LECTURE NOTES
ON
MECHATRONICS
5TH SEMESTER
(TH-3)
(MECHANICAL ENGINEERING)

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What do you mean by mechatronics?

Mechatronics is a subject which integrate varies brach of engineering namely mechanical, electrical. Control and Instrumention and computer science etc.

Give a few Application of Mechatronics?

i) Mechatronics system find application in the following field process control in chemical, mechanical textile paper rubber and similar industries.

ii) Production Centres for manufacturing assembly and maintances.

What are Components of a mechatronics System?

The term of mechatronics system (some times refeat to as smart device) compeises a myraid of devices and systems. Increasingly micro controls are embedded in the electric ~~mechatronic~~ mechanical devices creating much more flexibility and control possibility in system design. all component typical mechatronics System.

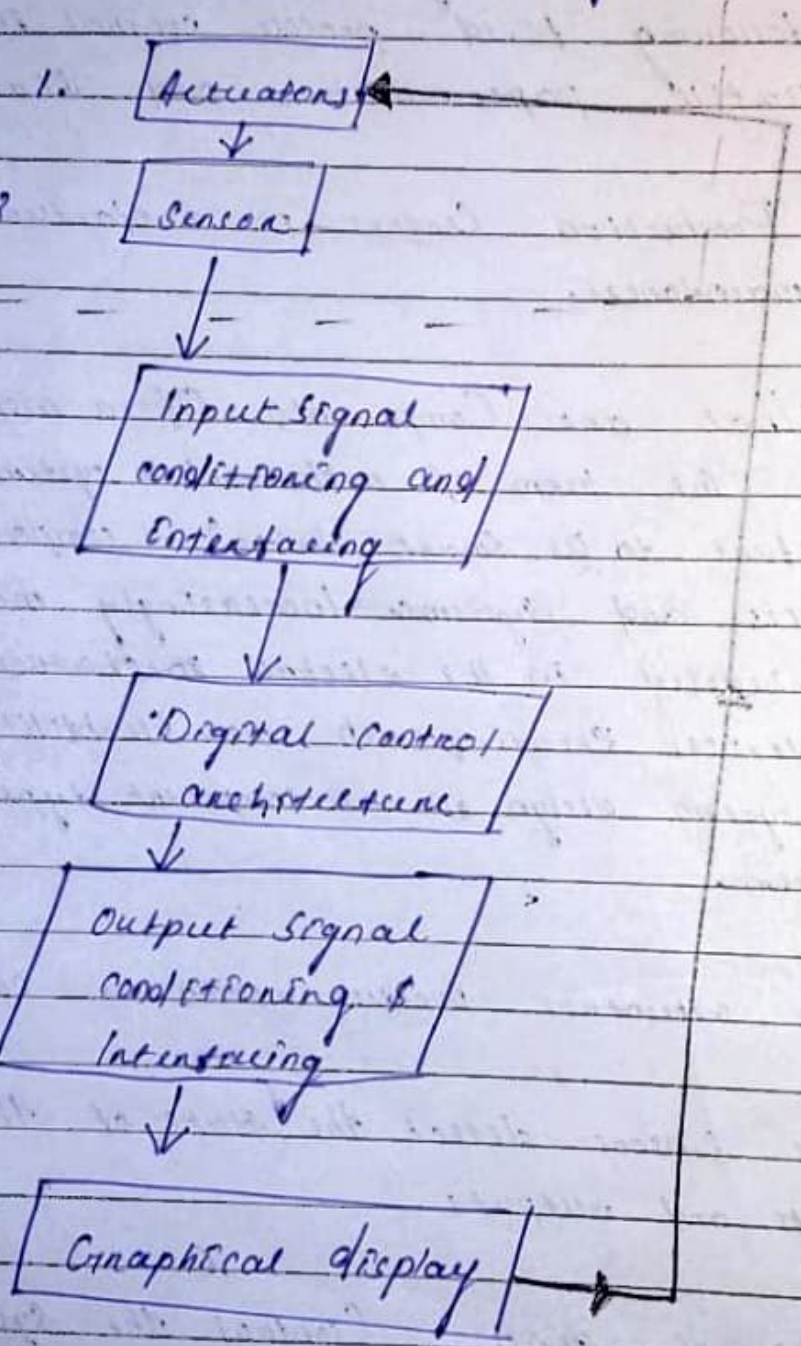
(i) The actuators produce motion or cause some action.

(ii) The sensors detect the state of the system parameter inputs and outputs.

(iii) Digital device (control the System)

→ Conditioning and interfacing circuits provide connection between the control circuits and the input/output devices.

→ Graphical display provide visual feedback to user.



1. Actuators :-

Solenoids voice coils : DC motors Stepper motors Servo motors hydraulics pneumatic.

2. Sensor :

Switches, potentiometer photoelectrice @ digital encoders Strain gauge thermocouple accelerometer etc.

3. Input signal conditioning And interfacing :-

Discreas circuit amperfiers filter A/D, D/A.

4. Digital Control architecture :

logic circuit microcontroller SBC, PLC, sequencing and timing logic and arithmetic control algorithms, communication.

5. Output Signal Conditioning And Interfacing :-

D/A, D/D, amplifiers pwm, power transistors, power Op - amps.

6. Graphical displays :-

LEDs digital display LCD, CRT

components of a typical methatronic system.

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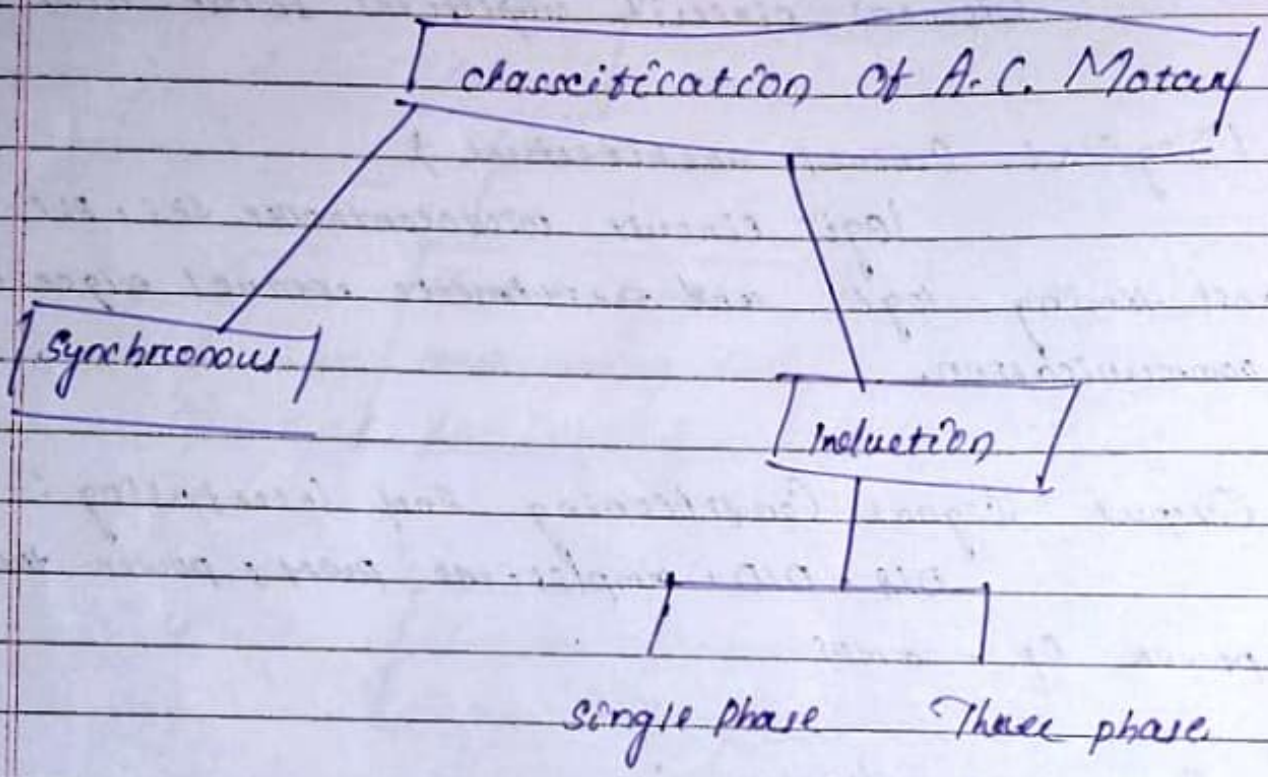
- → Switches And Relay
- → Solenocity
- → DC motor
- → Ac motor
- → Slepper motor
- → Specification And Control of slepper motor.
- → Servo motor DC / A.C

AC Motor :-



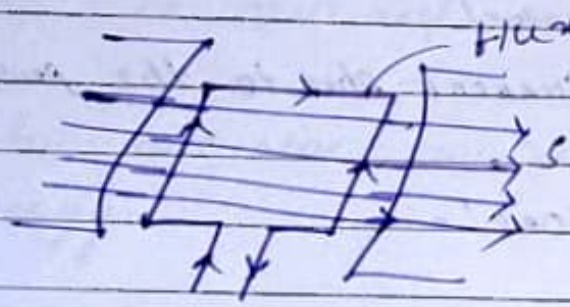
Basic Principle :-

→ An Ac motor is an electric motor driven by alternating Current (AC)

→

→ Principle of Operation for all Ac motors relies on the interaction of a revolving magnetic field created in the stator by ac current, with an opposing magnetic field either induced on the rotor or provided by a separate DC current source.

→ Resulting interaction produces usable torque which can be coupled to desired loads throughout the facility in a convenient manner.



DC

Rotar → Armature winding

Stator → field winding

Stator

The stationary section the constant the winding (magnetic field)

Rotar

The rotating section the content the conductors

Advantages Of Ac Motors:-

→ low cost
→ Seed variation
→ high power Sution
→ Reliable operation

Disadvantages Of Dc Motors:-

→ Inability to operating at low speed
→ poor positioning control
→ Ac will produce eddy Current due to the production.

Electrical Instruments:-

Dc motor

Working Of Dc Motor:-

Dc motors is electrical machine which convert Dc electrical energy into mechanical energy. Its operation is best on the principle that: "When a Current Caring conductor is placed in a magnetic field it is experience to the mechanical force". The direction of this force is given by left hand rules.

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Actuator

An Actuator is a component in machine or a system that moves or control the mechanism or the system

→ An actuator is something the converts energy into motion.

→ An actuator is a mechanism by which a control system.
is open and environmental.

→ An actuator requires a control signal and source of energy

Sources Of Energy :-

→ It can be mechanical electronics system, system by human or robots.

→ Solved electric motor.

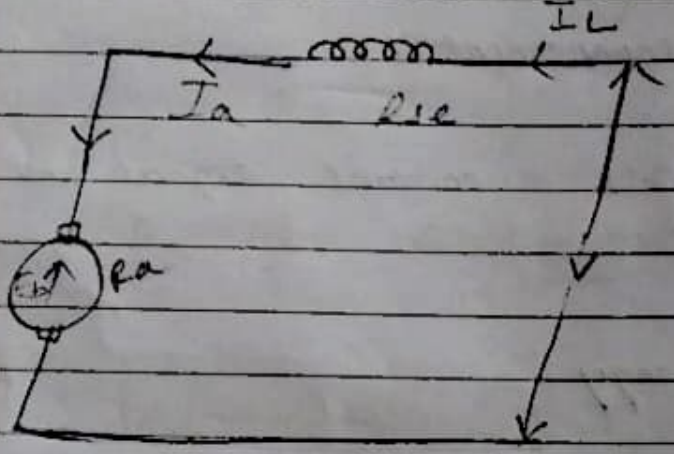
Electrical Actuator

→ DC Motor
→ AC Motor
→ Stepper Motor
→ Solenoid
→ Relays

Types Of DC Motor

Series motor Shunt motor compound

long shunt short shunt

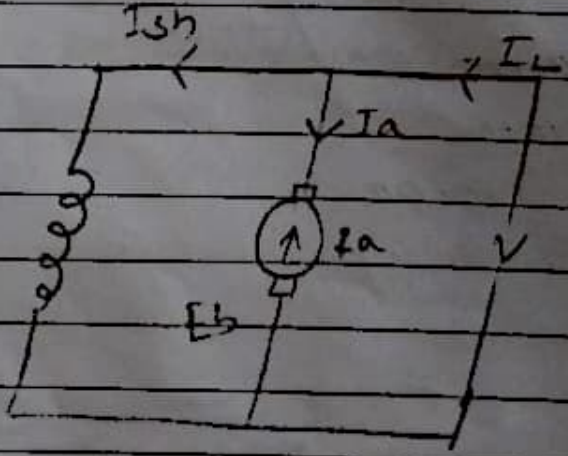


Eb = back emf

$V = E_b + I_a (R_a + R_{sc}) + B.d$

$I_L = I_a$

Shunt Motor

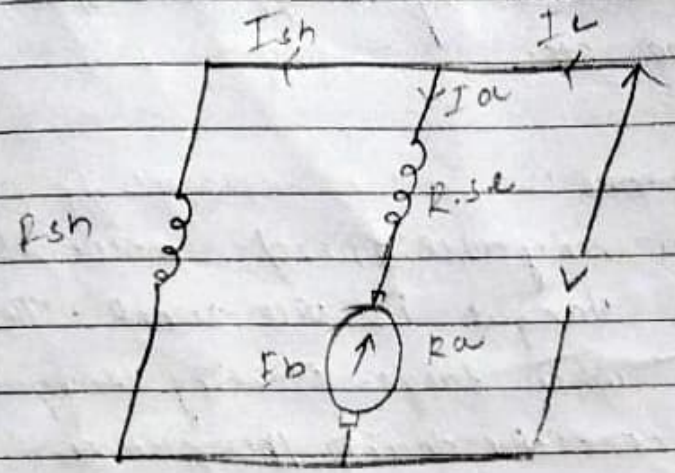


$I_{sh} = \frac{V}{R_{sh}}$

$V = E_b + I_a R_a$

$I_L = I_a + I_{sh}$

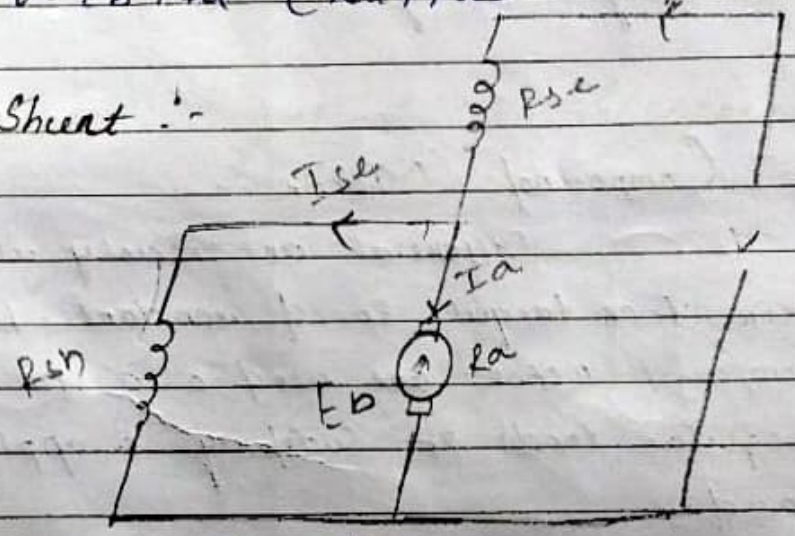
Long Shunt :-



$$I_{sh} = \frac{V}{R}$$

$$V = E_b + I_a (R_a + R_{se})$$

Short Shunt :-



$$I_L = I_a + I_{sh}$$

$$V = E_b + I_a R_{se} + I_a R_a$$

Application Of DC Motor :-

Shunt Motor :-

Shunt motor is a approximetic constant speed motor their for it is used in those application where speed remain constant from low load to full load of

Industrial Use:-

lathe drill, boring, shapper, spinning and wiring machine etc.

Series Motors:-

It is a very able speed motor, speed is low at high torque & vice-versa. Their for it is used where large starting torque is required ex- electric chain locomotives.

Industrial motors:-

electric traction trains, elevators, vacuum cleaners hear dryer sewing machine.

Compound Motor:-

Differential are nearly used because of their poor torque speed constant - but something compound motors are used when it required with irregular loads of suddenly & applied heavy load.

Industrial Uses:-

presses, shears, riveting, propeating machine DC series motor can not be started without load.

Stepper Motor :-

Stepper is also known as steps motor. The stepper motor is an electromagnetic motor that rotates by a specific of degree in respond to input electrical signal. The specific step size are 2° or 2.5°. 7.5° 15° etc each electrical pulse there is now continous energy conversion so that the rotor doesn't rotate continously as in a conventional motor. The stepper motor convert electrical pulse into proper incrementment there are two types of stepper Motor.

→ permanent magnet (PM) Stepper motor.
→ variable reluctance (VR)

Permanent Magnet (PM) Stepper Motor :-

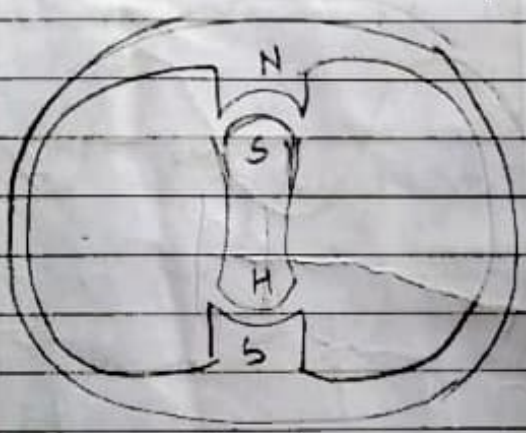
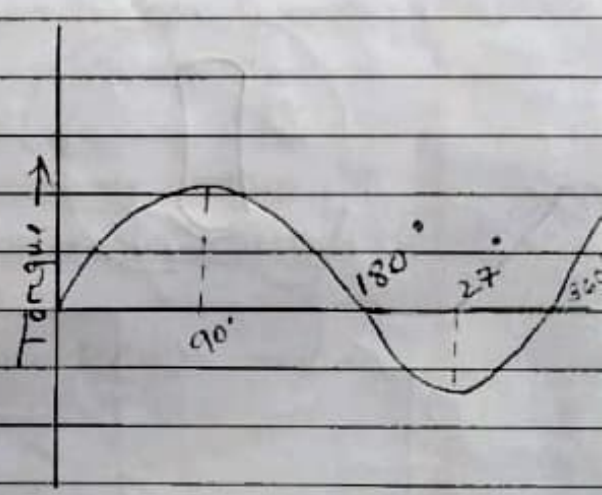


Fig: 1



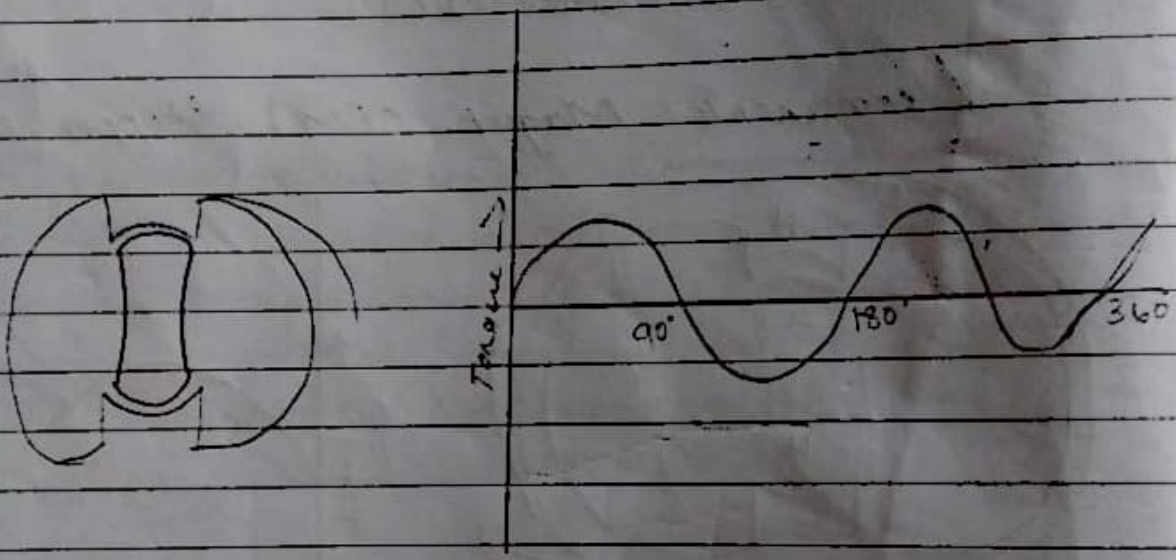
→ The figure 1 show at two pules single phase permanent stepper motor.
→ When a stator energise the external torque x on the rotor

→ The rotor will move a position where excitation of 0 that is that winding will be acting with the stator field.

→ Figure to show how saturated torque Vary rotor position for a pm rotor.

→ In this maximum torque is develop when the rotor is displaced from the stator field by either 90° or 270°.

Variable Reluctance (VR) Stepper Motor :-



→ Figure 1 show a two pulse single phase VR stepper motor.

→ When the stator is energized. It's reluctance where torque α of the rotor.

→ The rotore will be move a position where reluctance are minimum and air gap is maximum.

→ These means the rotore teeth will aline with the energised stator pole.

↓ X on figure-2 with the rotore at 0° or 90° no torque is develop at 45° and 135° which often the rotore to move to a position of minimum electrent.

(2)

Step Angle

The angle through which motor shaft rotate for each command pulse is called step angle. Step angle can be form the following relation.

i) In terms of Stator pole (Ns) and rotor pole (Nr)

$$\text{Step angle } \alpha = \frac{Ns - Nr}{Ns * Nr} \times 360$$

ii) In terms of stator phase (m) and rotor pole Nr.

$$\text{Step angle } \alpha = \frac{360}{m Nr}$$

m = no of stator phase
Nr = No of rotor teeth

Stepping Rate :-

The number of steps per sec is known as stepping rate and stepping frequency (f). The actual speed of a stepper motor depends on the step angle (α) & stepping frequency (f).

Speed of Stepper motor

$$N = \frac{\alpha f}{6}$$

where α - step angle

f - stepping frequency

Find out the step angle of a variable reluctance stepper motor with 12 teeth in stator and 8 rotor tooth.

$N_s = 12 \quad N_r = 8$

Step angle $\alpha = \frac{N_s - N_r}{N_s \times N_r} \times 360^\circ$

$= \frac{12 - 8}{12 \times 8} \times 360^\circ$

$= \frac{4}{96} \times 360^\circ$

$= 15^\circ$ / step

Ques-2 Calculate the stepping angle for a 3 phase 16 tooth rotor VR motor.

Step angle $\alpha = \frac{360^\circ}{MNR}$

$= \frac{360^\circ}{3 \times 16}$

$= \frac{360^\circ}{48} = \frac{15}{2} = 7.5^\circ$ Step.

Ques-3 A 3 phase 24 pole PM motor.

Step angle $\alpha = \frac{360^\circ}{MNR}$

$= \frac{360^\circ}{3 \times 24}$

$= \frac{360^\circ}{72} = 5^\circ$ /step.

Ques-4 A stepper with the step angle of 1.5° has a stepping frequency of 300 step/sec. What is the motor speed.

Step angle $\alpha = N = \frac{\alpha f}{6}$

$= \frac{15 \times 300}{6}$

$= \frac{4500}{6} = 750$ rpm.

A stepper motors has a step angle of 10° & is required rotate at 200 rpm. find pulse rate for this motor.

$$N = \frac{\alpha F}{6}$$

$$200 = \frac{10 \times F}{6}$$

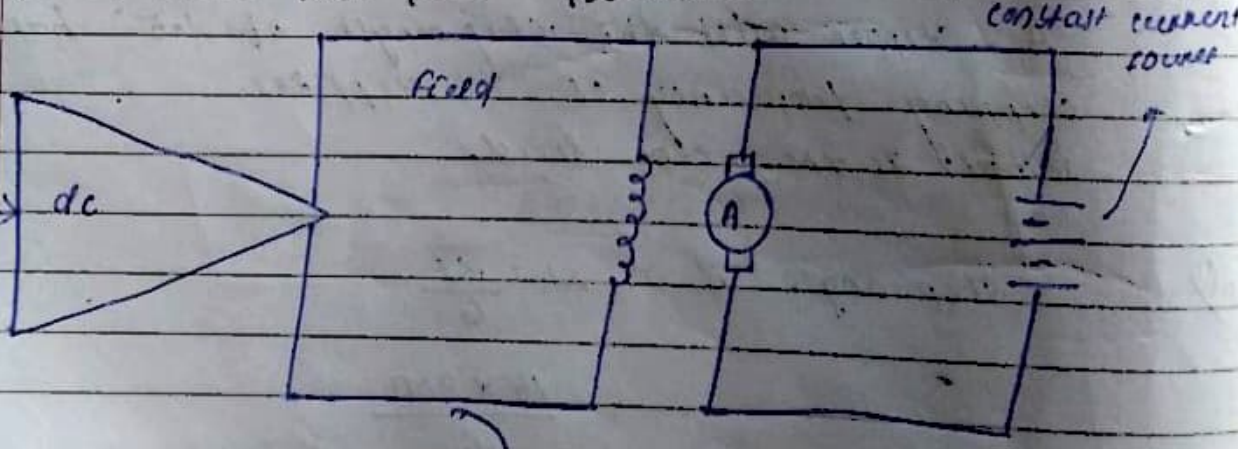
$$F = 20 \times 6 = 120 \text{ rpm}.$$

Servo Mechanism :-

→ a measuring device
→ error detector
→ Controller
a correcting device

DC Servo Motors :-

Field Controlled d.c Servomotor :-



To read field controlled d.c servomotor.

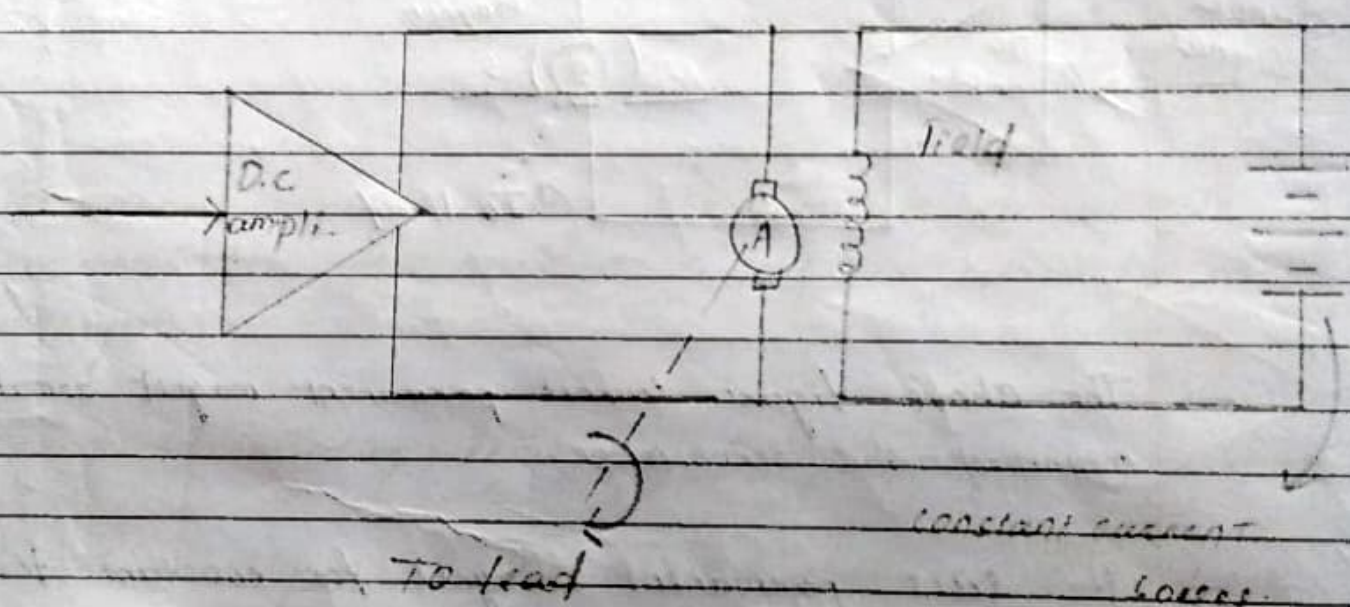
→ The figure sources d.c servo motor heat the field winding control by electronic amplifyer.

→ The armature is supplyer a constant current sources. The error voltage represent the difference bet' the measured signal & desired signal.

→ Since armature current is always constant there to torque is directly proportional field flow and it is also directly proportional to the field current i.e $T \propto \phi \propto I_a$

→ If the of the field reversed the motor direction is reversersed.

(2)

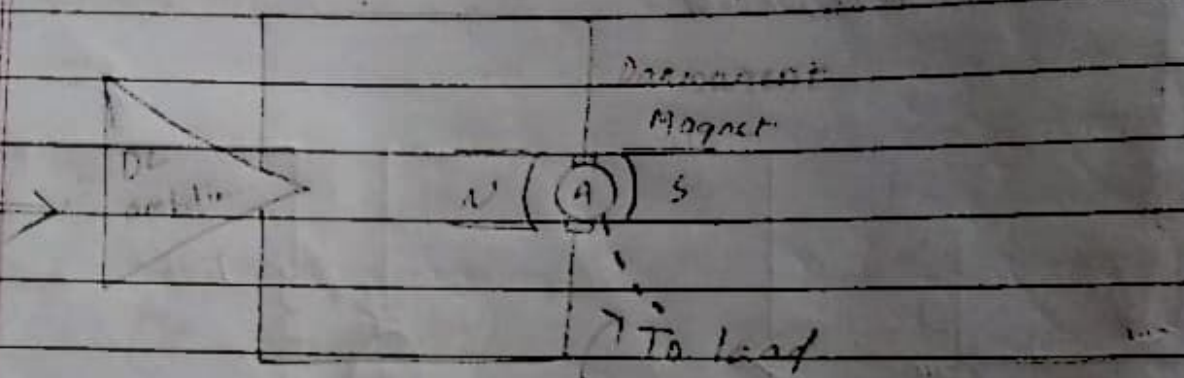


→ The above figure source the armature control d.c servo motor here the armature circuit is control by electronic amplifyer.

→ A sudden large or small change in armature voltage produced error signal will cause in immidiate response i.e to torque.

→ If the error signal and polarity of armature voltage are reversed then the direction motor will be reverse.

③ Parmanet Magnet Armature Controlled D.C Servo Motor:-

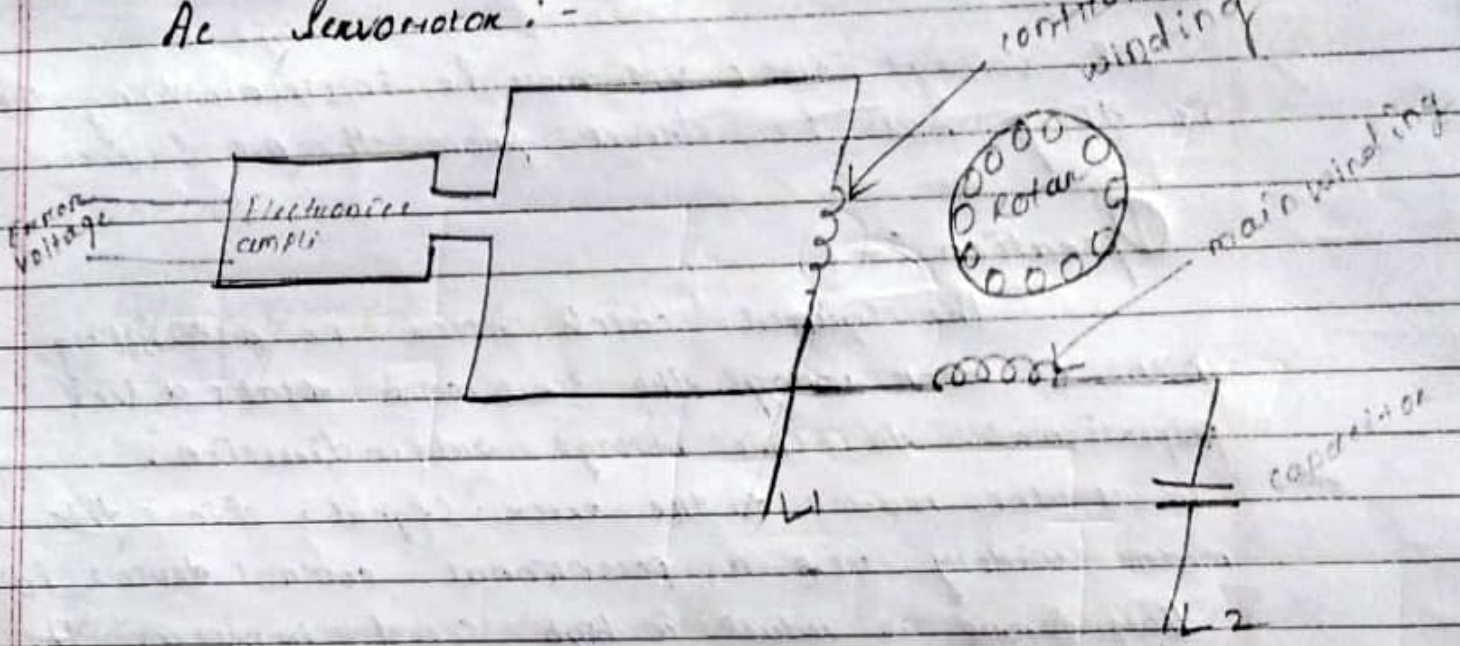


→ The above figure shows parmanent magnet armature controlled d.c servo motor.

→ Its uses parmanent magnet for constant field excitation.

→ permanent magnet has several advantages such as increase efficiency, reduce frame size and high torque. the popularity of these motor is due to their high efficiency compact designed & good commutation.

Ac Servomotor :-



→ The above figure shows the armature control dc servomotor here the armature circuit is control by electronic amplifier.

→ The field winding is supplied by constant current

→ The above figure shows a two phase squirrel cage types induction motor.

→ The squirrel rotor has high resistant & low inertial the stator has two winding which are displayed to each other 90° electrical.

→ Main winding is excited by fixed A.C voltage (V_M)

→ The control winding is fixed out voltage (V_{M2}) of a amplifier.

→ The voltage V_M & V_M must be in synchronising that is they must be drived from the A.C source.

Operation :-

The squirrel cage rotor is rotating with 0 error voltage the servo motor rotate & stop proportional to this voltage and in direction. So as the reduce to the error signal. Since this motor widely use a positional control device to that torque is reduce to high speed to prevent the motor from overshooting the desired position.

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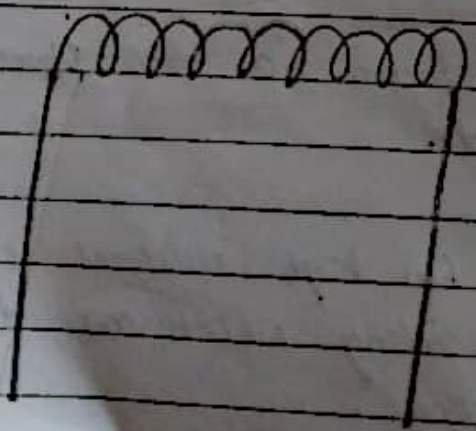
Solenoid



→ A solenoid is a long piece of wire which is wound in the shape of a coil. when the electric current passes through the coil it creates a relatively uniform magnetic field inside the coil.

→ The solenoid can current a magnetic field from the electric current & this magnetic field can be used to generate a linear motion with the help of a metal core.

Working Principle :-

→ The solenoid simply works on the principle electro-magnetism.

→ When the current flows to the coil magnetic field is generated.

→ If we place a metal core inside the coil the magnetic lines of flux is concentrated on the.

Core which increase the flux induction of the coil as compared to the air core.

→ Most of the flux is concentrated only on the core while some of the flux appears to the cancel the coil & a small amount of flux appears outside the coil.

→ The magnetic strength of solenoid can be increased by increasing the density of the turns or by increasing the current flow in the coil.

→ like all other magnetic the activated solenoid has both positive & negative poles through which an object can be attracted or repelled.

Type Of Solenoid :-

There are different type of solenoid available in the market.

The classification is based on material design & concerns.

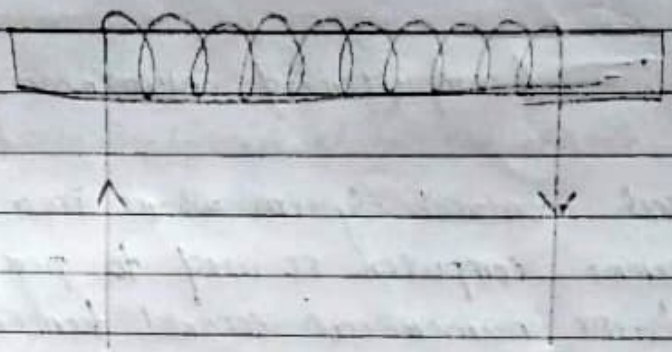
Types :-

i) A.C laminated solenoid
ii) DC C frame solenoid
iii) D.C D frame solenoid
iv) linear solenoid
v) Rotary solenoid

A.C Laminated Solenoid :-

The AC laminated solenoid consists of a metal core & a coil of wire the core is constructed with a laminated metal in order to reduce the stray current.

- This helps to improves the performance of solenoid.



NOV

1) How can you Specify a transducer ? 6mark
2) Explain working of switching device electrical actuator ? 10
3) What are the principle of measurement of linear or angular displacement with the help of a transducer ? 2mark
4) Define transducer ? 2mark
5) What is an actuator ? list of various system of electrical actuators ? 6mark
6) Explain briefly the working solenoid and state there application ? 6mark
7) How are transducer classified ? 6mark
8) Define clutch explain the working of an electro magnetic clutch ? 10mark
9) Explain briefly working of relays ? 6 mark.

(10) Classify electrical drives system? 6 mark
(11) Explain briefly about various DC Servo motor? 6 mark
(12) What is the function of Season & transistor? 6 mark
(13) Different bet? D.C & A.C Servo motor? 6 mark

25 NOV

What is CNC?-

CNC :- (computerised Numerical Control)

The numerical control system where in a dedicated stored programme computer is used to perform some or all basic numerical control function is accordance with the control programme stored in the read / write memory of computer.

Numerical Control :-

Numerical control can be defined as a form of programmable automation in which the process is control by numbers, letters & symbols in NC the number from a programme of instruction design for a particular job.

3) Define CAM (Computer Aided Manufacturing):-

Can be defined as the use of computer system or to plan, manage & control the operation of manufacturing plant through either direct or indirect. Computer interface with the plants production resources.

4) Classify NC System and state its application?

Classification of NC System:- The different NC system are classified on the basis of different criteria as follows.

(1) According to tool positioning or programming modes
(a) Absolute System
(b) Incremental System

(2) According to motion control systems.
(a) Point to point System
(b) Straight line or straight cut system.
(c) Contouring or continuous path system

(3) According to the types of feedback devices:
(a) Analog
(b) Digital

(4) According to Servo control System:
(a) Open-loop system.
(b) Closed-loop System.

Applications Of Numerical control:-

With a cut-throat competition in the industry, there is a continuous endeavour to reduce overall production cost without compromising the quality of the product. This is possible only by increasing production rate, optimizing machining conditions, improving dimensional control, minimising human involvement in actual processing, reducing non machining times and similar other measures. These requirements have led to a very wide application of numerical control in various manufacturing. A fairly large majority of commonly used metal cutting machine tools, such as Drilling machines, Lathes, Milling machines, Boring machines, Grinding machines, Sawing machines, etc. are therefore, now available with numerical controls. Other useful additions to this family of metal cutting NC machine tools are the Turning Centre and machining Centre.

However, numerical control cannot be advantageously used on all types of machine tools and for every type of metal cutting Operation.

(1) Machining of such components which require 100 percent inspection.

(2) Machining of parts which are likely to be subjected to be frequent design changes.

(3) Repetitive production of precision parts in small and medium lot sizes.

(4) When several operations are to be performed in machining of a part.

(5) When the part carries a complex geometry and a human error may occur in its conventional machining.

(6) When complex machining operations are involved.

(7) When the amount of metal to be removed is high.

(8) When the required dimensional accuracy on the part is very high.

(9) When economic considerations demand a substantial reduction in 'lead Time' for the manufacture.

(10) When conventional machining of parts will involve a heavy investment on jigs & fixtures and tooling for machining of these parts.

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① How can you specify a transducer?

Transducers are specified by the following

(a) Parameter to be sensed - pressure, temperature, displacement.

(b) Range for above - 0-10mm (or)
0-400°C

(c) Type of Sensor - resistive, strain gauge, capacitive etc.

(d) Output Signal - emf, changes in resistance, current

(e) Sensitivity (output per unit input) - MV/°C / MV/mm etc

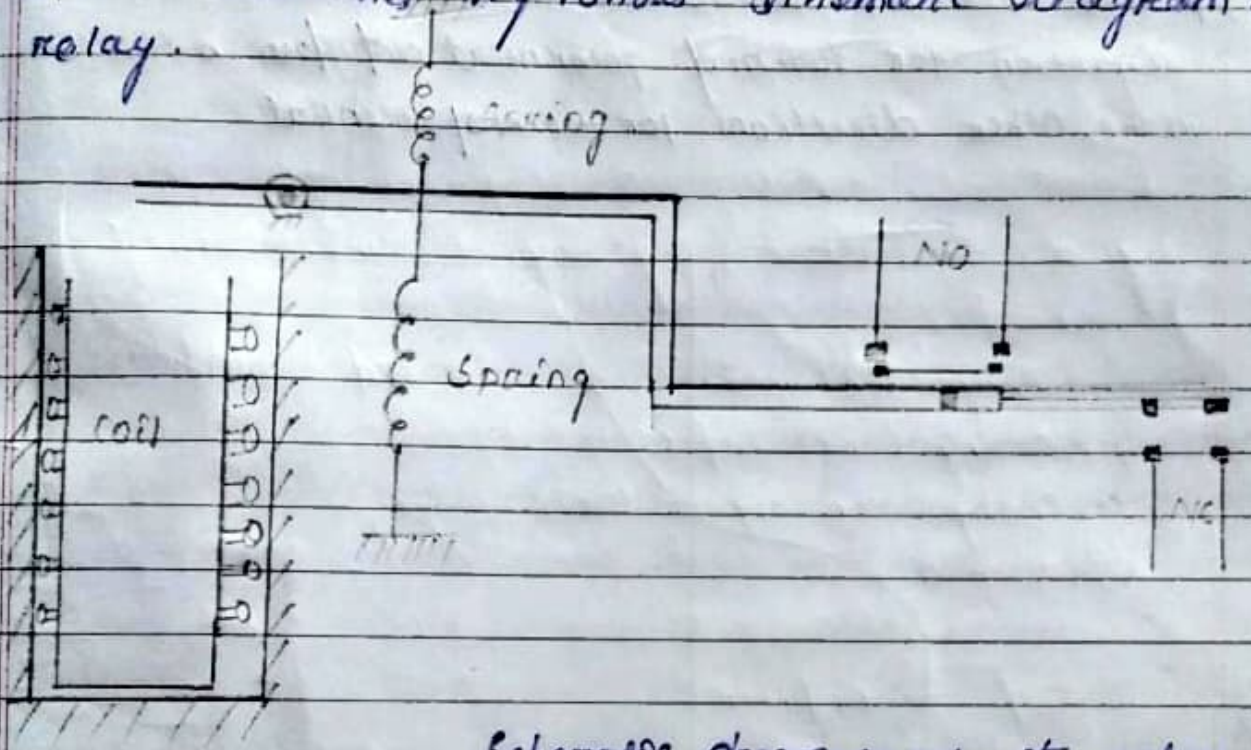
f) Excitation required - volts DC / AC

g) Resolution - 0.1mm / 0.1mpa / 0.1°C

Other things depending on on transducer linearity, hysteresis, repeatability, overload, dynamic response, stability, dimension, weight, connections, working environment etc.

2. Explain working of Switching device as electrical actuator.

Switching Device: In a mechatronic systems, switches are required for actuating electric devices. The switches may be classified into mechanical switches and solid state switches. Fig-1 shows schematic diagram of a relay.



Schematic arrangement of relay

→ This consists of a electromagnet and arm connected to contacts NO (normally open) and NC (normally closed). When magnet is energised, it pulls up the arm and closes contact NO and releases contact NC. When power supply to coil ceases, the arm returns to its position and NO is opened and NC is closed. Normally relay is meant for carrying current upto 1A. For higher current, contactors having bigger electromagnet are employed.

Solid state Switches include

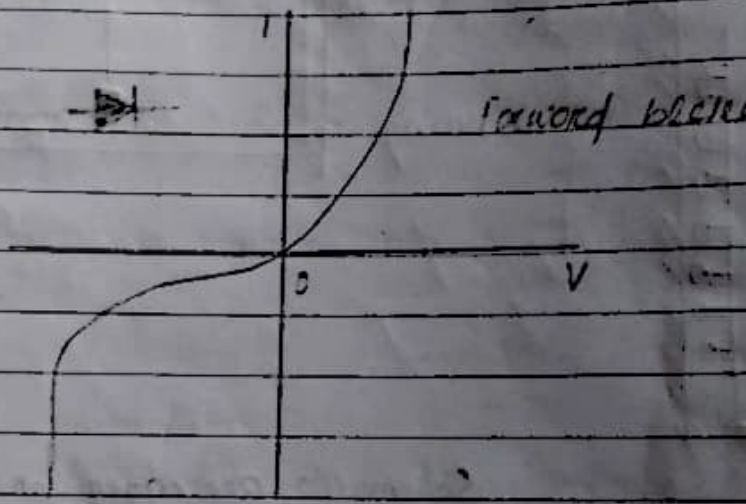
(a) Diodes

(b) Thyristors and triacs

(c) Bipolar transistors

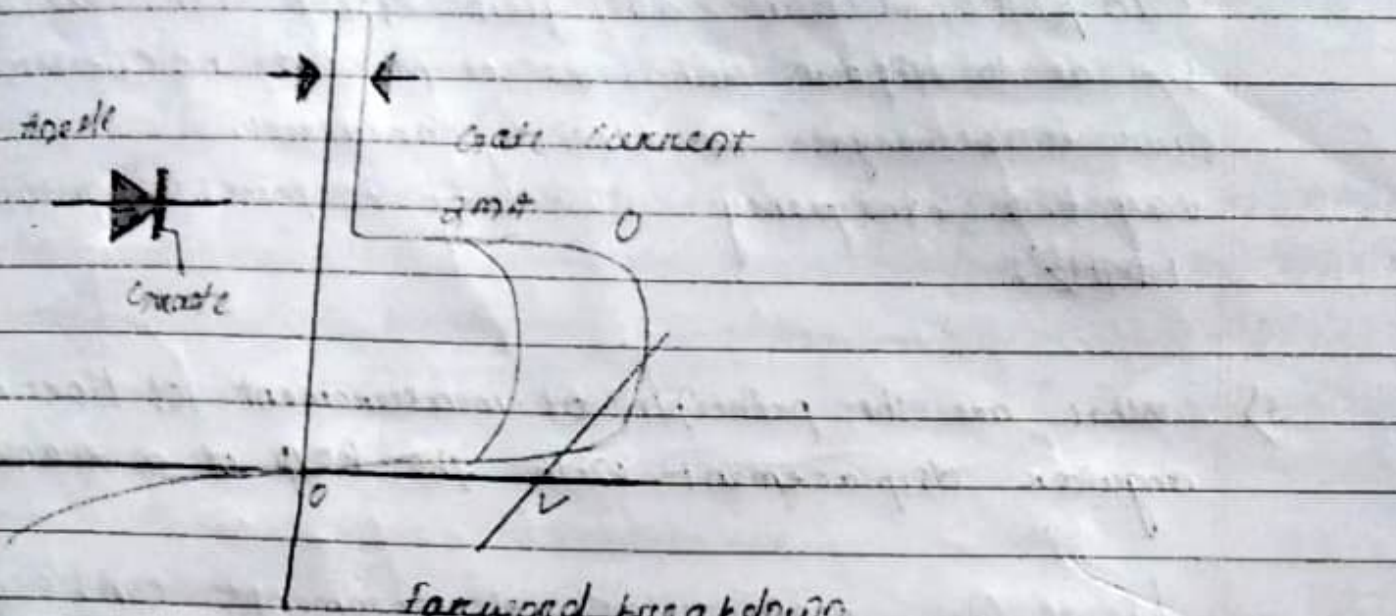
(d) Power MOSFETs

In the case of diodes it allows current in one direction for forward potential and does not allow in the other direction for reversed potential



Diode characteristic

In the case of thyristors (Or Silicon Controlled rectifiers) Switch operation is controlled by gate current is zero, the thyristor breakdown voltage may be 300 V and on breakdown the voltage will come down the voltages will come down to 1.2 V thereby increasing Current through thyristors (Eqn 3)



Thyristor Characteristic

⇒ The triac is similar to thyristor and is equivalent to pair thyristors in reverse parallel on the same clamp. These are used as rectifier, pulse width modulation for DC motor control and phase control.

MOSFET: Metal oxide field effect transistor) is similar to bipolar transistor except that no current flows into the gate to exercise the control. Very high frequency switching is possible upto 1 MHz.

3) What are the principle of measurement of linear or angular displacement with the help of a transducer?

Linear or rectangular displacements can be measured by a transducer by any of the following principles.

i) Changes of resistance
ii) Changes in inductance
iii) Changes in capacitance
iv) Digital

4) Define transducer?

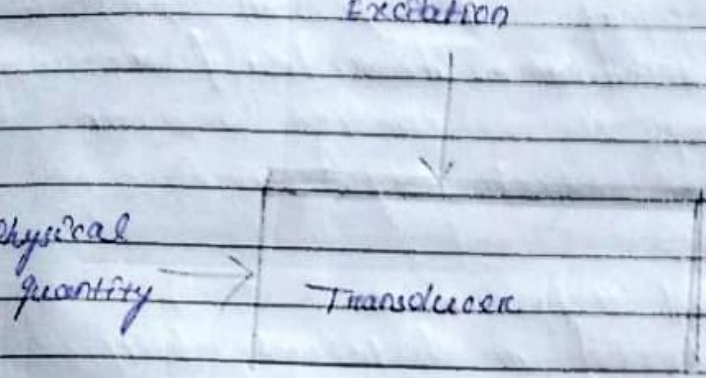
"A transducer is a device which converts the energy form one form to another".

Most of the transducers either convert electrical energy into mechanical displacement or convert some non-electrical physical quantity (e.g. force, sound, temperature etc) to an electrical signal.

" A transducer performs the following functions in an electronic instrumentation system.

(1) Detects Or Senses the presence, magnitude and changes in physical quantity being measured.

(2) Provides a proportional electrical output signal (usually)



5) What is an actuation? list of various system of electrical actuators?

General Aspects

Actuator: A Mechanical device on a system which has motion or movement is called an actuator.

Actuation System: A group of elements which is responsible directly or indirectly for imparting motion to an actuator is called an actuation system.

Electrical actuator: An actuator receiving electrical energy for motion is called an electrical actuator.

Electrical actuators systems include the following:

1) Switching devices:
   1) Mechanical switches
      (i) Solenoids
      (ii) Relay

2. Solid state switches
   (i) diodes.
   (ii) Tyristors.
   (iii) Transistors.

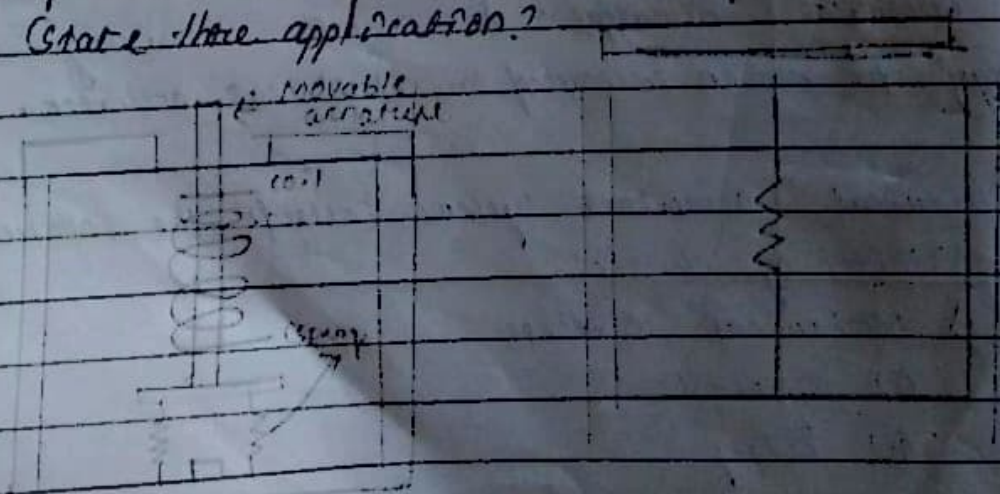
Here the control signal switches on or off some electrical device, perhaps a heater or motor.

ii) Drive systems
   (i) D.C motors
   (ii) A.C Motors and stepper motors

→ Amongst electrical motors, "D.C. Motors" are most straight forward to interface and control and hence, are most commonly used.

→ "A.C motors" and "Stepper motors" are versatile because A.C. Motors are difficult to control and Stepper motors have low torque capability moreover stepper motors cannot be used for certesian space trajectory tracking Operations (like plotting).

3) Explain briefly the working solenoid and State there application?



A 'Solenoid' consists of a coil and a movable iron core called the armature. When the current is passed through the coil it gets energized and consequently the core moves to increase the flux linkage by closing the air gap bet' the cores. The movable core is usually spring-loaded to allow the core to retract when the current is switched off. The force generated is approximately proportional to the square of the width of the air gap.

How are transducer classification?

Classification of transducers -

Transducers are broadly classified in to two groups as follows:

1) Active transducers - They are also known as self-generating type transducers. These transducers develop their own voltage or current. The energy required for production of an output signal is obtained from the physical phenomenon being measured.

2) Passive Transducer - They are known as externally powered transducers. These transducers develop their own drive the power required for the energy conversion from an external power sources. However they may absorb some energy from the physical phenomenon under study.

B. classification based on the type of output:

1) Analogue Transducers - These transducers convert the input physical phenomenon into an analogous output which is a continuous function of time.

2) Digital Transducer - These transducers convert the input physical phenomenon into an electrical output which may be in form of pulse.

c) Classification based on electrical Principle involved:-

1) i) Variable - resistance type:
   i) Strain and pressure gauges
   ii) Thermistors, resistance gauge thermometer
   iii) photoconductive cell etc.

2) Variable - inductance type:
   i) linear voltage differential transformer (LVDT)
   ii) Reluctance pick-up
   iii) Eddy Current gauge.

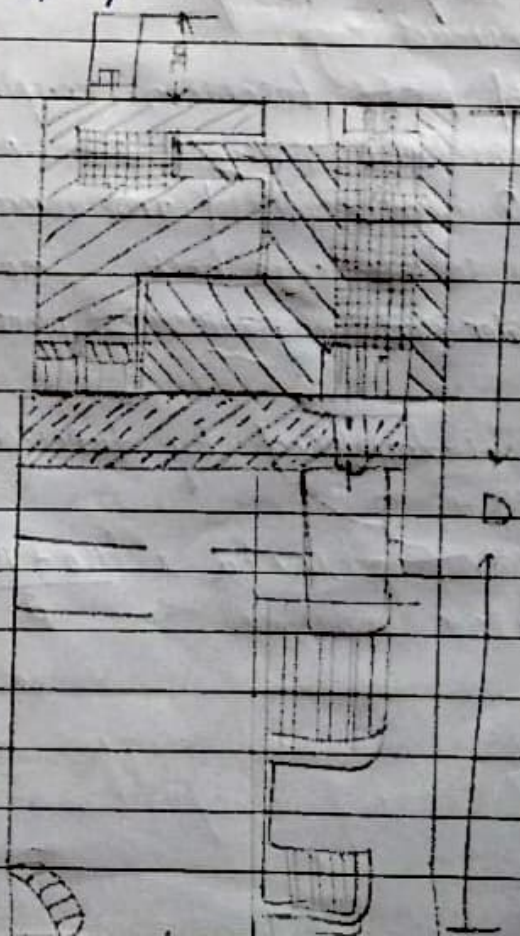
3) Variable - Capacitance type:
   i) Capacitor microphone.
   ii) Pressure gauge
   iii) Dielectric gauge

4) Voltage - generating type :
   i) Thermocouple.
   ii) Photovoltaic cell
   iii) Rotational motion tachometer
   iv) Piezoelectric pick-up

5) Voltage - divider type :
   i) Potentiometer actuated voltage divider.

8) Defined Clutch explain the working of an electro magnetic clutch ?

Clutches are the devices for transmission of power bet^n two shafts at will. The power bet^n shafts will be transmitted either by mechanical friction or electromagnetic coupling. Positive clutches are used only for slow speed.



Electro-magnetic clutch

The schematic arrangement of electromagnetic clutch is shown in fig. This consists of two friction discs one connected to input and other output shaft. The friction disc of output shaft is provided with spline (toothed profile) and can freely move along axis of shaft. These discs are held by axial compression springs and torque is transmitted by friction. When we want disengagement the disc of output shaft is drawn in axial direction by an electromagnet and gap is created between discs. In that position output shaft is disengaged. This is the case where clutch is normally ON i.e it is in engaged position when solenoid or magnet is not energised. Normally OFF versions are also available. These clutches are available as standard units and are specified by dia of shafts and torque rating.

Instead of friction coupling, electromagnetic coupling is also possible. simpler to coupling existing between stator field and rotor in a synchronous motor. But in this case both 'motor' and rotor will have identical magnetic pole pitch and locked.

Torque transmitted by friction clutch is given by,

$$T = \mu \times f_a \times \frac{(r_o + r_i)}{2} \times n$$

Where - μ = friction coefficient

F_a = axial force on the disc

$\frac{(r_o + r_i)}{2}$ = mean radius of the disc

n = Number of friction surfaces (in case of multi disc clutch) for single plate clutch n=1

q) Explain briefly Working of relay.

Relays :- Relays are electrically Operated Switches in which changing current in one electrical circuit Switches or which a current on or off in another Circuit.

Relays are often used in control System; the output from the controller is a relatively small current and a much larger current is needed to switch on or off the final connection element e.g. the current required by an electric heater in a temp. control system or a motor.

Relays are used in power switches and electromechanical control elements.

A relay performs a function similar to a power transistor switch circuit but has the capability to switch much larger currents. The input circuit of a relay is electrically isolated from the output circuit unlike the common emitter transistor circuit, where there is a common ground between the input and output. Since the relay is electrically isolated noise, induced voltages, and ground faults occurring in the output circuit have minimal impact on the input circuit.

(10) Classify electrical drive system?

Electric motors are frequently used as the final control element in electrical drive system control systems.

Electric motors for mechatronics robotic applications can be classified by electrical configuration as follows:

1) D.C Motors
   i) Permanent magnet.
   ii) Series wound
   iii) Shunt wound
   iv) Compound wound

2) A.C Motors
   i) Single phase
   - Squirrel Cage:
     - Split phase
     - Capacitor start
     - Permanent Split Capacitor.
     - Shaded pole
     - Two - valve capacitor.

   - Wound Rotor
     - Repulsion
     - Repulsion start
     - Repulsion induction

b) Synchronous:
- Shaded pole
- Hysteresis
- Reluctance
- Permanent magnet

(ii) Polyphase
(a) Induction
- Wound rotor
- Squirrel cage

(b) Synchronous

iii) Universal motors.

- In modern control systems, D.C motor are mostly used

11) Explain briefly about various D.C Servo Motor:

D.C. Servo Motors: These motors are preferred for very high power systems since they operate more efficiently. (as compared to A.C servomotors).

These motors may be of the following types:
Series motors.
Split Control motors
Shunt Control motors
permanent magnet (fixed excitation) shunt motor.

i) Series Motors:

- This motor has a high starting torque.
- It draws large current.
- The speed regulation is poor.
- Reversal can be obtained by reversing field voltage polarity with split series field windi

from D.C amplifier.

ii) Split Series motors:-

The D.C series motors with split field (small traction kW) may be operated as a Separately excited field controlled motors.

- A typical torque curve show the following
  - High stall torque
  - Rapid reduction in torque with increase in speed

iii) Shunt Control Motor:
- This type of motor has two separate windings field winding placed on the stator and the armature winding placed on the rotor the of the machine. Both the winding are connected to a D.C supply source.
- Whereas in a conventional D.C shunt motor, the two windings are connected in parallel across the D.C supply mains but in a ~~parallel~~ servo application the winding are driven by seperate D.C supplies.

iv) Permanent Magnet Shunt Motor:
- It is a fixed excitation shunt motor where the field is actually supplied by a permanent magnet.
- Its performance is similar to that of armature controlled fixed field motor.

~~v) What are the [illegible] of [illegible]:~~

State benefits of CAD & CAM:
- Improved accuracy of accuracy of design and produce manufacturing.
- Improved quality assurance.

- Standardize product design and manufacturing.
- Reduced requirements of skilled personels.
- Improved engineering productivity and more customer satisfaction.
- Design and modifications in product easily made.
- Provides better and accurate kenetional analysis to reduce prototype testings.
- Errors are minimised in part programming.
- Saves materials and machining time by optimization algorithms.
- Assistance in inspection of complicated parts.
- Better engineering drawings and greater legibility
- Reduced lead time and in-process inventories.
- Cost saving in tool design and other capital investments.
- Provides increased capacity due to reductions in set up times.
- Reduced material handling costs.

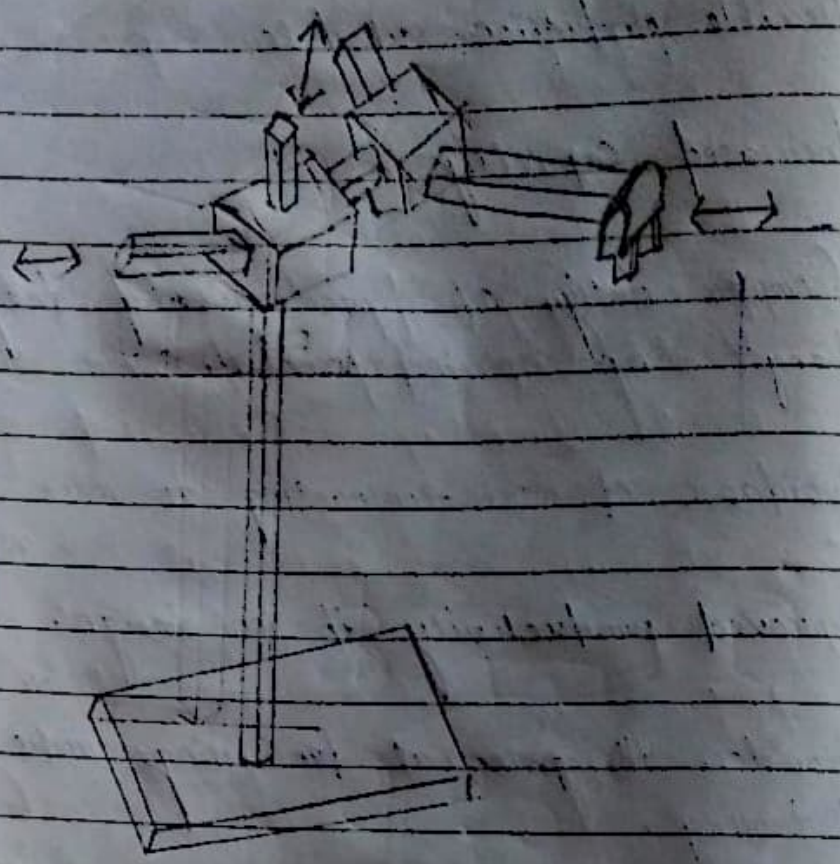
- High equipment utilisation and reduced waste.
- Flexible production schedule.
- Increased capacity.
- Complex design of product and frequent design changes can be incorporated.
- Avoidance of sub-contracting to meet schedules.
- Improved productivity in tool design.
- Provides the potential for using more existing parts and tooling.
- To create a data base for manufacturing.
- Better communication interface and greater understanding among engineers / designers / drafters / managements and different project.

Configuration Of Robot :-

The majority of commercially available robots can be grouped into four basic configurations:

i) Cartesian co-ordinate configuration
ii) Cylindrical configuration
iii) Spherical configuration
iv) Jointed-arm configuration

(i) Cartesian Co-Ordinate Configuration :-



- The cartesian or rectilinear robot also termed as gantry robot, has three mutually perpendicular axes which define as rectangular work volume.
- In this, the simplest of configurations the links of the manipulator are constrained to move in a bilinear manner. Axes of a robotic device that behave in this way are referred to as "prismatic".
- The cartesian devices may be of two types :-

(a) Cantilevered Cartesian:

- Such devices tend to have a limited extension from the support frame, are less rigid, but have a less restricted workspace than other robots.

- They have good repeatability and accuracy (even better than screw types) and the easier to program because of the 'more' natural" co-ordinate system.

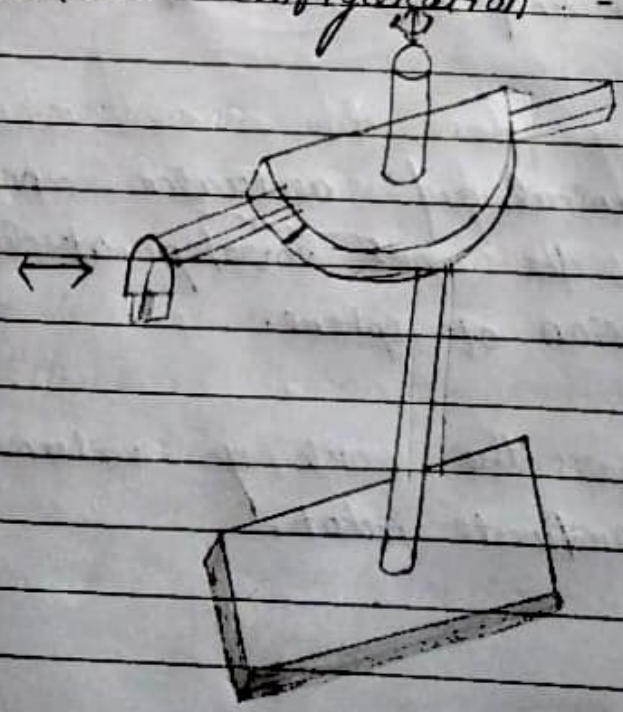
(b) Gantry-Style Cartesian:-

- Such robots are used when extremely heavy loads must be precisely moved.

- They are often mounted on the ceiling.

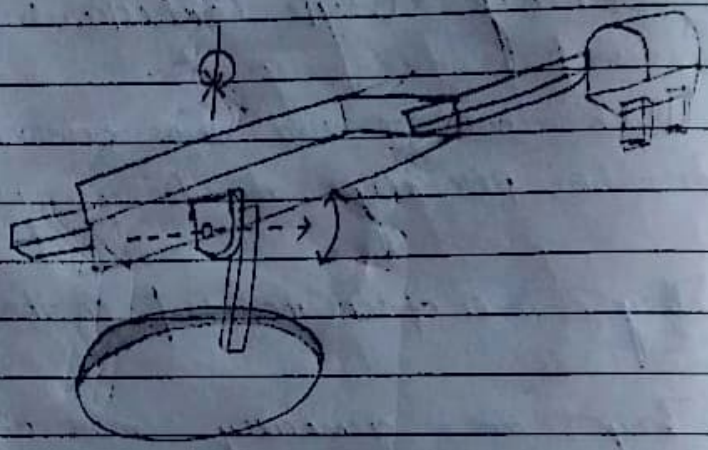
- They are generally more rigid but may provide less success to the work-space

ii) Cylindrical configuration:-



- Cylindrical configured robot:- use a vertical column with the robot arm attached to a side which can move up and down the column. Simultaneously, the arm can move radially with respect to the column.

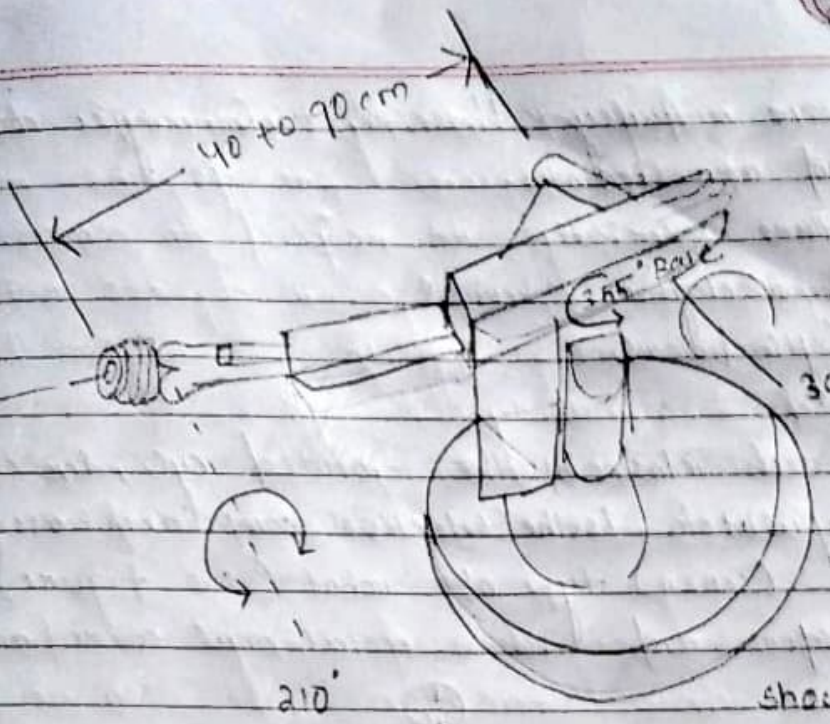
iii) Spherical (Polar) Configuration:-



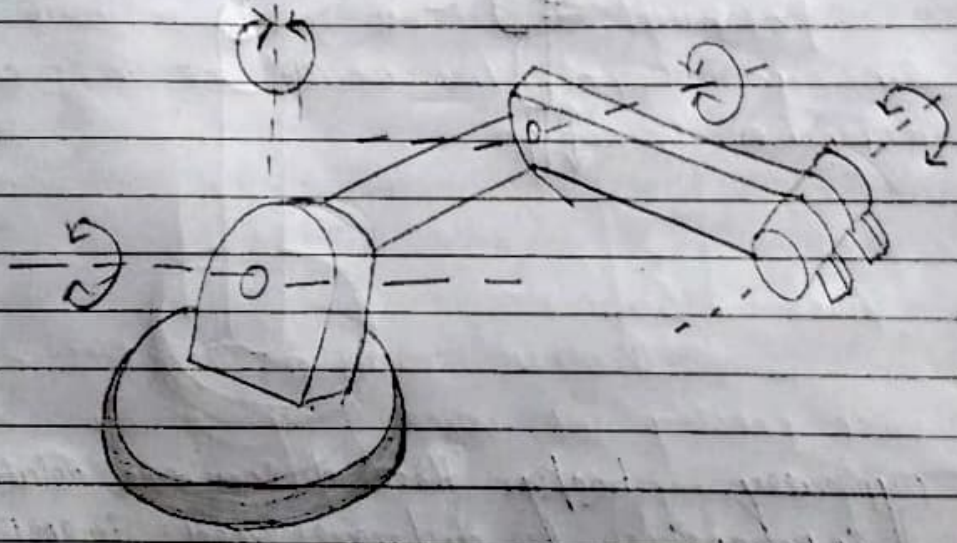
- The configuration has a telescope arm which pivots about a horizontal axis and also rotates about a vertical axis.

- Owing to mechanical and actuator connection limitations, the work envelope of such a robot is a portion of sphere.

figure below shows the working volume of Spherical co-ordinate robot.



iv) Jointed - arm configuration. (Revolute):



- The jointed arm robot most resembles a human arm and consists of a series of links connected by rotary joints which when referenced from base are referred to as the shoulder, arm and wrist joints.

- There are actually three different types of jointed arm robots.
  (a) Pure spherical
  (b) Parallelogram spherical
  (c) Cylindrical

- A sub-class of the jointed cylindrical manipulator is the selective compliance assembly robot arm (SCARA) type of robot (see figure); its shoulder and elbow rotational axes are vertical

- Typically, these devices are relatively inexpensive and are used in applications that require rapid and smooth motions.

Sensor Used in Robot :-

For certain robot applications, the type of work station control using interlocks is not adequate. The robot must take on more human like senses and capabilities in order to perform the task in a satisfactory way. We will divide the types of sensors used in robotics into the three categories:

(i) Vision Sensors
(ii) Tactile and proximity Sensors
(iii) Voice Sensors.

(i) Vision Sensors :-

This is one of the areas that is receiving a lot of attention in robotics research. computerized visions systems will be an important technology in future automated factories. Robot vision is made possible by means of a video camera, a sufficient light source and a computer programmed to process image data.

Retrieve parts which are randomly oriented on a conveyor.

Recognize particular parts which are intermixed with other objects.

Perform visual inspection tasks.

perform assembly operations which require alignment.

ii) Tactile And Proximity Sensors:

— tactile sensors provide the robot with the capacity to respond to contact forces between itself and other objects within its work volume. Tactile sensors can be divided into two types:

(a) Touch sensors
(b) Stress Sensors (also called force sensor)

- Touch sensors are used simply to indicate whether contact has been made with an object. A simple micro switch can serve the purpose of a touch sensor.

Potential uses of robots with tactile sensing capabilities would be in assembly and inspection operation.

iii) Voice Sensors:

— Another area of robotics research is voice sensing of voice programming. voice programming can defined as the oral communication of commands to the robot or other machine.

— The robot controller is equipped with a speech recognition system which analyzes the voice input and compares it with a set of stored word patterns.

Applications Of Robots in automation of manufacturing:

Robots find applications in automation of manufacturing in the following areas.

(a) Material transfer and machine loading / unloading
In this category, the robot moves parts from one location to another. Some of the applications are material handling in metal machining operations, die casting, plastic moulding and forging operations.

(b) Processing applications - In this category, robot uses a tool as an end effector to accomplish some processing operation on the work parts that is positioned for robot during the work cycle. Spot welding are welding, spray painting and certain machining operations fall under this category.

(c) Assembly and inspection - Assembly and inspection are relatively new applications for robots. The robots is used to put the components together into an assembly. Or robot is used to perform some of automated inspection operation.

Various types of joints/pairs used in robots :-

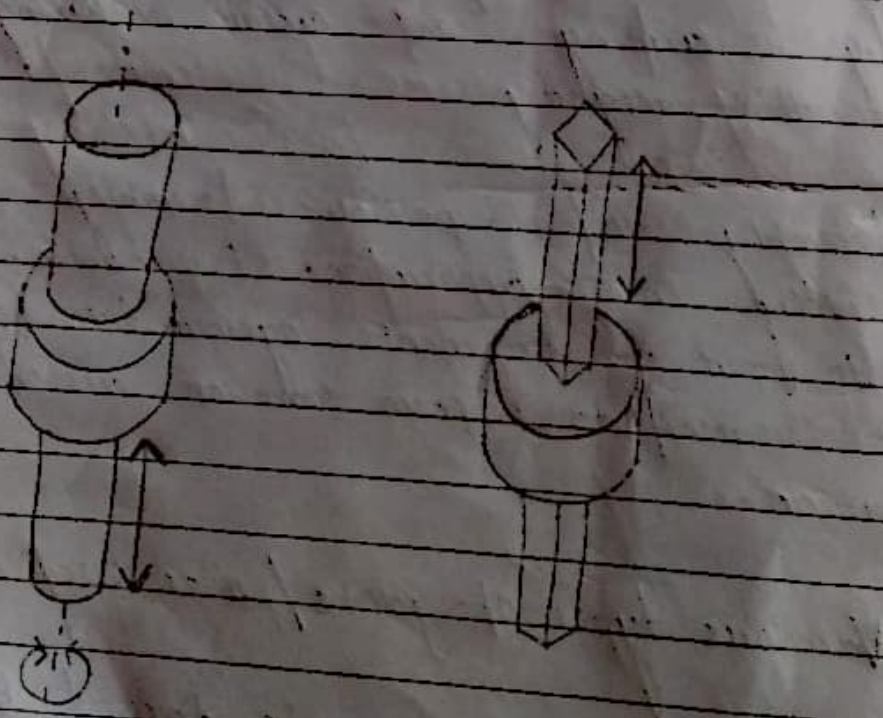
- A joint is a lower pair formed bet? two links.
- The motion in the joint can be translatory (linear/sliding) or rotary / rotational, about or rotary/rotational, or along the cartesian axes.

- The joints can exhibit one or more relative motion (s) at a time, depending on that they are classified as follows

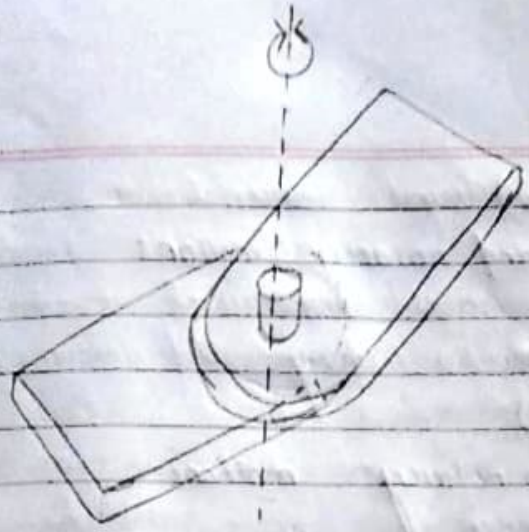
i) Cylindrical pair : fig (i)
   - One sliding and one rotary motions.
   - DOF (Degree of freedom) : Two

ii) Prismatic pair : fig (ii)
   - Sliding motion
   - DOF : One

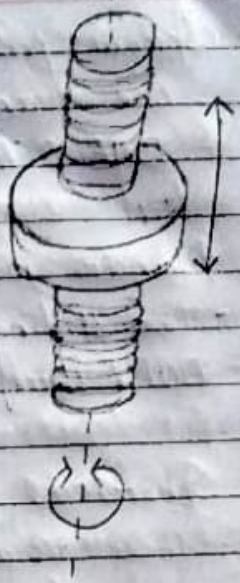
iii) Revolute pair : fig (iii)
   - Rotary motion
   - DOF : One

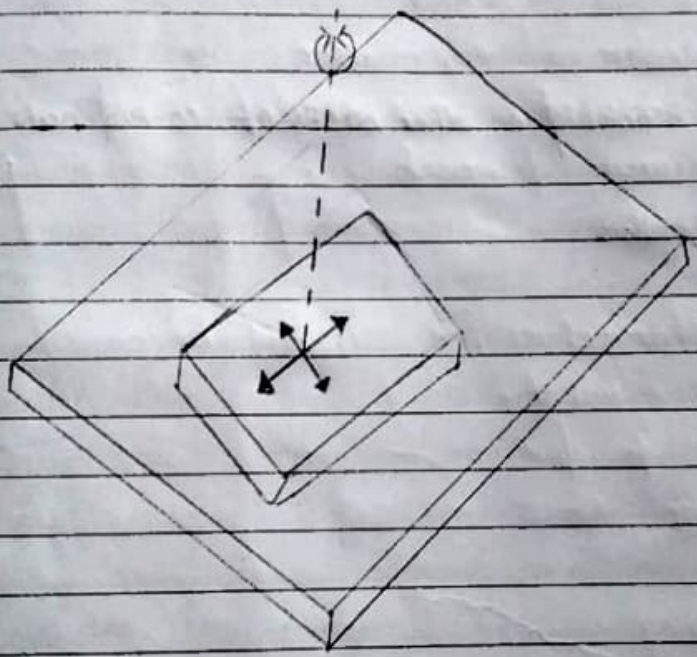


(i) Cylindrical pair (ii) prismatic pair

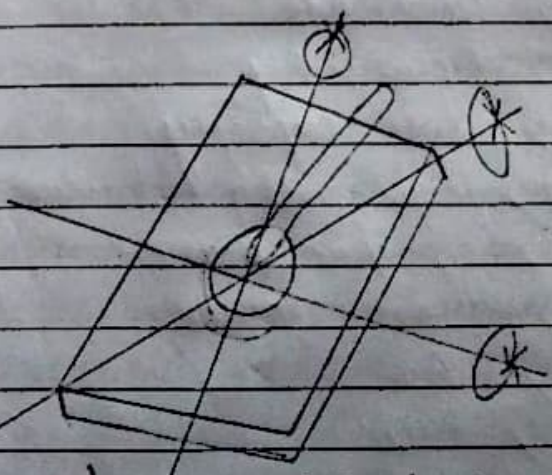


(iii) Revolute pair





(v) planer joint



(joints/pairs used in robot)

(vi) spherical joint

iv) Screw pair joint (iv)
- One translatory and rotary motions
- DOF : Two

v) Planner joint : Eg. (v)
- Two sliding and one rotary motions
- DOF : Three

vi) Spherical joint : Eg (vi)
- Three rotary motions
- DOF : Three

Comparision of robots on other basis of co-ordinate system

S.No	Type of robots

10	Type of robot	Axes	Merits	Demerits
1	Cartesian or robot (e.g. IBM's RS-1 robot and the Sigma robot from Olivetti)	3 linear axes	• Rigid structure. • Linear axes make for easy mechanical stops • Easy to visualise. • Easy to program off-line.	• Axes hard to seal. • Requires large floor space for size of work envelope. • Can only reach in front of itself.
	Cylindrical robot (e.g. Versatran 600 robot from Prab)	2 linear axes, 1 rotary axis	• Rotational axis easy to seal. • Can reach all around itself. • Reach and height axes rigid.	• Cannot reach around obstacles. • Cannot reach above itself • Base rotation axis is less rigid than a linear axis. • Horizontal motion is circular.
	Spherical (polar) robot	1 linear axis 2 rotary axes	• Long horizontal reach	• Generally has short vertical reach • Cannot reach around obstacles.
	Revolute Or articulated robot	3 rotary axes.	• Largest work area for least floor space. • Can reach above Or below obstacles	• Two or more ways to reach a point. • Most complex manipulator. • Difficult to program off-line.
	SCARA	1 linear axis 2 rotating axes.	• Can reach around obstacles. • Height axis is rigid • Large work area for floor space.	• Highly complex arm. • Two ways to reach a point. • Difficult to program off-line.

Applications of Industrial robots :-

Many commercially available industrial robots are widely used in manufacturing and assembly tasks such as:

a) Spot / arc welding.
b) Material handling
c) Parts assembly.
d) paints spraying
e) Loading and unloading NC (numerically controlled) machines.
f) Space and undersea exploration.
g) Handling hazardous materials
h) Handling arm research

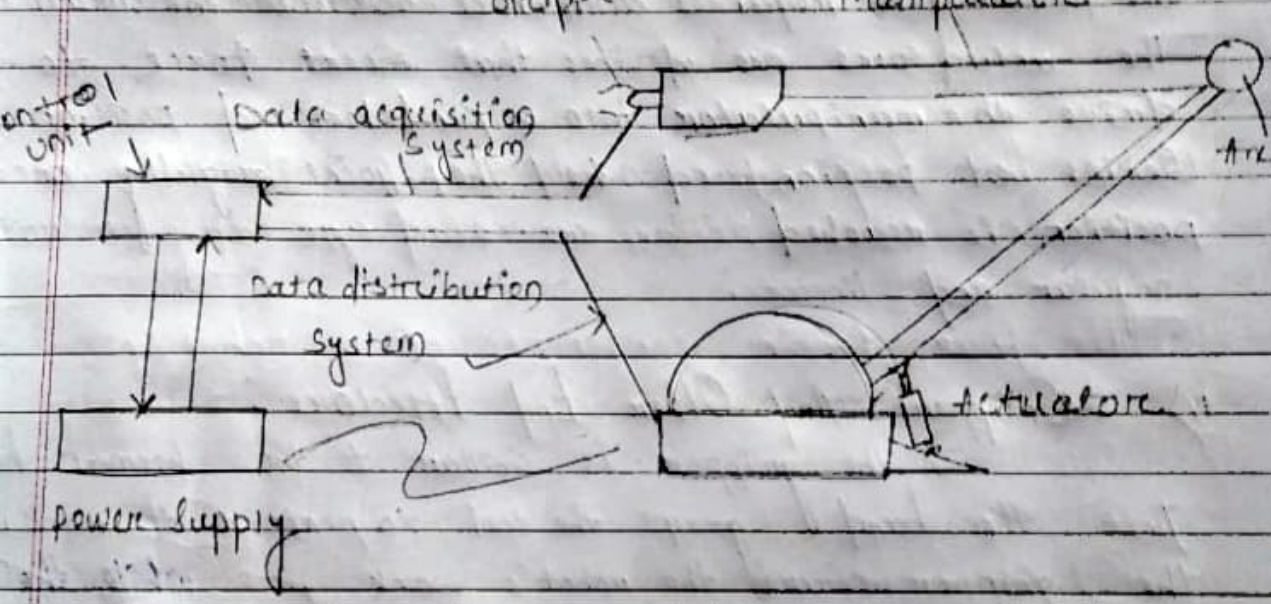
* The following characteristics should be considered while selecting a robot:
  i) Degrees of freedom
  ii) Size of class
  iii) Velocity
  iv) Drive type
  v) Control mode
  vi) Repeatability
  vii) Lift capacity
  viii) Right - left traverse
  ix) Up - down traverse
  x) In out traverse
  xi) Yaw
  xii) Pitch
  xiii) Roll
  xiv) weight of the robot.

Explain robot anatomy and configuration.

Anatomy of a robot :

The anatomy of an industrial robot deals with the assembling of other components of robot such as wrist, arm and body.

Many similarities exist b/t a robotic system and a human manipulator system. Both systems have advantages and disadvantages. In order to understand the robotic system, it is helpful to compare it to the human system, as illustrated in figure below.



Human and Robotic Manipulator Systems :-

i) Manipulator :- Robot arms must move tools through various motions so that they may perform the operations that are required of them. Because the tools may be heavy, some sort of rigid structure must provide support while the tools are being manipulated.

ii) Axes (Joints) Or Degrees Of Freedom).

while the manipulator provides the support needed, there must be flexible joints in the system to follow for movement in different direction. The axes are flexible joints in the system to allow for movement in different directions. The axes are flexible pivots in the mechanical skeleton that allow the bending of the structure at that point.

iii) Actuators:

Just as the human body requires muscles the robot arm requires actuators to move the manipulator. The actuators are devices that exert force to drive the manipulator into a predetermined position or series of position and hold the joint rigidly once the position is reached. There are two type of actuators angular and linear.

iv) Grippers And Other End Effectors:-

The gripper is similar to the human hand. Just the hand grasps the tool to perform the work, the gripper secures the robot's work piece while the operation is being performed. The shape of the gripper is determined by the task it has to perform. These include tools designed to weld, paints, or perform machining operations such as milling and grinding.

v) Control Unit :-

The control unit is much like the human brain which co-ordinates the motors of the body. It keeps track of time, the position of the joints and the movements of the manipulator. It does this in accordance with a list of stored instructions. The instructions are stored in a part of the control unit called the memory. The control unit can be either mechanical (cam logic), pneumatic (pneumatic logic), or electrical (micro-computer).

Unlike the human brain, the control unit is incapable of the creative thinking required for adaptive behaviour.

vi) Power Supplies :-

Just as the human digestive system converts food into usable energy the robot power supply provides the actuators and the control unit with the energy that they need to function. The energy must be in a form that the robot system can use.

vii) Data Distribution Systems :-

In the human body, the motor neurons receive messges from the brain and pass those messages on to the muscles. In the same way the data distribution system receive messages from the control unit and passes them on to the actuators.

viii) Data Acquisition System:

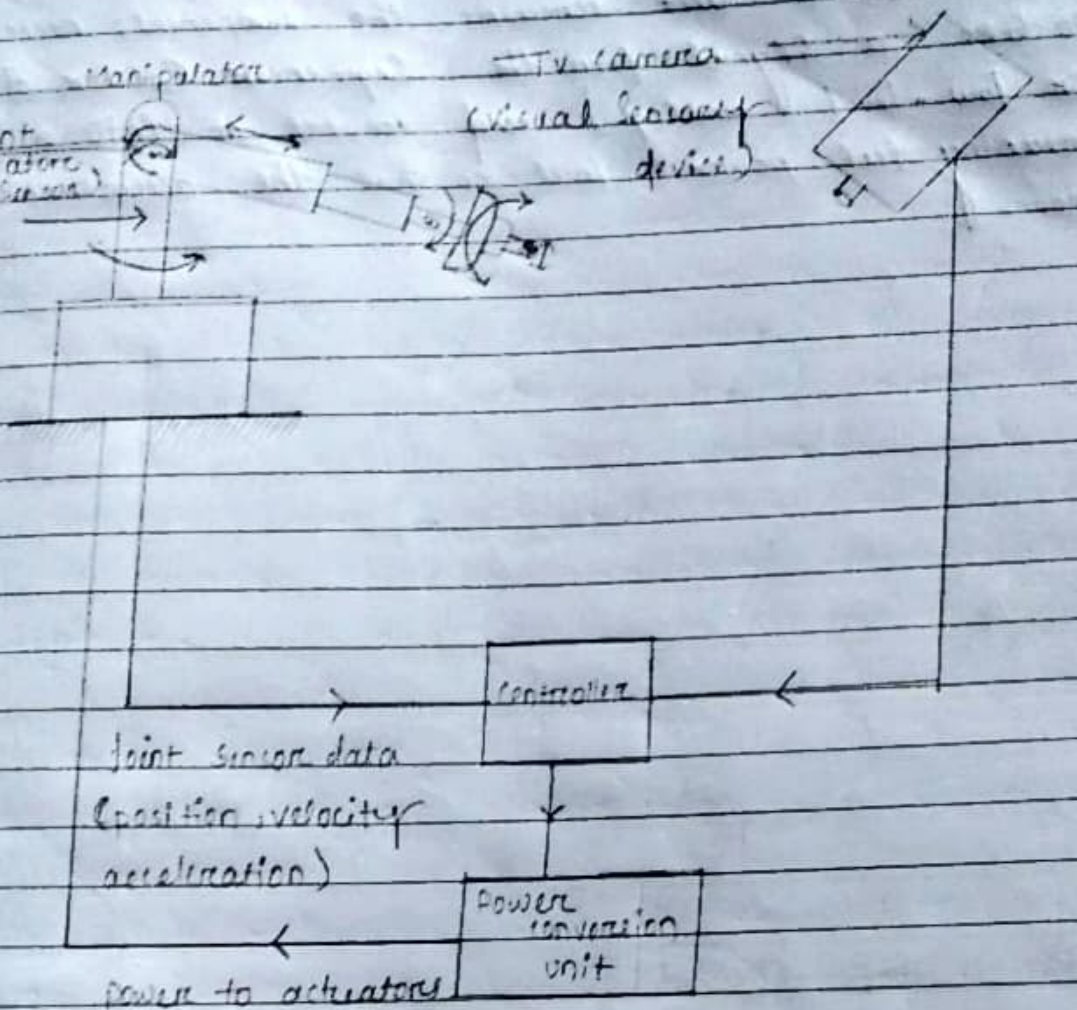
Sensory neurons in the human body receive messages from the environment and pass these messages to the brain. Human Sensory neurons respond to touch stimuli, such as contact with objects or changes in temperature. After receiving these messages, the brain can make judgements about the environment. For instance if a human being has walked into reach of the robot manipulator, then the robot must be able to sense his presence and cease functioning so as not to hurt the individual.

With the help of a neat sketch show the basic components of a robot connected as a System.

The four basic components of a robot system these are:

1. Manipulator
2. Sensory devices
3. Controller
4. Power conversion unit

It may be noted that the sensory devices are spread throughout the system. For example, in addition the the TV Camera (a visual sensor each point contains sensors for position, velocity, and/or acceleration.



(Components of a robot System)

- The manipulator is composed of the following three divisions: (i) The major linkages (ii) The minor linkages (wrist components) (iii) The end-effector (gripper or tool).

- Sensory devices may monitor position, speed, acceleration or torque.

- Controller provides the 'intelligence' to cause the manipulator perform in the manner described by its trained users.

— Power conversion unit contains the components necessary to take a signal from the Sequencer (either digital or low-level analog) and convert it into a meaningful power level so that the actuators can move.