First Semester B.E./B.Tech. Degree Examination, Feb./Mar. 2022
Elements of Mechanical Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. *Answer any FIVE full questions, choosing ONE full question from each module.*
2. *Use of Steam tables is permitted.*

Module-1

1 a. Explain the role of Mechanical Engineering in Industries and Society. (06 Marks)
b. Explain formation of steam at constant pressure with T – h diagram. (06 Marks)
c. Calculate the specific volume and enthalpy of 5kg of steam at 1.2 MPa
i) When the steam is 12% wet ii) When the steam is superheated at 360°C. (08 Marks)

OR

2 a. Determine the density of 1 kg of steam initially at a pressure of 10 bar absolute, having a dryness fraction of 0.78. If 500 kg of heat is added at constant pressure, determine the condition and internal energy for the final state of steam. Given specific heat of superheated steam = 2.1kJ/kg. K. (10 Marks)
b. Explain with neat sketch, construction and working of a nuclear power plant. (10 Marks)

Module-2

3 a. Write short note on Smart material and shape memory alloys. (08 Marks)
b. Give comparison of welding , soldering and brazing. (08 Marks)
c. Give brief classification of Metals. (04 Marks)

OR

4 a. Explain briefly fibre reinforced and metal matrix composites. (08 Marks)
b. Give a brief introduction of TIG and MIG welding. (08 Marks)
c. Brief heat transfer in automobile radiators. (04 Marks)

Module-3

5 a. Explain the working of two stroke petrol engine with neat sketch. (08 Marks)
b. Define the following with respect to refrigeration and air conditioning :
i) COP ii) Ton of refrigeration iii) Refrigeration iv) Refrigeration effect. (08 Marks)
c. List out components of Electrical and Hybrid vehicles. (04 Marks)

OR

6 a. What is a Refrigerant? What are its characteristics? (08 Marks)
b. Briefly explain applications of IC engines in Power generation. (08 Marks)
c. Mention advantages and disadvantages of EVs and hybrid vehicles. (04 Marks)

Module-4

7 a. A simple gear train consists of 3 gears. The number of teeth on the driving gear is 60, on the roller gear is 40 and on the driven gear is 80. If the driving gear rotates at 1200 rpm, find speed of driven gear and also the velocity ratio. Sketch the arrangement of gear drive. (04 Marks)

b. Explain different types of belt drives with their applications. (08 Marks)
c. Briefly explain Robot Anatomy with neat figure. (08 Marks)

OR

8 a. It is required to transmit a power of 20kW between 2 parallel shafts by means of belt drive arrangement. The speeds of driving and driven shafts are 150 rpm and 250 rpm respectively. Distance between parallel shafts is 2.7m. Driven pully diameter is 60cm. Coefficient of friction between belt and pulley is 0.25. Determine the tensions and length of the belt for cross drive arrangement. (08 Marks)
b. Classify Robot configurations. Explain any two with neat sketch. (08 Marks)
c. Define Machines and Mechanisms. (04 Marks)

Module-5

9 a. Explain the construction and working of milling machine and applications. (08 Marks)
b. Explain Lathe Operations - Turning , Knurling , Boring , Taper turning. (08 Marks)
c. What are the components of CNC? (04 Marks)

OR

10 a. Explain Construction and working of lath. (08 Marks)
b. Explain the concepts of smart manufacturing and industrial IOT. (08 Marks)
c. Give a brief introduction of modern machining tools and techniques. (04 Marks)

Q1a. Role of Mechanical Engineering in industry & Society

Role of Mechanical Engineering in Society:

Mechanical Engineering is associated with design, development, construction ~~and~~ (manufacturing) and maintenance of all physical devices and systems. This will be pertaining to various sectors like:

- Transport [automobiles, railways, aerospace, marine, off-highway vehicles]
- Energy [Energy production & distribution]
- Agriculture [agriculture equipment, farm machinery]
- Others - machinery, equipment, healthcare, textile, arms & ammunition etc.

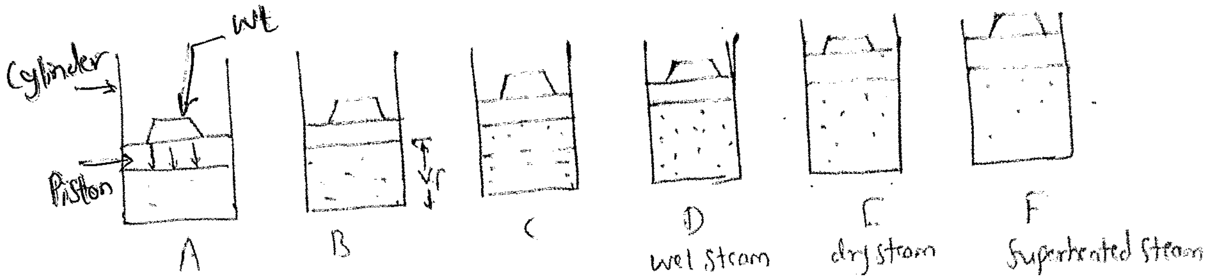
P.T.O.

Role of Mechanical Engineering in industries:

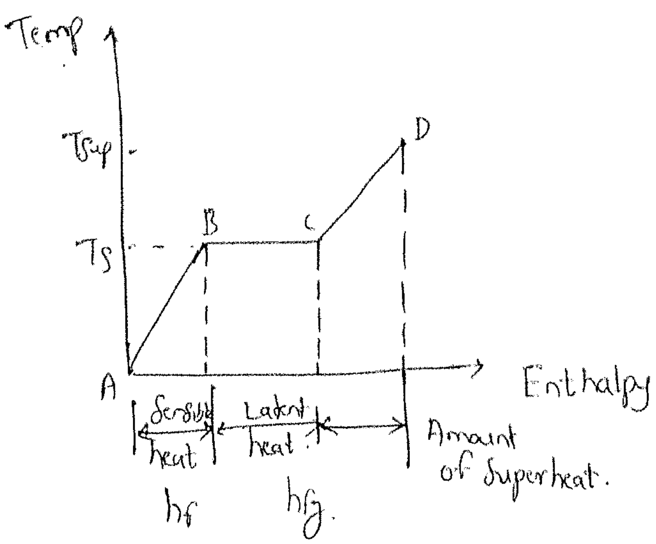
Mechanical Engineering has multifold responsibilities in the industry. Some of which can be listed as below:

- Design and development of products/machinery/equipment
- Selection of proper material and heat treatment processes
- Design and development of manufacturing process and equipment/tools associated with it
- Preparation of plant layout
- Production planning and control
- Continuous production and quality control
- Plant maintenance
- Automation, robotics, new technology development
- field service, purchase, marketing and others.

Q1.b. Formation of Steam: @ constant pressure



- 1kg water is taken at 0°C in a cylinder & piston arrangement (A)
- Some appropriate wt is placed on the piston to apply constant pressure 'p' on the water.
- Water is heated at constant pressure, its temp rises till the boiling point is reached.
- When H_2O is heated, it expands and there will be slight increase in the vol of water (@ boiling point) (fig b).
- This is saturation temp. It is defined as the temperature at which the water begins to boil at stated pressure. This is represented by point B



The amount of heat required to raise the temp of 1kg of H_2O from 0°c, to the saturation temp T_s°c. at a given constant pressure is defined as the sensible heat. (h_f).

- Further heating initiates evaporation of H_2O, while the temp remains constant. Till all the H_2O is converted into vapour - there will be no raise in temp. All the heat is used to evaporate (change of phase). This is represented by line BC on the graph.

C - indicates completion of steam formation.

The amount of heat required to evaporate 1kg of H_2O @ saturation temp into steam (dry) of 1kg at the same saturation temp @ constant pressure is called latent heat of evaporation (h_{fg}).

EME

Problems solved from previous question paper – Feb/March 2022.

Q1. c. Calculate the specific volume and enthalpy of 5 kg of steam at 1.2 MPa.

i) when the steam is 12% wet

ii) when the steam is superheated at 360°C

Soln: 1.2 MPa = 12 bar.

From steam table @ 12 bar pressure,

Saturation temp $T_S = 188°C$.

Specific volume of dry steam, $V_g = 0.16321$

" " " saturated H_2O, $V_f = 0.001139$

" " " wet steam, $V = x V_g + (1-x) V_f$

wet = 0.12 (12%) ∴ x (dryness fraction = 1 − 0.12 = 0.88

→ $V = 0.88(0.16321) + (1-0.88)\,0.001139$

1 kg: $= 0.1436 \quad + 0.0001$ ← (Note: 2nd term can be neglected often a very small value)

$= 0.1437\ m^3/kg$ //

Enthalpy of steam:

$h_f = 798.4\ kJ/kg \quad h_{fg} = 1984.3\ kJ/kg$.

1 kg: $h = h_f + x\,h_{fg}$

$= 798.4 + (0.88)(1984.3)$

$= 2544.584\ kJ/kg$ //

for 5 kg, $V = 0.1437 \times 5 = 0.7185\ m^3/kg$.

$h = 2544.584 \times 5 = 12722.92\ kJ/kg$.

ii) When the steam is superheated @ 360°C (from steam table)

Pressure = 12 bar , $T_s = 188°C$

$V_f = 0.001139$, $V_g = 0.16321$

$h_f = 798.4$ $h_{fg} = 1984.3$ $h_g = 2782.7$

$$\frac{V_{sup}}{T_{sup}} = \frac{V_g}{T_s}$$

$$\therefore V_{sup} = \frac{V_g}{T_s} \times T_{sup}$$

$$= \frac{0.16321 \times (360+273.15)}{(187+273.15)}$$

$$= \frac{0.16321 \times 633.15}{461.15} = 0.224 \ m^3/kg$$

for 5 kg = 5 × 0.224 = 1.12 m^3/kg.

$h_{sup} = h_f + h_{fg} + C_p(T_{sup} - T_s)$ Assuming $C_p = 2.25 \ kJ/kg°K$

$= 798.4 + 1984.3 + 2.25(360-188)$.

$= 3169.7 \ kJ/kg$

for 5 kg, = 14300.5 kJ/kg.

2a. Determine the density of 1 kg of steam initially at a pressure of 10 bar absolute, having a dryness fraction of 0.78. If 500 kg of heat is added at constant pressure, determine the condition and internal energy for the final state of steam. Given specific heat of superheated steam = 2.1 kJ/kgK.

<u>Soln</u>:

$P = 10$ bar, saturation temp $= 179.9°C$

$V_f = 0.001127$ $\quad V_g = 0.19430$

$X = 0.78$

Specific volume, $V = X V_g + (1-X) V_f$

$= 0.78(0.19430) + (1-0.78).\,0.001127$

$= 0.1516 \; m^3/kg.$

density $= \rho = \dfrac{\text{mass}}{\text{volume}}$ $\quad$ mass $= 1$ kg (given).

$\therefore \; \rho = \dfrac{1}{0.1516} = 6.59 \; kg/m^3$

@ 10 bar, $\quad h_f = 762.6 \quad h_{fg} = 2013.6 \quad h_g = 2776.2$

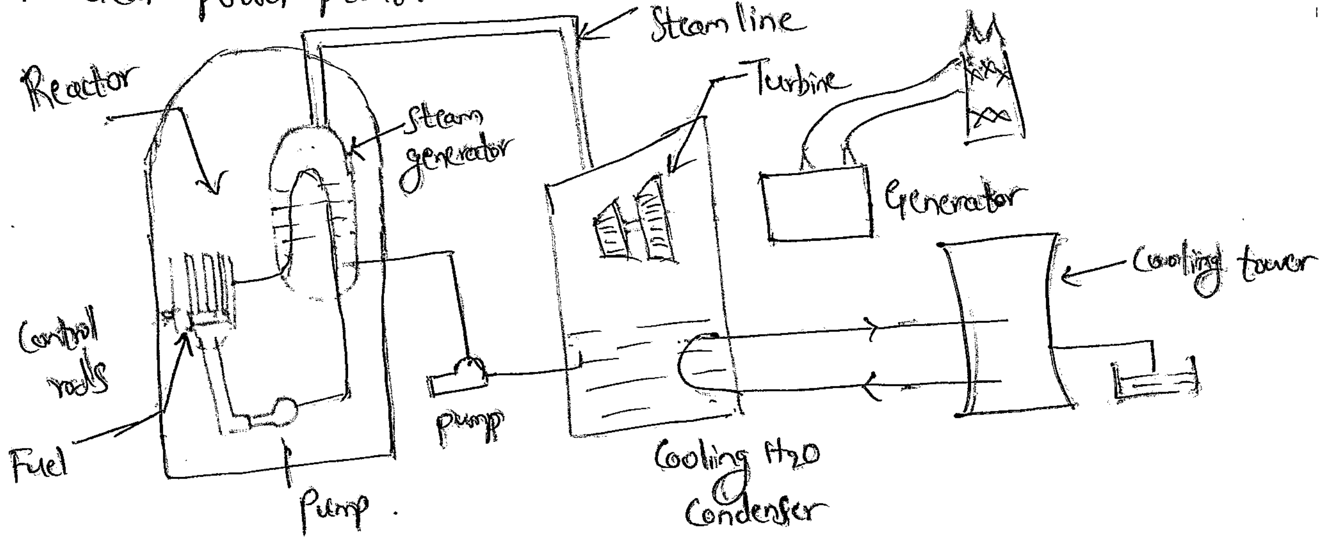
enthalpy $h = \underbrace{h_f + x\,h_{fg}}_{\text{initial condition of steam}} + \underbrace{500}_{\text{extra heat added}}$

$= 762.6 + 0.78(2013.6) + 500$

$= 2833.208 \; kJ/kg.$

enthalpy (h) $2833.208 > h_g\,(2776.2)$ $\quad \therefore$ Steam is superheated in its final condition.

Q2.b. Nuclear power plant:



Nuclear power plant consists of nuclear reactor (nuclear reaction is initiated, controlled & sustained), a steam generator, cooling water condenser, cooling tower, turbine and a generator.

- Reactor & generator are contained in a steel & concrete structure to avoid the escape of harmful radiations.
- Nuclear fuel is uranium/plutonium.
- Fission reaction is initiated by bombardment of neutrons.
- This further produces neutrons & chain reaction is initiated.
- Rate of reaction is controlled by control rods.
- Heat generated is taken away by circulation of coolant.

- The steam produced is used to run the turbine which is coupled with generator, which generates electricity.

Q3a. Smart materials:

These are the materials which have the ability to sense external environmental stimuli (temperature, stress, light, humidity and electric and magnetic fields) and respond to them by changing their properties (mechanical, electrical or appearance) structure or functions. Such materials are called as smart materials.

Smart materials or the systems that use them consist of sensors and actuators. The sensor detects the change in the environment and the actuator performs the specific function.

Smart materials

- Shape memory alloys
- Piezoelectric ceramics.

Shape memory alloys: These are metal alloys that once strained revert back to their original shape upon an increase in temperature above a critical transformation temperature. This is because of change in crystal structure above the certain temperature.

ex: Usage of stent (for biomedical application) for expanding narrowed arteries. The deformed stent is first delivered to the appropriate position and then it expands to original shape because of body temperature.

ex: NiTi alloys.

Piezo electric materials: These materials produce an electric field when exposed to a mechanical force conversely, a change in an external electric field will produce a mechanical response in the same material. Such materials are used to detect undesirable vibrations in the machines and critical products.

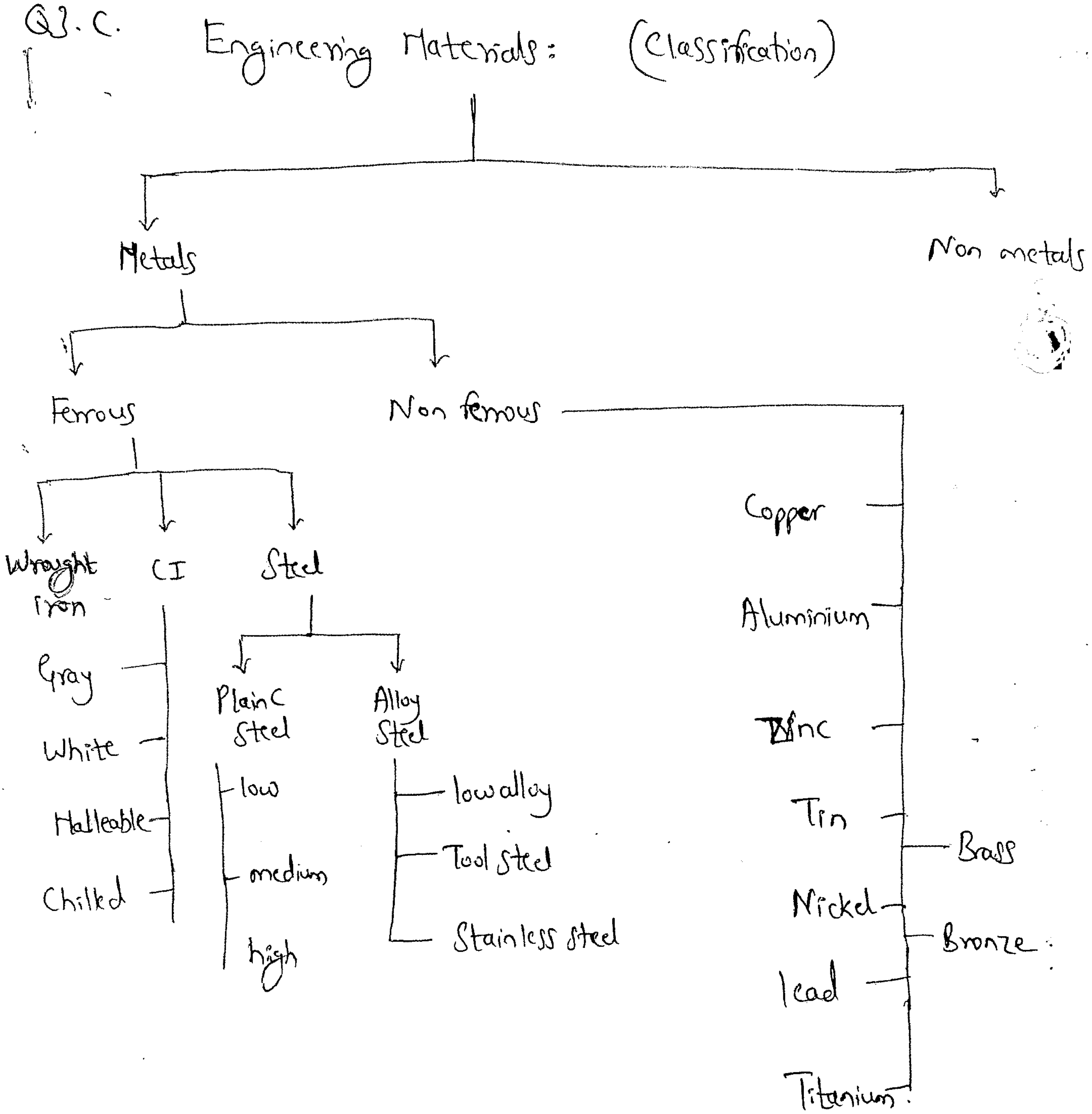
Ex: quartz, berlinite, topaz

Q3b.

Comparison b/w Soldering, brazing & welding.

	Soldering	Brazing	Welding
1.	definition	defn	defn
2.	Base metals donot melt (filler metal melts)	Base metals donot melt (filler metal melts).	Base metals melt along with filler metal & fuse together.
3.	Joint strength is comparatively less.	Joint strength is in between soldering & welding.	Joint strength is highest.
4.	~~Melting~~ Working temp is below 500°C.	Working temp is above 500°C but below ~~800~~ 900°C	Working temp is above 2500°C.
5.	Filler metal – alloy of lead & tin.	Cu base alloys, Silver base alloys, Al base alloys.	Filler metal will have almost same composition as base metal.
6.	No distortion of workpieces, no residual stresses.	Very less distortion & residual stresses.	Distortion & residual stresses are higher (∵ of high temp)
7.	Skill required for operation — Minimum	Medium level of skill	High skill
8.	Suitable for joining thin metals.	Thick metals	Thick metals

Q3. C.



Engineering Materials: (Classification)
Metals
Non metals
Ferrous
Non ferrous
Wrought Iron
CI
Steel
Gray
White
Malleable
Chilled
Plain C Steel
Alloy Steel
low
medium
high
low alloy
Tool steel
Stainless steel
Copper
Aluminium
Zinc
Tin
Nickel
lead
Titanium
Brass
Bronze

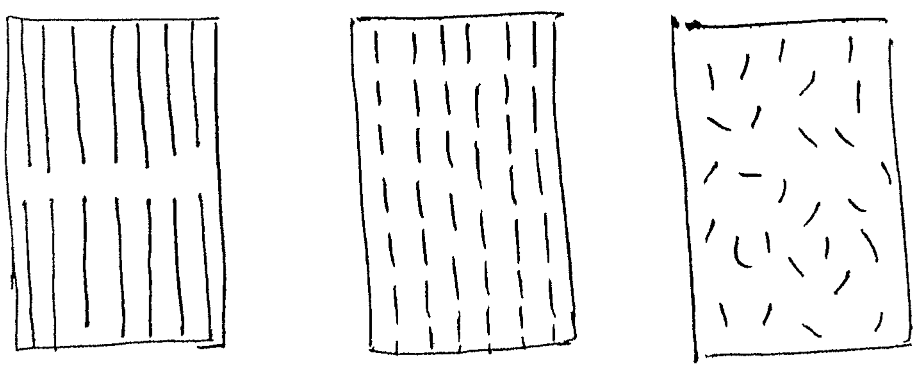
Q4a. Fiber reinforced Composites:

These composites are technologically the most important composites (dispersed phase is in the form of fiber). The most important aspect while designing such composites is high strength and/or stiffness on a weight basis. These characteristics are expressed in terms of specific strength and specific modulus parameters.

$$\text{Specific strength} = \frac{\text{tensile strength}}{\text{specific gravity}}$$

$$\text{Specific modulus} = \frac{\text{modulus of elasticity}}{\text{Specific gravity}}$$

Fiber orientation & concentration:



(a) Continuous & aligned (b) discontinuous & aligned (c) discontinuous & radomly oriented.

These are used extensively in automotives and aerospace.

Metal Matrix Composites (MMC)

These are the composites which employ metals (with ductility) as ~~matrix~~ matrix material & reinforcement can be ceramic or any fiber.

The superalloys as well as alloys of Al, Mg, Ti & Cu are employed as matrix materials. The reinforcement may be in the form of particulates, both continuous & discontinuous fibers & whiskers.

Concentration : 10 to 60% vol.

Continuous fiber materials : C, SiC, B, Al_2O_3

Discontinuous " " : SiC whiskers, powder of Al_2O_3

Advantages : - Utilisation @ high service temp than their base metal
- improvement in specific stiffness, specific strength, abrasion resistance, creep resistance, dimensional stability, non flammability.

Processing of MMC:

i) Consolidation / synthesis - introduction of reinforcement into matrix

ii) Shaping / forming operation.

Applications:

Automobile: Some engine components are made up of Al alloy matrix reinforced with Al_2O_3 & C fibers.

- drive shafts
- suspension & transmission components.

Aerospace: Al alloy composite with boron fiber are used in space shuttle orbitter, hubble telescope.

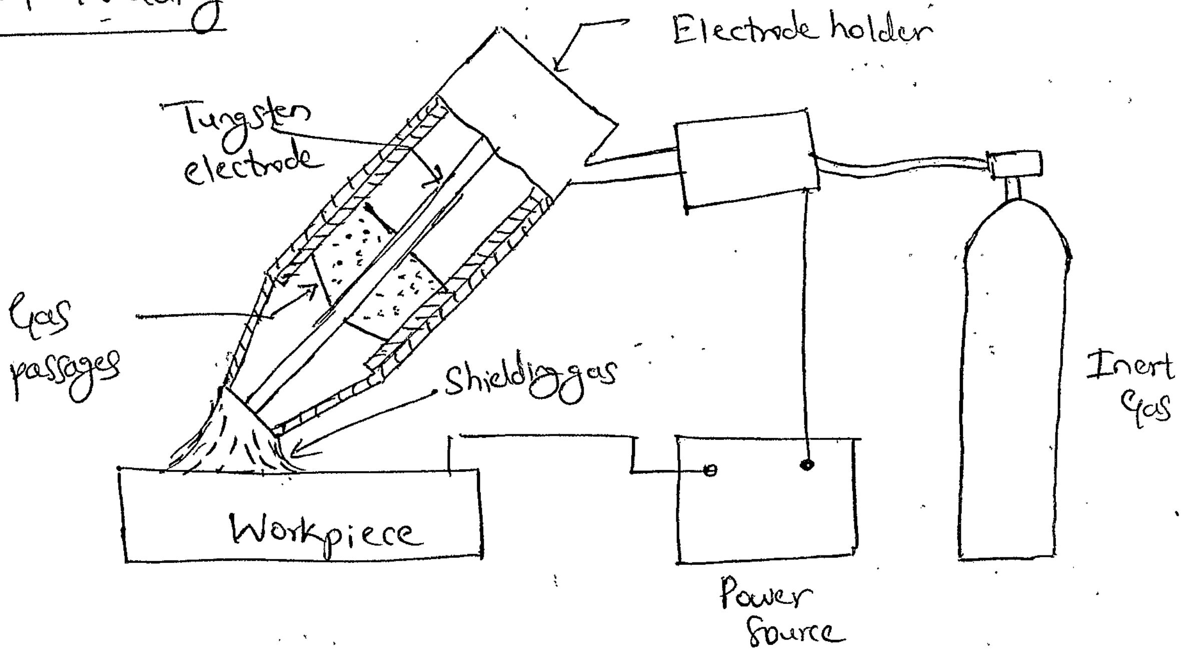
Q4.c. Radiators are the heat exchangers used to transfer heat or carry away heat from automobile engines. Heat transfer from radiator occurs by thermal radiation and convection into flowing air or liquid and by conduction into the air or liquid.

Radiator consists of several tubes as coolant passes through the radiator tubes, it transfers its heat to the tubes which inturn transfer the heat to fins that are lodged between each row of tubes. The fins then release the heat to the ambient air.

Q4b. <u>Introduction to TIG Welding & MIG Welding</u>

TIG Welding & MIG Welding processes are an improvement over metal arc welding where in weld environment is shielded with inert gases to exclude oxygen/other gases to obtain strong and homogeneous joint.

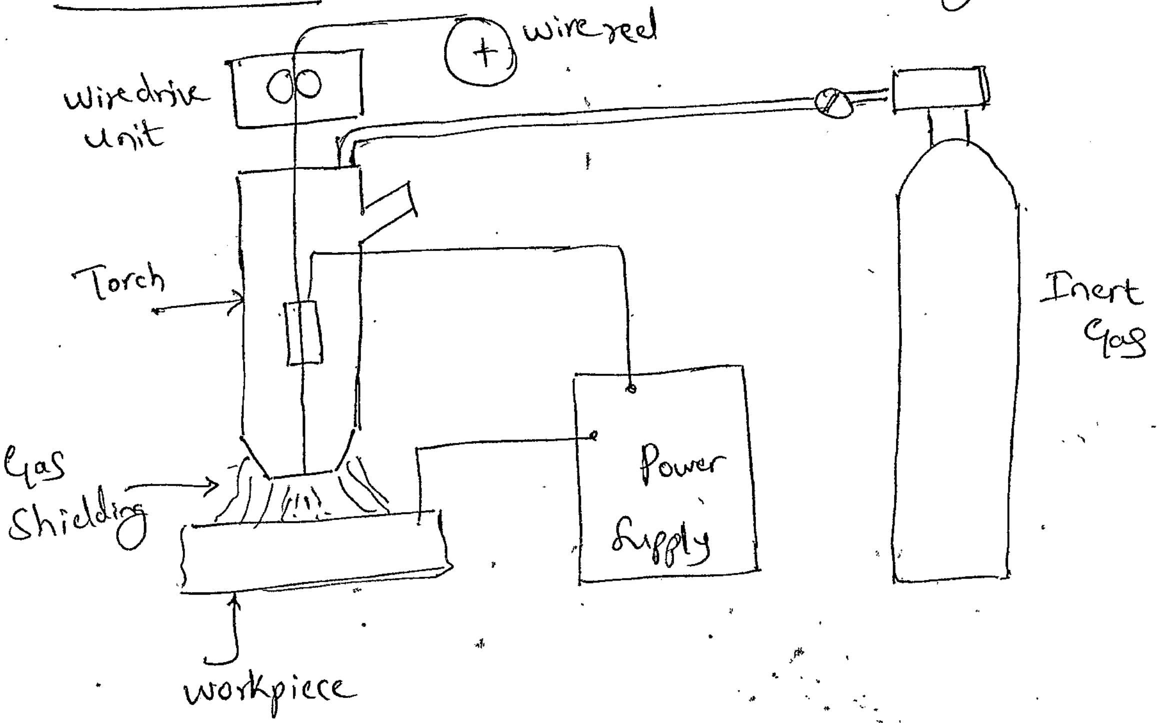
<u>TIG Welding</u>



- Tungsten inert gas welding (TIG) is an inert gas welding [inert gas used for shielding the arc] process which uses non consumable electrode.
- Electrode → Pure tungsten
  → Tungsten + thorium oxide + zirconium oxide

  Additives to electrode increase the current carrying capacity and help in maintaining stable arca.
- Setup consists of welding torch [electrode @ centre], power supply & inert gas supply
- Used for welding of Al, Mg, Stainless steel

MIG Welding: (Metal Inert Gas Welding)



- MIG welding utilises consumable electrode and hence the name metal inert gas welding.

- When thicker sheets/ workpieces are to be welded, filler metal requirement is more & MIG is preferable over TIG.

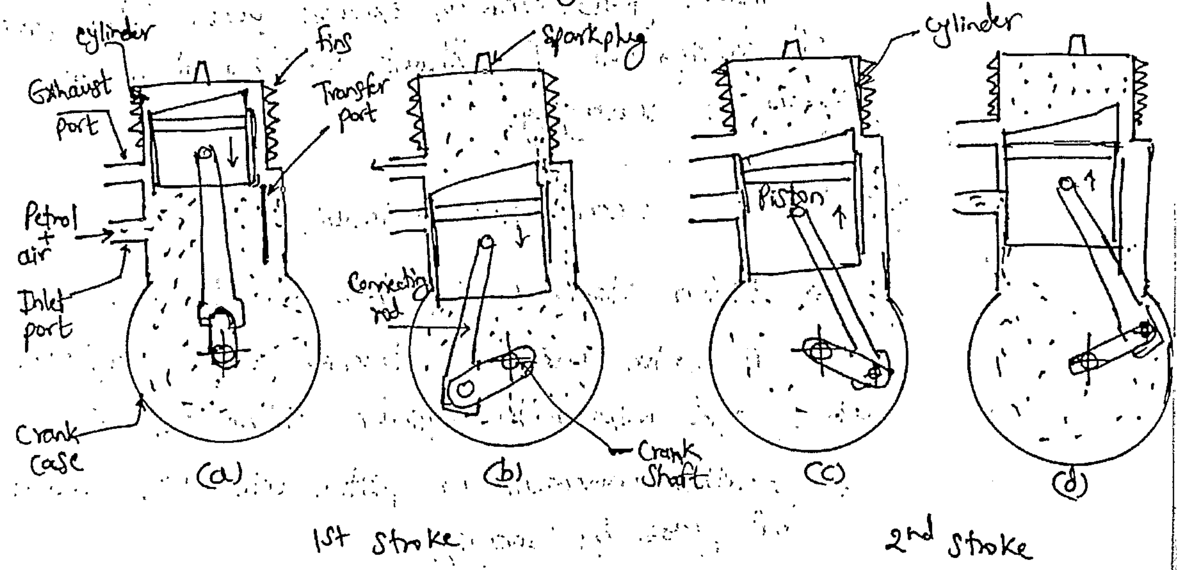
- The typical setup for MIG is as shown in the figure. Consumable electrode is in the form of reel which is fed at constant rate through the feed rollers into the torch.

- Torch receives the shielding gas through hose. The electrode & workpiece are connected to power supply.

Q5. a.

2 stroke petrol engine:

2 Stroke engine performs only 2 strokes to complete one working cycle. Here the suction & exhaust are not performed in seperate strokes, rather both take place during working & compression stroke itself. Construction of 2S engine is as shown in figure. It consists of cylinder fitted with hermetically sealed crank case. Inlet & exhaust ports are provided on the circumference of cylinder. A transfer port is provided, diametrically opposite to exhaust port - just @ little lower level. Spark plug is provided for spark initiation.



Entry of petrol & air mixture:

→ As the piston starts moving up (fig-d), partial vacuum is created in crankcase. Further movement of piston opens inlet port.

→ Air & petrol mixture is drawn inside crankcase through carburetor (because of pressure difference)

→ Suction of petrol & air mixture will continue till the inlet port is closed by piston during its next downward movement.

1st Stroke: (Power Stroke & exhaust)

→ Piston is at TDC. Air & petrol mixture is already compressed [∵ of previous stroke].

→ Spark plug creates spark & combustion takes place

→ Energy released moves the piston down.

→ As the piston uncovers exhaust port, burnt gases will start escaping through exhaust port.

→ As the piston ~~cov~~ uncovers transfer port, fresh air & fuel from crank case will flow into cylinder. Fresh air & fuel mixture will drive out the burnt exhaust gases through exhaust port. This process of driving out of exhaust gases by fresh charge is known as Scavenging.

2nd stroke: (compression & intake)

→ Piston starts moving from BDC to TDC.

→ As piston covers the transfer port, supply of air & fuel mixture to cylinder will be cut off.

→ Further movement of piston will stop exhaust of gases by scavenging.

→ Further movement of piston will compress air & fuel mixture [comp ratio = 7:1 to 12:1]

→ As inlet port is open, fresh air & fuel mixture will be drawn inside & next cycle will continue.

In each stroke crankshaft makes half revolution, totally 1 revolution

P.T.O.

Q5 b.

1. COP (Co-efficient of Performance):

The performance of refrigerating machine or heat pump is expressed by COP. The COP of a refrigerator/heat pump is the ratio of useful heat to work.

$$COP\ (\text{theoretical}) = \frac{Q}{W}$$

Q = Amount of heat extracted
W = Amount of work done

2. Ton of refrigeration: It is unit of refrigeration. It is equivalent to the production of cold at the rate at which heat is to be removed from 1 tonne of water at 0°c to freeze it to ice at 0°c in 24 hours.

1 ton of refrigeration = 3.5 KW or 200 BTU/min.

3. Refrigeration: is defined as the process of removing the heat from a system under controlled conditions and maintaining the temperature below the general temperature of its surroundings.

4. Refrigeration effect: The cooling effect brought in a system by extracting the heat continuously is called refrigeration effect. It indicates the rate @ which heat is extracted.

Q5c: Components of electric vehicle & hybrid vehicle.

Following are important components of electric vehicles:

- Traction battery pack
- Inverter
- Controller [EM controller]
- Electric traction motor
- Transmission
- Charger
- DC-DC converter
- Auxiliary battery
- etc.

Components of hybrid vehicle:

- Traction battery pack
- DC/DC converter
- DC-AC inverter
- Auxiliary battery
- Electric traction motor
- Electric generator
- Controller
- IC engine
- Fuel tank & fuel filler
- Cooling system
- Exhaust system
- Transmission system

Q6. a.

The refrigerant is a heat carrying medium which during the cycle in the refrigeration system absorb heat from a low temperature system and discard the heat so absorbed to a higher temperature system.

The suitability of a refrigerant for a certain application is determined by its physical, thermodynamic, chemical properties and by various factors.

Desirable properties of refrigerant: (Characteristics)

- Thermodynamic properties.
  - low boiling point
  - low freezing point
  - high latent heat of vaporisation
- Physical properties
  - low specific heat of liquid
  - Comparatively high specific heat in vapour
  - low specific volume of vapour.
  - High critical temperature
  - Low viscosity

Safe working properties → Non toxic
- → Non corrosive
- → Chemical stability
- → Non flammable
- → Non explosive.

Other properties → Ease of locating leaks by odour or suitable indicator.
- → Low cost
- → Should mix well with oil

Q6b. Applications of IC engines in power generation.

Internal combustion engines coupled to generators, produce electricity.

- Internal combustion engines drive large electric generators that power electrical grids. Large power plants are installed to produce electricity. IC engines can be found in the form of combustion turbines with a typical electrical o/p in the range of few hundred MW.

- Combined / hybrid power plants use the power of internal combustion engine and steam turbine to produce the electric power. These use the high temperature exhaust of IC engines to boil and superheat the water/steam to run a steam turbine.

- Small scale diesel generators are also used extensively for providing electrical back up in industries, institutions, business areas and in residential areas. These reduce the dependency on main power supply and also ensure uninterrupted power supply in many establishments.

Q6. C.

Advantages of electric vehicles:

- Control of emission / air pollution
- Reduced dependency on fossil fuels
- Lower running cost
- Simple power transmission system
- Lower maintenance [Less number of moving parts, hence reduced requirement of lubrication, overhauling and spares]
- High performance
- Lower noise levels
- Light in weight
- More scope of research and innovation
- Reduced mining [∵ of lesser demand for engine making materials]

Specific to hybrid vehicle:

- Combination of IC engine & electric motor provides advantage of high speed & torque advantage.
- Gradual transition is possible

Disadvantages of electric vehicles:

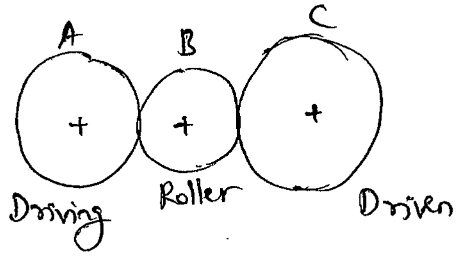
- Higher initial cost of the vehicles
- Problem with charging
  - More charging time
  - Availability of charging station for charging
  - Power required for charging (with increased number)
- Driving range after charging [How many kms/miles the vehicle can run after each charging]
- Replacement of batteries
- Safe working [vehicles are yet to be proved]
- Disposal of batteries

Specific to hybrid vehicles.

- Increased number of parts and space accommodation because both components are present.

Q7.a. A simple gear train consists of 3 gears. The number of teeth on the driving gear is 60, on the roller gear is 40 and on the driven gear is 80. If the driving gear rotates @ 1200 rpm, find the speed of driven gear and also the velocity ratio. Sketch the arrangement of gear drive.

Soln:



$T_A = 60$

$T_B = 40$

$T_C = 80$

$N_A = 1200$ rpm.

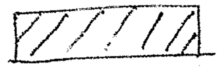
$$\frac{N_A}{N_B} = \frac{T_B}{T_A} \quad \& \quad \frac{N_A}{N_C} = \frac{T_C}{T_A}.$$

$$N_C = N_A \cdot \frac{T_A}{T_C} = 1200 \times \frac{60}{80} = 900 \text{ rpm.}$$

$\therefore$ Speed of driving gear (c) = 900 rpm //

$$\text{Velocity ratio} = \frac{N_{Driving}}{N_{Driven}} = \frac{N_A}{N_C} = \frac{1200}{900} = 4:3 \,//$$

Q7.b. Different types of belt drives:

Flat belt drives: 

- Flat belts are of rectangular cross section and are simplest among the belts used for power transmission.
- They are used over the flat pulleys, where centre distance is large.
- Flat belts are made up of fabric, leather, polyester, polyamide, etc.

Applications: Low power applications — Simple farm equipment, flour mill

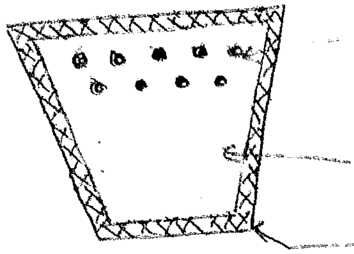
Advantages:

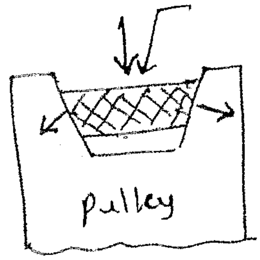
- Suitable for large centre distances
- high speed
- Economical system [pulley & belt - both are cheap]
- Small thickness of the belt causes little bending loss
- Durable.

Disadvantages:

- Not suitable for small centre distances
- Slip & creep of the belt causes loss of power
- Exact velocity ratio cannot be maintained
- Not suitable for high power transmission

V-belts:





V belts are trapezoidal in section. They are moulded as endless loops from rubber reinforced with fibrous material. They run in the V-grooves made in the pulleys. V-belts are made up of outer fabric cover, which is filled with some kind of elastomer (base rubber).

Tension chords are embedded into the rubber compound of V-belt, creating composite structure. These are power transmitting components. These are made up of polyester, steel or aramid fibers.

Advantages:

- They can transmit higher power
- can be used for small centre distances
- No slipping
- large speed ratios
- Several machines can be driven from single driving shaft.

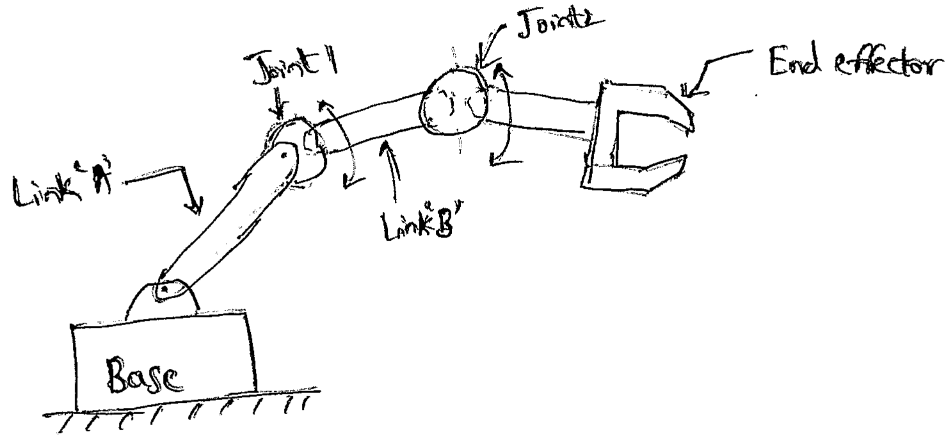
Q7c.

Robot Anatomy :

Basic parts in robot are :

- Base , body , arm and wrist (Together it is called as manipulator)

Robot is made up of joint , link and end effector



<u>Link:</u> Link is the rigid member of robot assembly. Links will be of 2 types : input link & output link

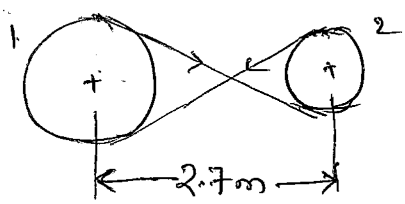
<u>Joint :</u> Joint is the member which integrates 2 links to provide relative movement between the 2 links.

<u>End effector:</u> It is the last part in robot arm which is designed to do the required function like holding or it can be a tool also.

End effector
- gripper [for holding applications]
- tool [ex: drilling, welding operation etc.]

Q8a. It is required to transmit a power of 20 kW between 2 parallel shafts by means of belt drive arrangement. The speeds of driving and driven shafts are 150 rpm and 250 rpm respectively. Distance between parallel shafts is 2.7 m. Driven pulley diameter is 60 cm. Co-efficient of friction b/w belt & pulley is 0.25. Determine the tensions and length of the belt for cross drive arrangement.

Soln:



$D_{driven} = 60\ cm = 600\ mm$

$\mu = 0.25$

$N_{Driving} = 150\ rpm$

$N_{Driven} = 250\ rpm$

$P = 20\ kW$. $X = 2.7\ m = 2700\ mm$

$$\frac{N_{Driving}}{N_{Driven}} = \frac{D_{driven}}{D_{driving}}$$

$$\frac{150}{250} = \frac{600}{D_{driving}}$$

$$D_{driving} = \frac{600 \times 250}{150} = 1000\ mm$$

$r_1 = 1000/2 = 500\ mm$ $r_2 = 600/2 = 300\ mm$.

For crossed belt drive,

$$L = \pi (r_1 + r_2) + \frac{(r_1 + r_2)^2}{X} + 2X$$

$$= \pi (500 + 300) + \frac{(500+300)^2}{2700} + 2(2700)$$

$$= 8150.307\ mm$$ //

For calculating tension,

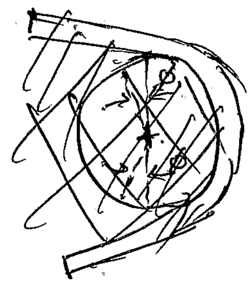
from the derivation,

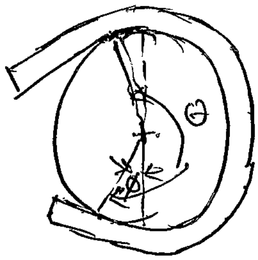
$$\phi = \sin^{-1}\left[\frac{r_1+r_2}{X}\right] = \sin^{-1}\left[\frac{500+300}{2700}\right] = ~~0.2986~~ \text{ radians}$$

$$= 16.02^\circ$$

Angle of contact:

$$\theta = 180 + 2\phi = 212.04$$
$$= 3.7 \text{ radians}.$$





$$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25\times3.7} = 2.522$$

$$\frac{T_1}{T_2} = 2.522 \qquad T_1 = 2.522\,T_2 \quad \text{—(1)}$$

πx Diameter of any 1 pulley × RPM of that pulley

Linear speed of belt

$$V = \frac{\pi D N}{1000} \text{ m/min}$$
$$= \frac{\pi\times600\times250}{1000}$$
$$= 471.238 \text{ m/min}$$

Power transmitted, $P = \frac{(T_1-T_2)V}{60\times1000}$ kW

$$20 = \frac{(T_1-T_2)\,471.238}{60\times1000}$$

$$T_1 - T_2 = 2546.48$$

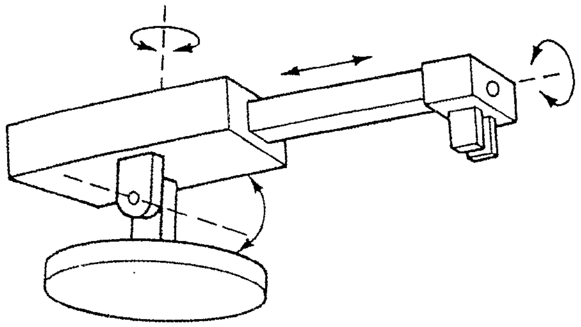
$$2.522T_2 - T_2 = 2546.48$$
$$1.522\,T_2 = 2546.48 \qquad \therefore T_2 = 1673.11 \text{ N}$$

$$T_1 = 2.522\,T_2 = 4219.59 \text{ N}$$

∴ Tensions of the belt are 1673.11 N & 4219.59 N

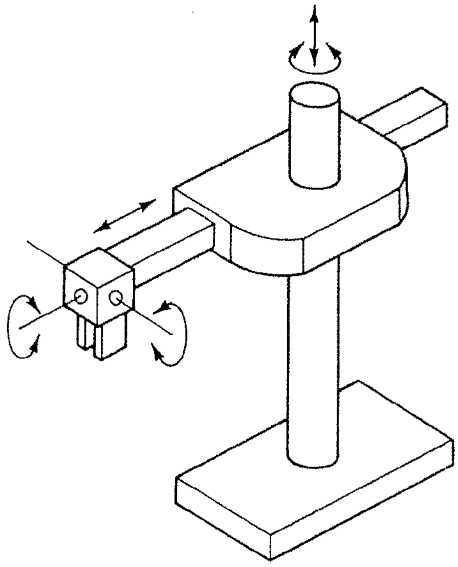
Q 8b. Classification of Robot Configurations:

1) Spherical Configuration
2) Cylindrical "
3) Cartesian "
4) Jointed arm "



(a)

Spherical Configuration



(b)

Cylindrical configuration.

1) <u>Polar configuration (Spherical) :</u>

- Work volume of this robot is near to spherical in shape
- It has one arm with linear (L) joint , one rotational (R) joint about a pivot & one twisting (T) joint.

ex: Unimate 2000 series robot

2) <u>Cylindrical configuration :</u>

- Work volume is cylindrical in shape
- It has a vertical column and a slide that can be moved up & down on the column, (Linear & twisting joints). The slide has got another linear joint for the movement of end effector.

ex: GMF robot.

Q8C. **Machines and Mechanisms**

Machine: A machine is a device that transforms energy available in one form to another to do certain type of desired useful work. The parts of the machine move relative to one another. Its links (elements) may transmit both power and motion.

Ex: Lathe, milling m/c, internal combustion engine, washing machine etc.

Classification:

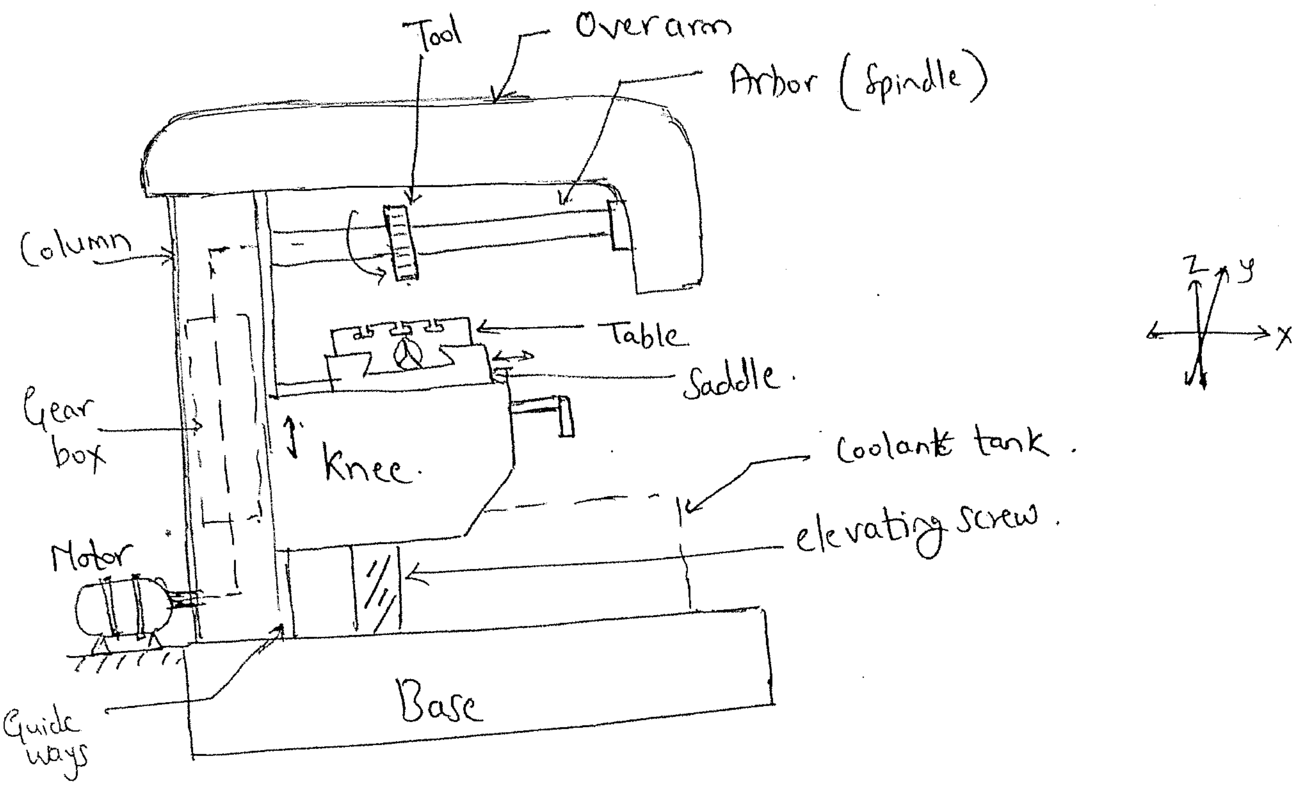
Simple machine: There is one point of application for the effort and one point for the load to be lifted.
ex: lever, screw jack etc.

Compound machine: There are more than one point of application for the effort and load. → Combination of many simple machines. ex: lathe, grinding machine etc.

Mechanism: A mechanism is a set of machine elements or parts arranged in a specific order to produce a specified motion. The machine elements (links) are considered rigid which do not deform under the action of forces. These machine elements transmit the forces with negligible deformation.

Q 9. a.

Horizontal Milling Machine.



Principal parts of horizontal milling m/c. :
(Column & Knee type)

- Base
- Column
- Overarm
- Knee
- Saddle
- Table
- elevating screw
- Motor
- Gearbox.

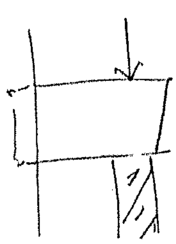
→ This machine is called so, because it consists column (where spindle is fixed) and knee which holds the work table.

→ The base supports all the other parts and may also act as reservoir for cutting fluid.

→ Knee moves up & down in the guideways provided on the column and elevating screw helps for movement. A saddle is mounted on the knee, over which work table is mounted.

→ The column houses the motor, gear arrangement required for adjustment of speeds. The spindle is mounted horizontally in the column & overarm with the help of bearings. The cutter is mounted on the spindle.

→ Although the m/c is rigid to hold the workpieces of medium to large size, extremely large components cannot be machined, ∵ of the weight limitations.

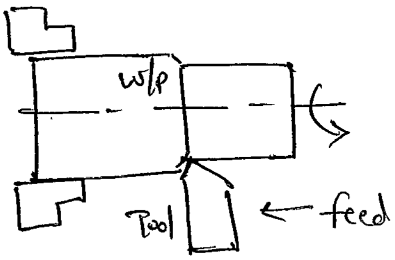


This is used for slab milling, slot milling & gear cutting operations.

Applications: Machining of flat surfaces, slots, key ways, gear machining, machining of curved profiles, other operations like drilling, tapping etc.

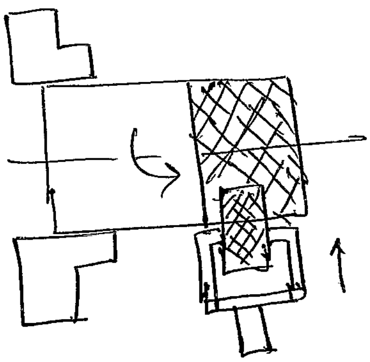
Q 9.b. **Lathe operations:**

1) **Turning:**



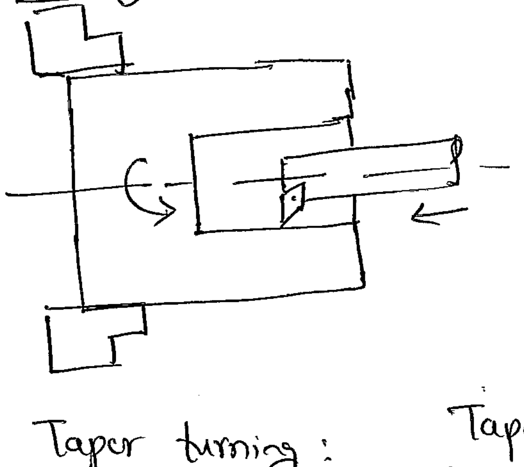
Turning is machining of cylindrical surface of a workpiece to obtain required diameter by rotating the workpiece against the cutting tool. Single point tool is moved (feed) along the axis of workpiece

2) **Knurling:**



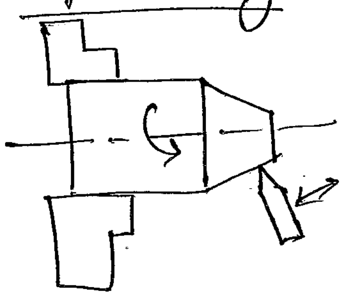
Kurling is operation of producing serrations/ intentionally hard surface on the surface of workpiece. Knurling tool (wheels with serrations) is moved ⊥r to axis of workpiece. Diamond or straight serrations can be produced

3) **Boring:**



Boring is a process of enlarging the already present hole. Earlier hole is made by drilling or may be present in the w/p. Then the boring tool (Single point) held in the tailstock is moved against the rotating w/p to enlarge the hole.

4) **Taper turning:**

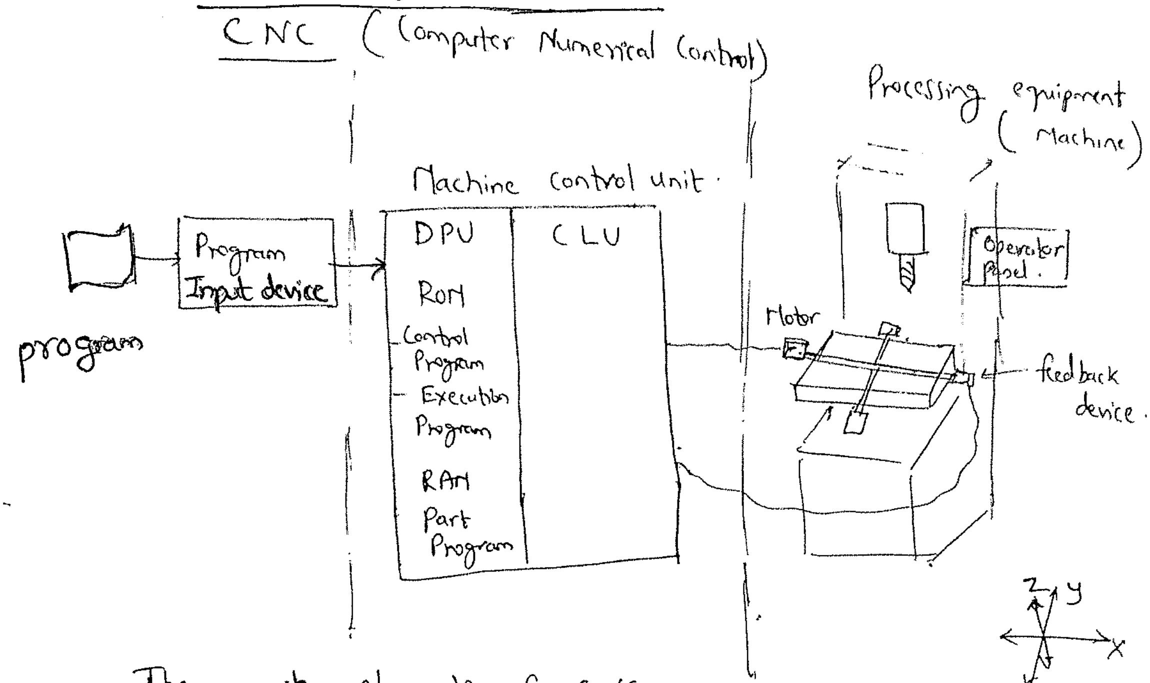


Taper turning is the operation of producing taper of required ∠le (or draft) on the workpiece. It can be done by:

1) Swivelling of compound rest [Shown in the fig. Compound rest is rotated by required ∠le & tool is given feed movement by hand wheel]
2) offset of tailstock
3) form tool method
4) taper turning attachment.

Q9. C. Components of CNC:

Block diagram of CNC:



The main elements of CNC are:

* Program & Program input device.
* Machine control unit
* Processing equipment (Machine)

CNC machine will have one dedicated computer.

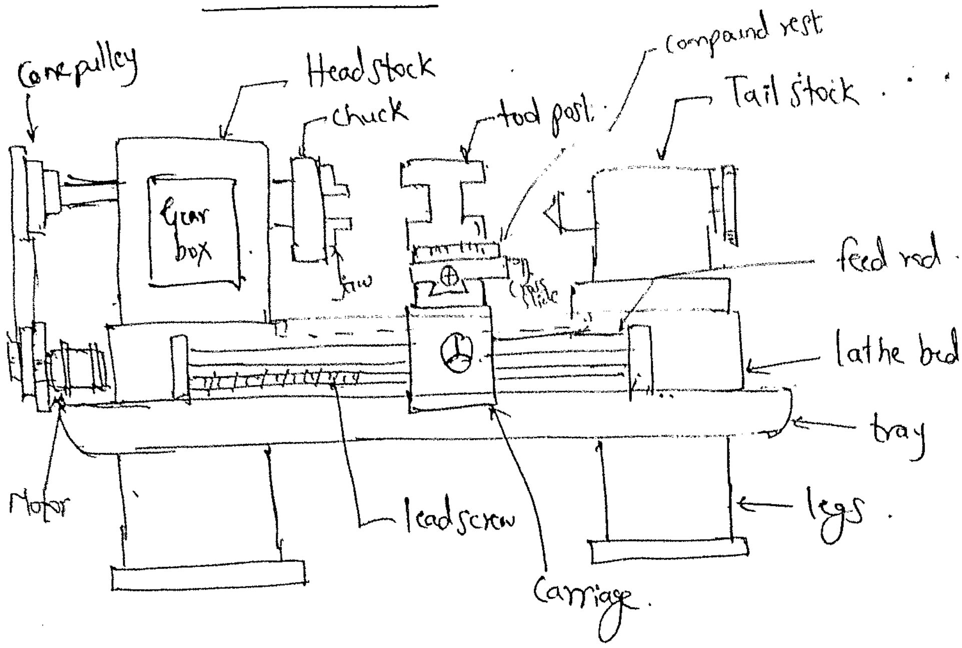
→ Step by step instructions to complete the entire operation sequence, Program is written using codes

MCU controls & co-ordinates the operations of m/c converts the codes in to mechanical actions.

→ Machine can be lathe/ milling m/c/ drill & tap machine/ press.

Q10. a. **Construction and Working of Lathe (Centre lathe):**

Centre lathe:



Head stock : Houses all the mechanisms, spindle, bearings, gear box to give drive to w/p. (fixed end)

Tail stock : It is movable end to adjust to length of w/p & for end operations.

Chuck : Work holding device (includes jaws). types - 3 jaw, 4 jaw.

Lathe bed / legs : Lathe bed supports all the parts of m/c & also includes tray for collecting chips.

tool post : tool holding device, normally square tool post is used.

Carriage : Movable mechanism for moving the tool. It moves with rack & pinion mechanism, with the rotation of hand wheel.

Feed rod / lead screw : These are the large diameter rods meant for automatic feeding. Feed rod is a plain rod, while lead screw is a threaded rod.

Q10b. **Smart Manufacturing & Industrial IoT**

Smart manufacturing, which is the fourth revolution in the manufacturing industry (part of Industry 4.0) is the collection of cutting-edge technologies [advanced technologies] that support effective and accurate engineering decision making in real time through the introduction of various technologies and the convergence with the existing manufacturing technologies. It is considered as new paradigm in manufacturing.

It improves competitiveness of manufacturing industry and helps for sustainance in the changing market.

It employs computer-integrated manufacturing, high levels of adaptability, rapid design changes, digital information technology, and more flexible technical workforce training. It is also aimed at, i) quick adoption to fast changes in production requirement ii) optimisation of supply chain iii) efficient production and iv) recyclability.

Smart manufacturing supports streamlined business operations, optimised productivity and improved return on investment.

Example: PLC (Programmable Logic control) controlled assembly machine or test rig is an example for mechatronic systems. Such machines will have basic mechanical elements like structural parts, fixtures, motors, actuators along with sensors, controller & programmer. Program will be written for definite sequence of operations for assembly of components or for testing of a product. Sensors will help in detection of presence of parts, measurement of physical parameters like pressure, temp & etc & will give feed back to controller. This improves accuracy & productivity of machines.

Other ex: NC/CNC machine, automobile systems such as airbag system, antilock braking system, airconditioning system, medical diagnostic equipment etc.

Q10.c Modern machining tools and techniques:

Modern machining tools and techniques include an improved methodology as compared to conventional methods. Here manual work content and skill dependency is reduced by automation processes. All / most of the operations like unloading of finished component, loading of raw material, speed movement, feed movement, tool change, coolant supply, chip disposal are made automatic.

New range of CNC machines equipped with state of art facilities, new generation tools (to enable high cutting parameters) are employed along with robots. Some machines are also equipped with in process measurement.

Non conventional machines and methods are also extensively employed in manufacturing. Few examples are: laser machining, electron beam machining, electrochemical machining, electric discharge machining etc.

Another remarkable advancement in the field is 3D printing or additive manufacturing, which saves lot of time and money in new product development.

(Gurunath Mewundi)

S D K
HOD
Mechanical Engineering
KLS Vishwanathrao Deshpande
Institute of Technology
Haliyal-581329