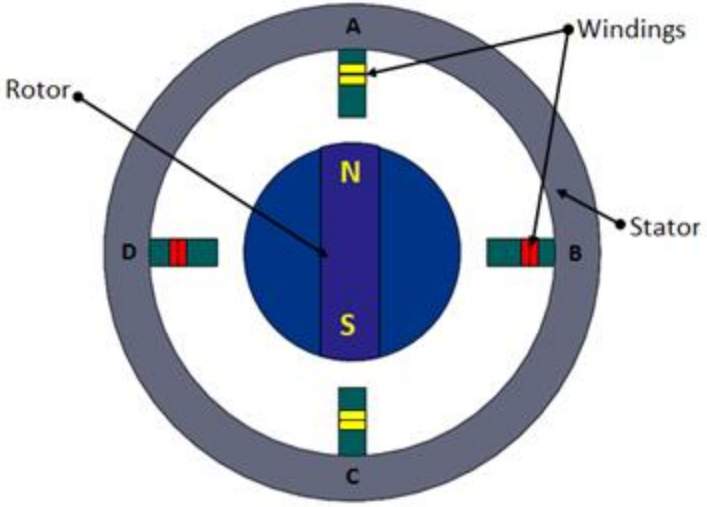


Stepper motors

- **Stepper motor**
  - A stepper motor is a pulse-driven motor that changes the angular position of the rotor in steps.
  - Due to this nature of a stepper motor, it is widely used in low cost, open loop position control systems.
- Types of stepper motors:
  - Permanent Magnet
    - Employ permanent magnet
    - Low speed, relatively high torque
  - Variable Reluctance
    - Does not have permanent magnet
    - Low torque

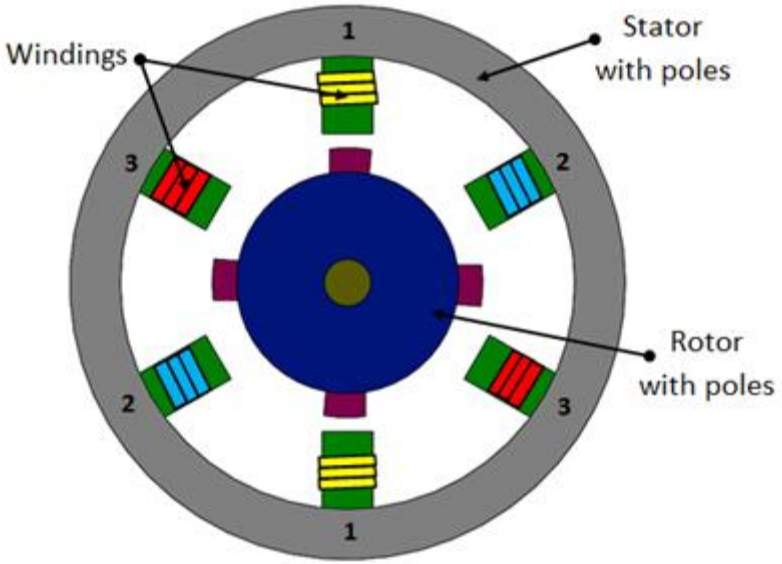
Permanent magnet (PM) stepper motor

- In this type of motor, the rotor is a permanent magnet
- PM motor rotor has no teeth and is designed to be magnetized at a right angle to its axis.
- 90^{o} PM motor with four phases (A-D). Applying current to each phase in sequence will cause the rotor to rotate by adjusting to the changing magnetic fields. Although it operates at fairly low speed, the PM motor has a relatively high torque characteristic. These are low cost motors with typical step angle ranging between 7.5^{o} to 15^{o} .



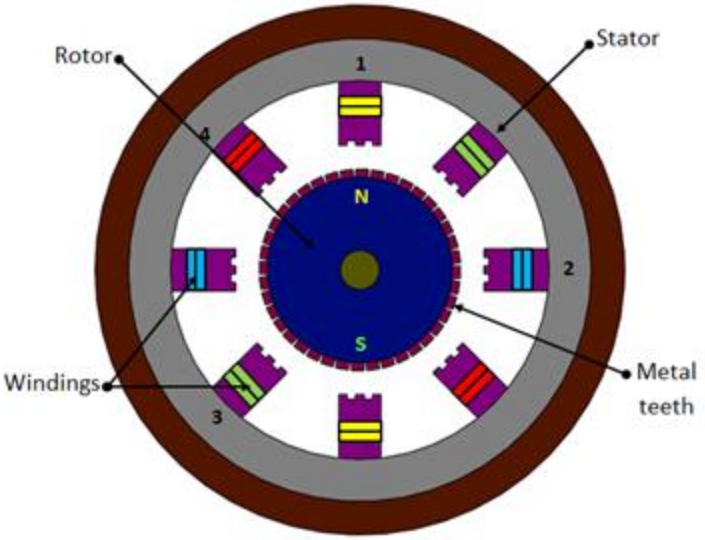
Variable Reluctance Motor

- The cylindrical rotor is made of soft steel and has four poles as shown in Fig
- It has four rotor teeth, 90^o apart and six stator poles, 60^o apart.
- Electromagnetic field is produced by activating the stator coils in sequence.
- It attracts the metal rotor.
- When the windings are energized in a reoccurring sequence of 2, 3, 1, and so on, the motor will rotate in a 30^o step angle. In the non-energized condition, there is no magnetic flux in the air gap,
- This type of stepper motor is called a variable reluctance stepper.



Hybrid stepper motor

- Hybrid stepping motors combine a permanent magnet and a rotor with metal teeth to provide features of the variable reluctance and permanent magnet motors together.
- The number of rotor pole pairs is equal to the number of teeth on one of the rotor's parts. The hybrid motor stator has teeth creating more poles than the main poles windings



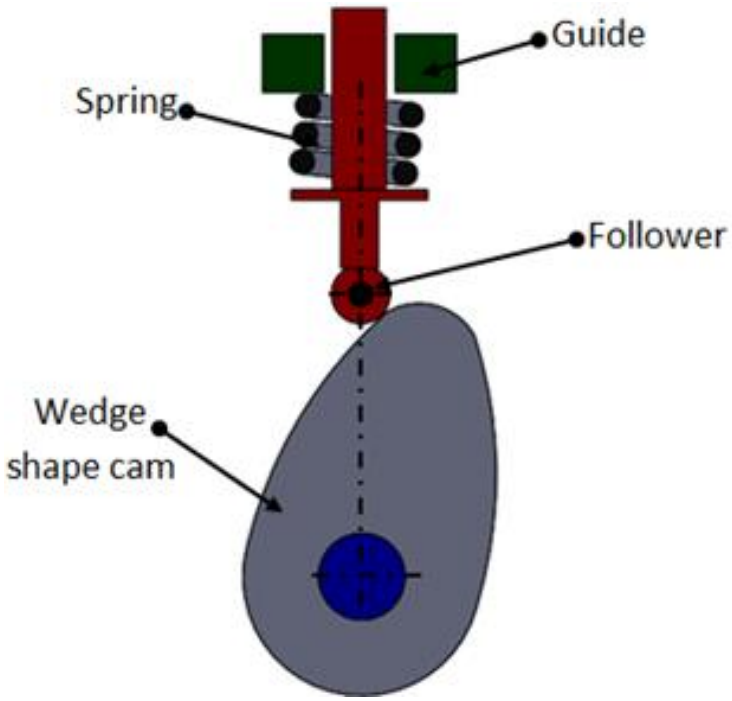
- Advantages of stepper motors :
  - Low cost
  - Ruggedness
  - Simplicity of construction
  - Low maintenance
  - Less likely to stall or slip
  - Will work in any environment
  - Excellent start-stop and reversing responses
- Disadvantages of stepper motors :
  - Low torque capacity compared to DC motors
  - Limited speed
  - During overloading, the synchronization will be broken. Vibration and noise occur when running at high speed.

Automation using CAMS, Geneva mechanisms, gears

- Definition : Cams are mechanical devices which are used to generate curvilinear or irregular motion of mechanical elements.
  - They are used to convert rotary motion into oscillatory motion or oscillatory motion into rotary motion.
  - Two links:
    - cam - input member.
    - follower - output member is called the follower. the
  - The cam transmits the motion to the follower by direct contact

Necessary elements of a cam mechanism are

- A driver member known as the cam
- A driven member called the follower
- A frame which supports the cam and guides the follower



Classification of cams

- **Wedge and Flat Cams**
- **Plate cam**
- **Cylindrical cam**

Wedge and Flat Cams

- A wedge cam has a wedge of specified contour and has translational motion. The follower can either translate or oscillate. A spring is used to maintain the contact between the cam and the follower

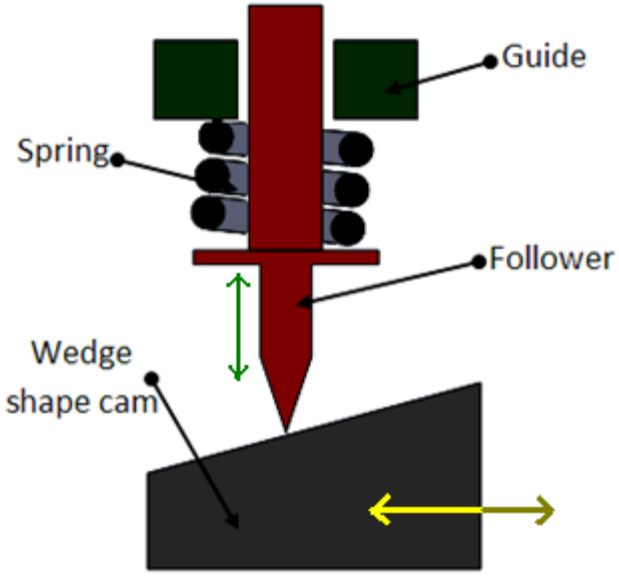
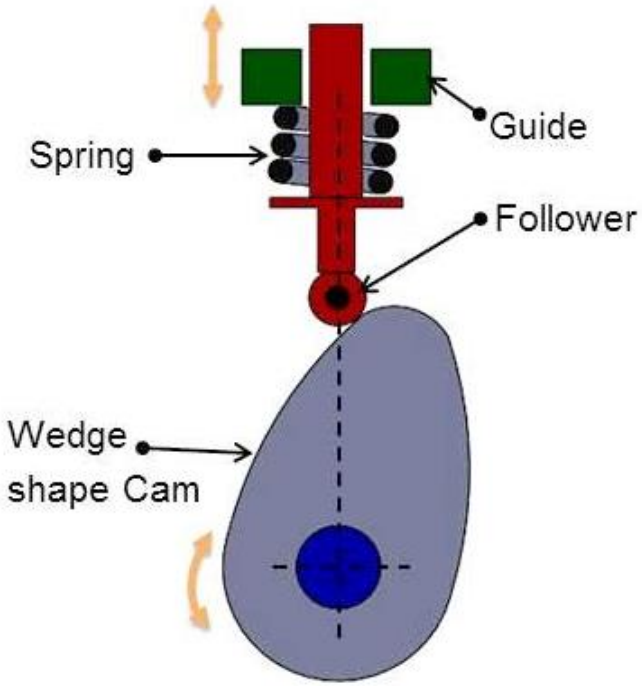


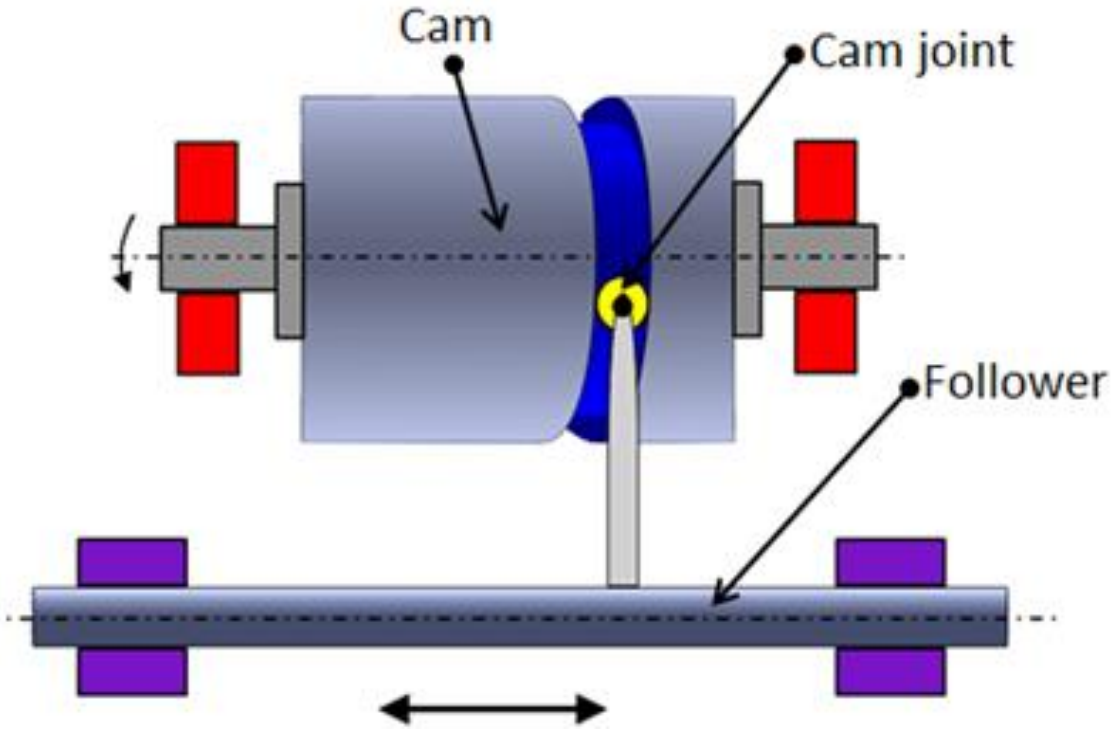
Plate cam

- Follower moves in a radial direction from the centre of rotation of the cam



Cylindrical cam

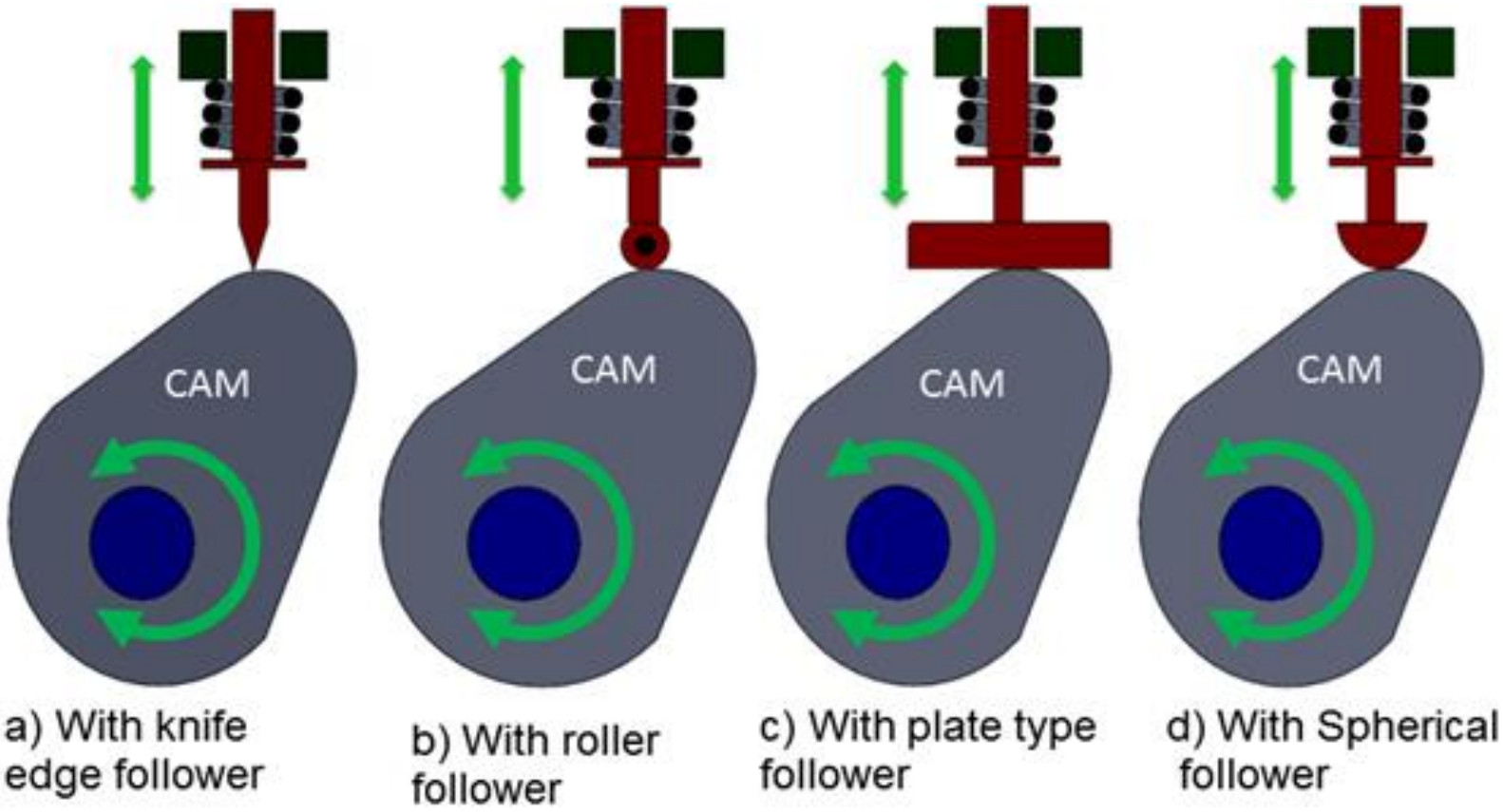
- Cylinder has a circumferential contour cut in the surface and the cam rotates about its axis



Classification of followers

- Type of surface contact between cam and follower
- Type of follower motion
- Line of motion of followers

Classification based on type of surface contact between cam and follower



a) With knife edge follower

b) With roller follower

c) With plate type follower

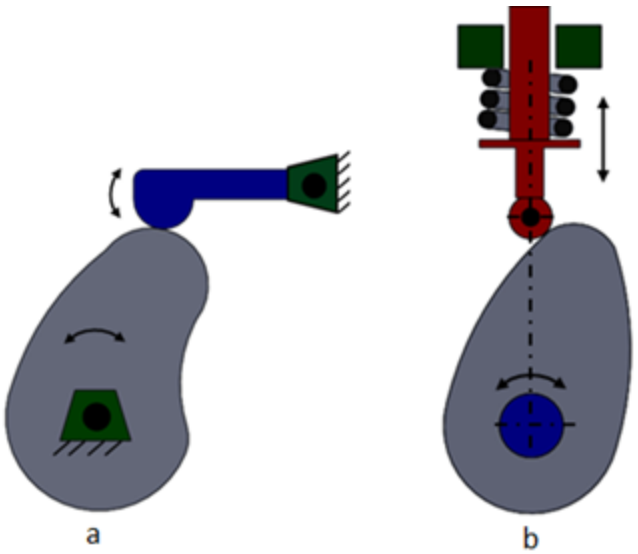
d) With Spherical follower

Classification based on type of surface contact between cam and follower

- *Knife edge follower*
  - Contacting end - sharp knife edge
  - A sliding motion exists between the contacting cam and follower surfaces.
  - It is rarely used in practice because the small area of contacting surface results in excessive wear.
- *Roller follower*
  - Cylindrical roller which rolls on cam surface.
  - Rolling motion between the contacting surfaces, the rate of wear is reduced in comparison with Knife edge follower.
  - The roller followers are extensively used where more space is available such as gas and oil engines.
- *Flat face follower*
  - Follower face is perfectly flat.
  - It experiences a side thrust due to the friction between contact surfaces of follower and cam.
- *Spherical face follower*
  - Contacting end of the follower is of spherical shape which overcomes the drawback of side thrust as experiences by flat face follower.

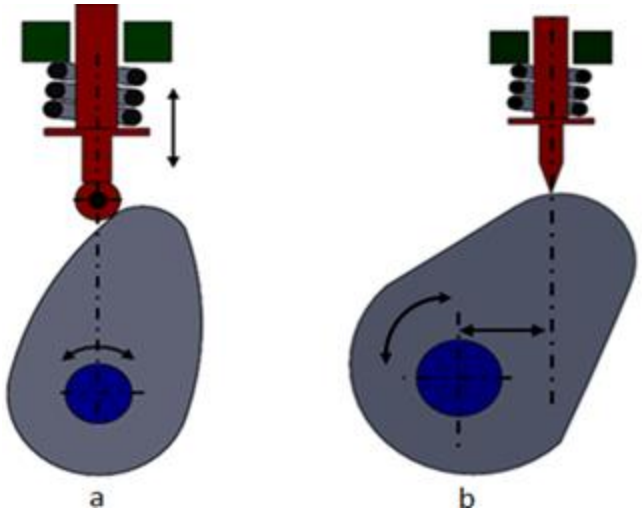
Classification based on followers motion

- *Oscillating follower (fig a)*
  - Rotary motion of the cam is converted to predetermined oscillatory motion of the follower
- *Translating follower (fig b)*
  - Follower reciprocates in the ‘guide' as the cam rotates uniformly



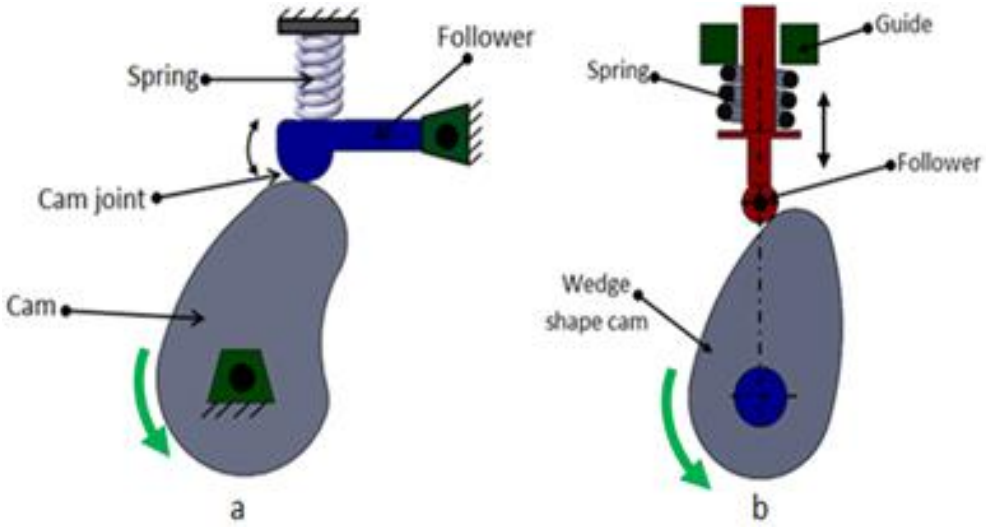
Classification based on line of motion

- *Radial follower (Fig a)*
  - The line of movement of the follower passes through the centre of the camshaft
- *Offset follower (Fig b)*
  - The line of movement of the follower is offset from the centre of the cam shaft



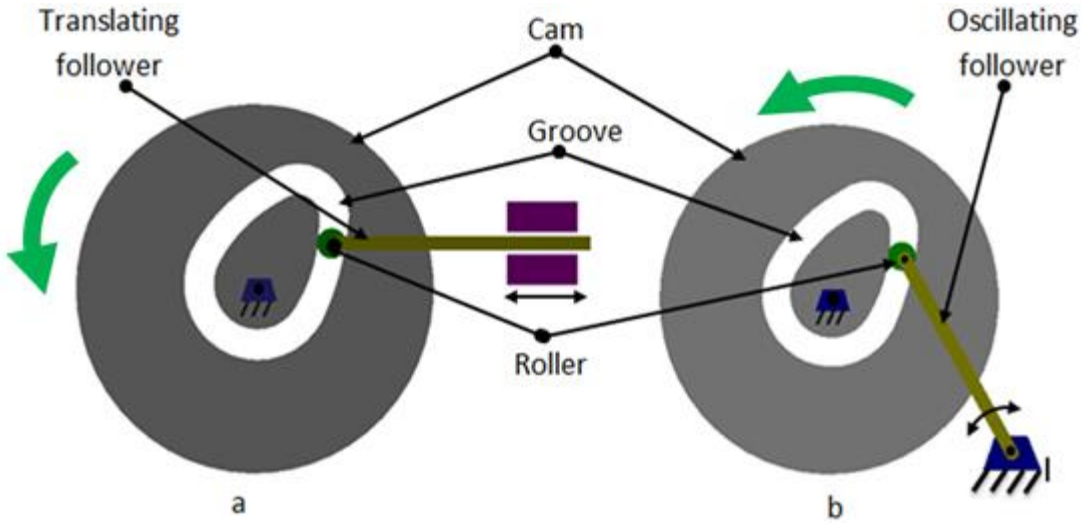
Force closed cam follower system

- In this type of cam-follower system, an external force is needed to maintain the contact between cam and follower.
- Generally a spring maintains the contact between the two elements



Form closed cam follower system

- In this system a slot or a groove profile is cut in the cam. The roller fits in the slot and follows the groove profile



Three-dimensional cam or Camoid

- Camoid is a combination of radial and axial cams.
- Three dimensional surface and two degrees-of-freedom.
- Two inputs are rotation of the cam about its axis and translation of the cam along its axis.
- Follower motion is based on both the inputs.

Automation by using Geneva mechanisms