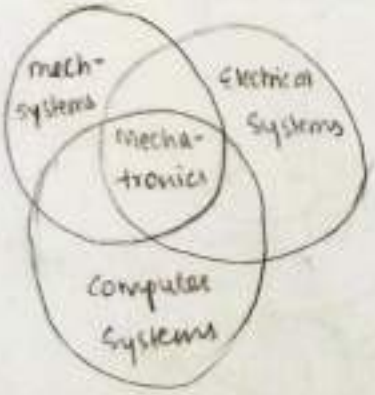
UNIT-5 : MECHATRONICS

→ Mechatronics is defined as the synergistic integration of mech. engg. with electronics & intelligent computer control in the design & manufacturing of products and process.

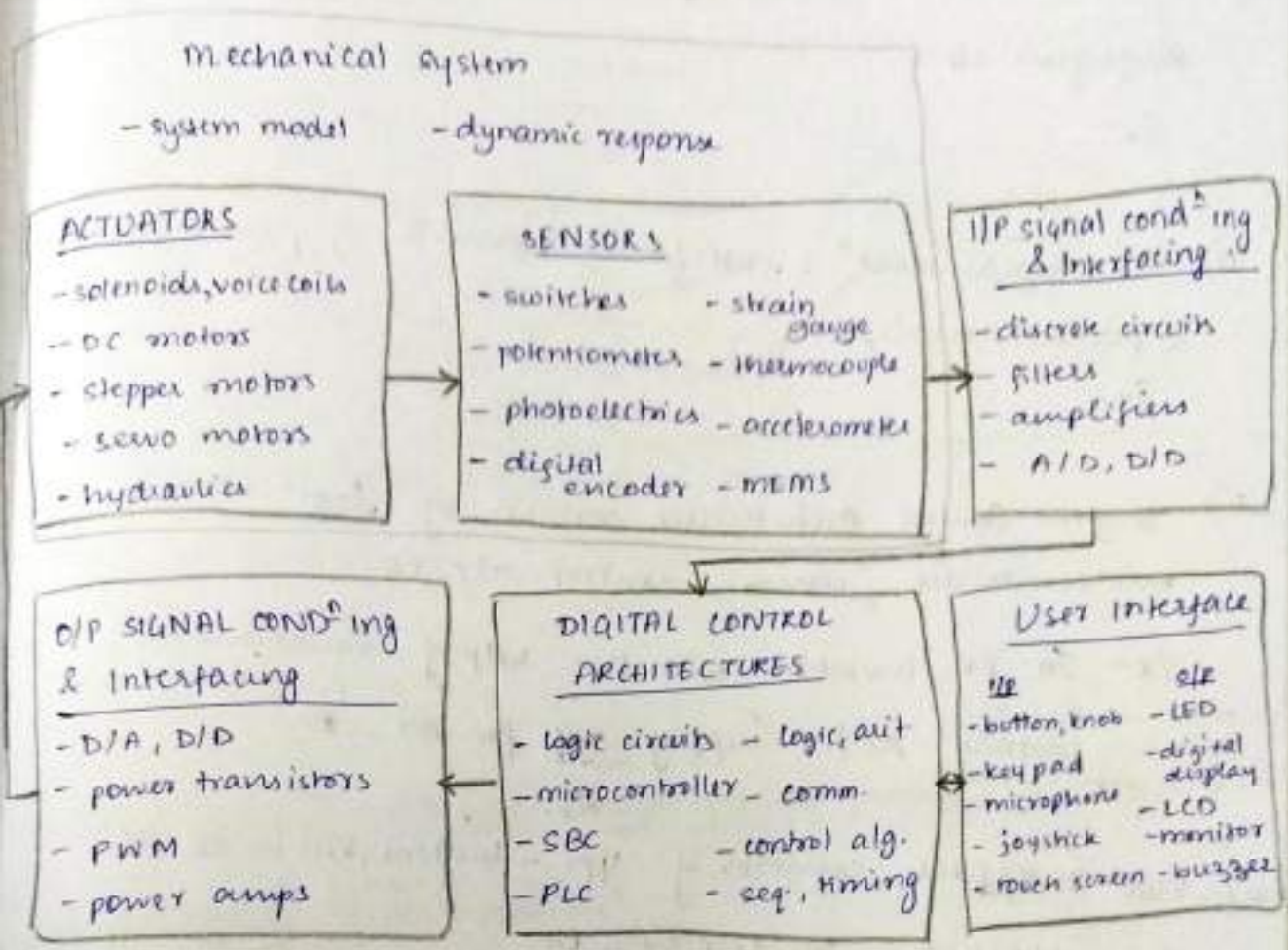
Domain of Mechatronics



Example- Taking the example of a CNC machine which consists of (continue with stuff from prev. chp)

. . . .

Key elements of Mechatronics System



The above diagram shows the key elements of mechatronic systems:

1) Actuators consists of solenoids, DC motor, etc which are used in - - -

2) sensors consist of switches, potentiometer etc.
Ex: Thermocouple is used in household refrigerator to control the temperature by switching on/off the refrigerator motor.

3) I/P signal cond^n & interfacing consisting of discrete circuits, amplifiers, etc.

Ex-

4) O/P signal cond^n & interfacing consists of power transistor & power amplifier

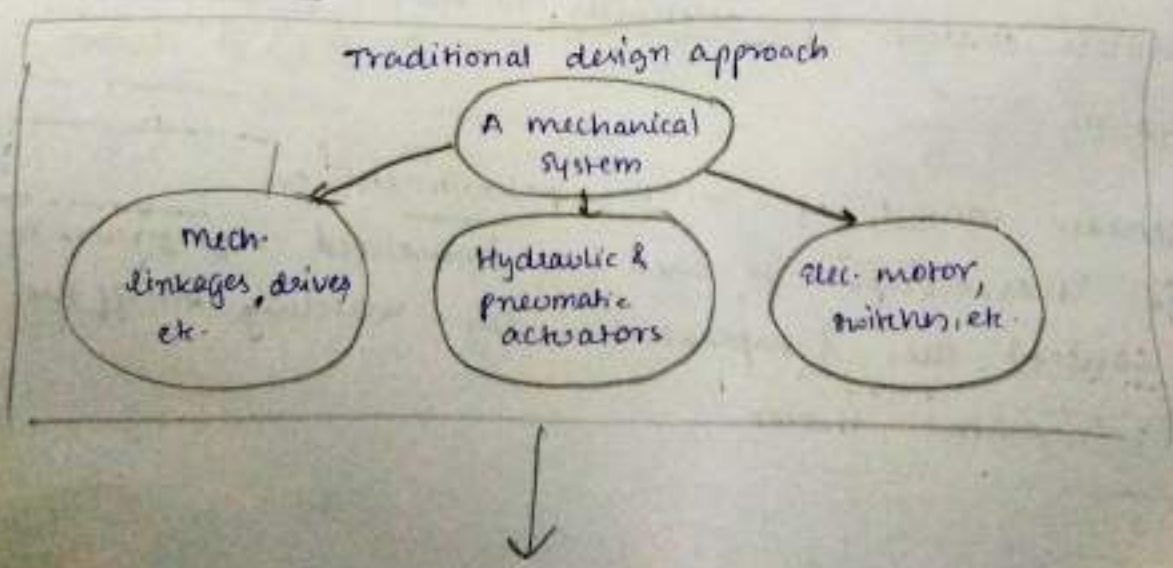
Ex-

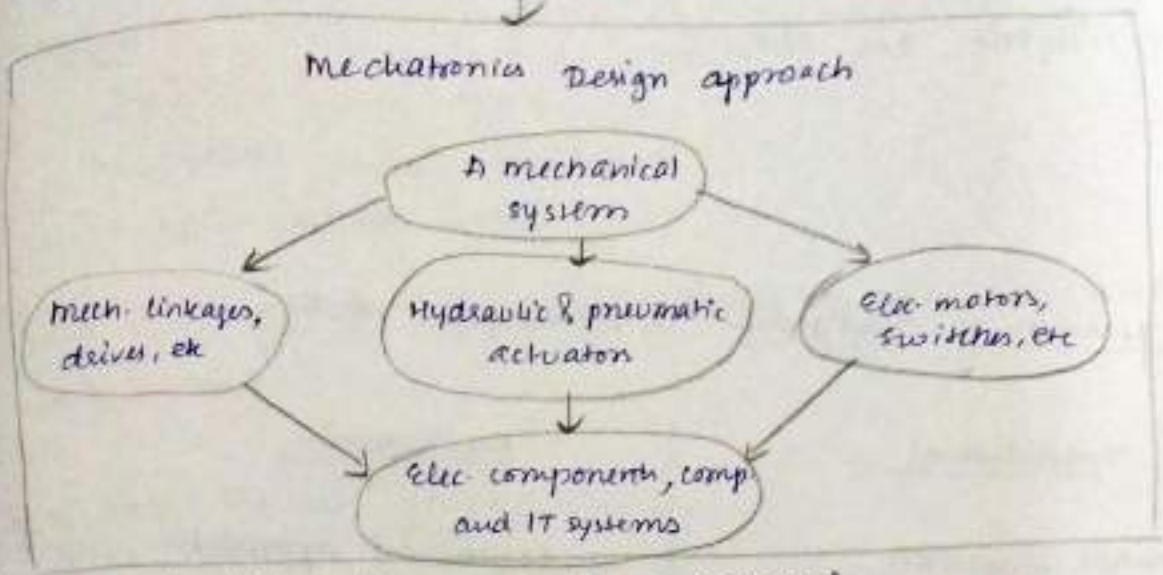
5) Digital Control Architecture consists of logic circuits, microcontroller, comm., control alg, etc.

Ex- In EV, inverter with the help of microcontroller controls AC/DC supply ~~reg. for~~ ~~EEC~~ ~~EV~~.

6) User interface consists of I/Ps - buttons, knobs, etc & O/Ps - LEDs, LCDs for display, etc.

#Mechatronics Design Process



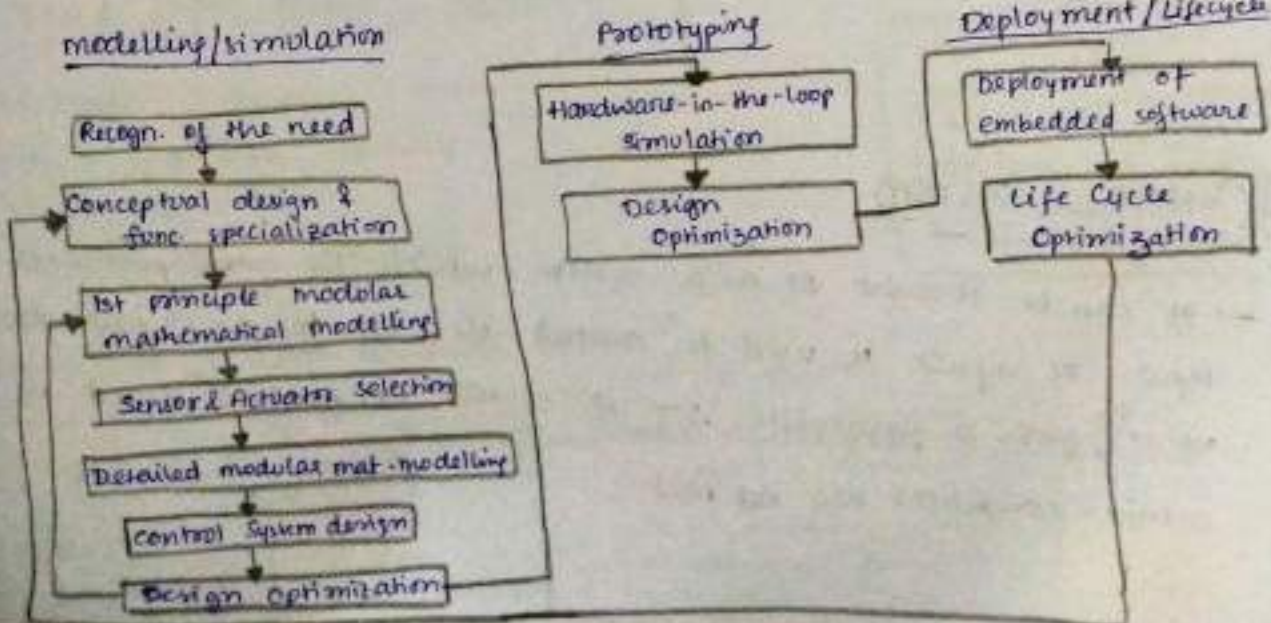


Q. With a neat diag, explain mech design process?

Taking an example of -

Phases of Mechatronics System design process

1) modelling & simulation
2) Prototyping
3) Deployment



22 Ex- Hybrid tia car

Comparision of Traditional & mechatronic Design

Traditional	Mechatronics
→ Sequential approach	→ Concurrent approach
→ Prodcn controlled by relay logic	→ microprocessor based prog. logic controller
→ more wiring to control comp. & control room	→ Reducing wiring & machine cycles stored & executed via local control loops.
→ manual handling process for loading & unloading.	→ use of general purpose robotic for handling & automatic tool changing
→ maintenance on a preventive or breakdown basis	→ Based on in-line diagnostics & cond° monitoring.

CONTROL SYSTEM

→ It can be thought of as a system which for some particular input or inputs is used to control its o/p to some particular value, give a particular seq. of events or give an event if certain conditions are met.

→ Example-

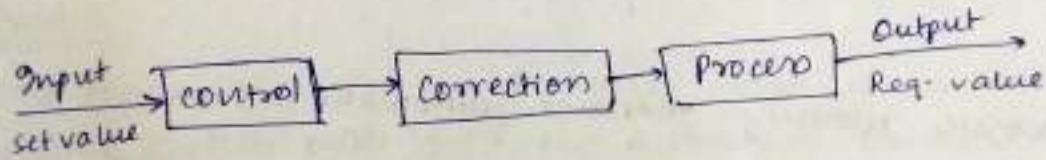
→ central heating system
→ Domestic washing machine
→ Safety locking system

→ Two basic forms of control systems are open loop and closed loop.

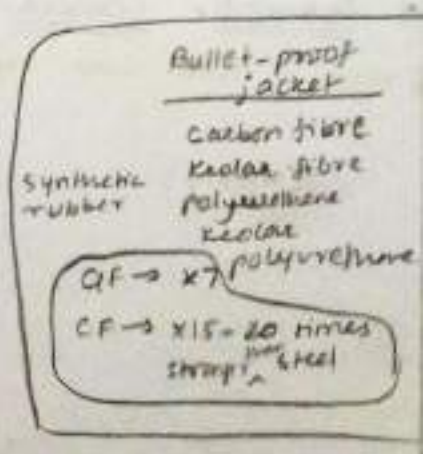
Open loop Control System:

→ Basic elements of an open loop control system are-

- Control element
- Correction element
- Process



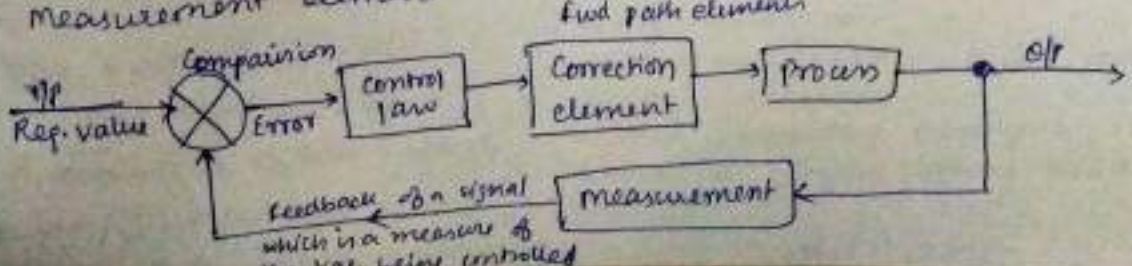
→ For eg: In an automatic toaster system, knobs will be given for temp. control.



Closed loop Control System:

→ Basic elements are-

- Comparision element
- control law
- Correction element
- Process
- Measurement element



Q. With flowchart explain open-loop & closed-loop CS.

Control System of a Mechatronic System

→ It can be classified as either a discreet event control system or a feedback control system.

→ In discrete event system, the controller controls the execution of a sequence of events.

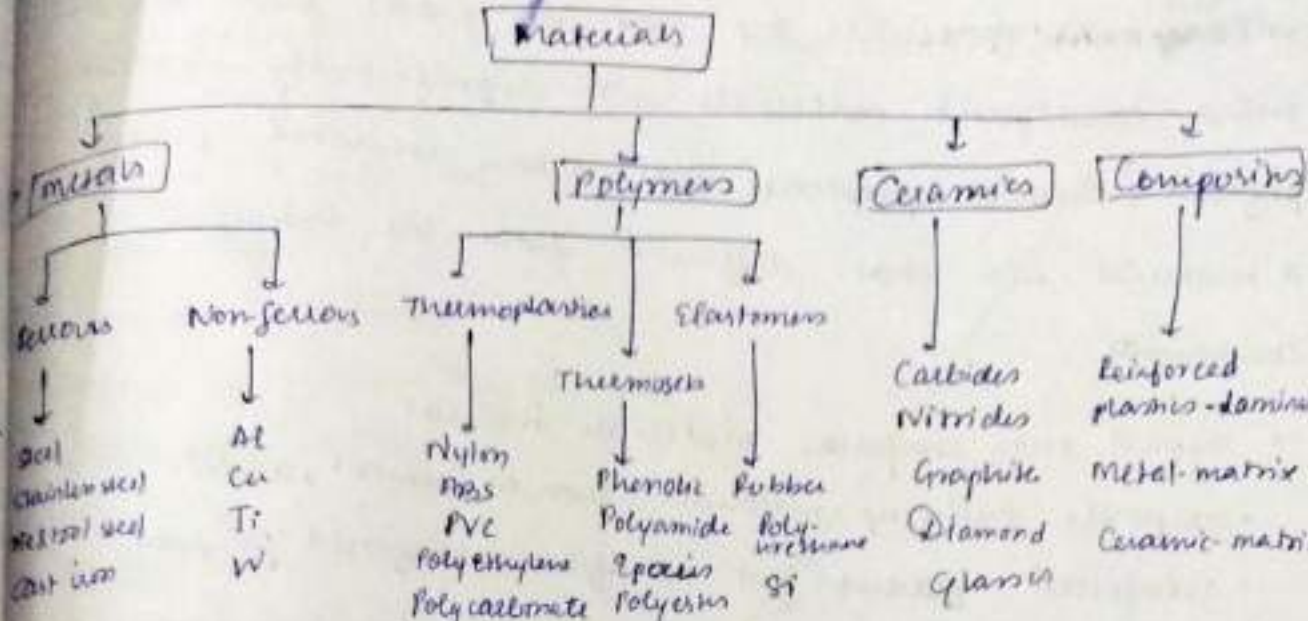
→ In a feedback control system, the controller controls one or more variables using feedback sensors & feedback control laws.

→ Ex: automatic washing machine, automatic camera

Automatic Camera

Q. With a neat diag. explain aut camera

Classification of Engg. Materials

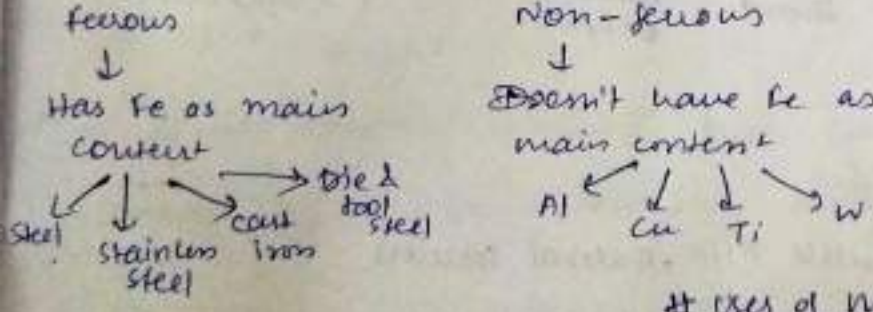


Metals

- solid material which is typically hard, shiny, malleable, fusible & ductile with good elec & thermal conductivity.

→ Ex: Fe, Ag, Au, Al, alloys

Classification



Properties

→ Strong, malleable, ductile
→ Sonorous, high mp & bp
→ Good conductors of heat & ele
→ Shiny, form ve ions, high S
→ react with O_2 to form basic oxide.

Uses of metals

→ made to jewellery due to hard & shiny appearance.
→ used to make pans as they're good conductors of heat
→ build scaffolding & bridges cuz strong.
→ make a ringing sound hence used in bells.
→ used in elec. cables.

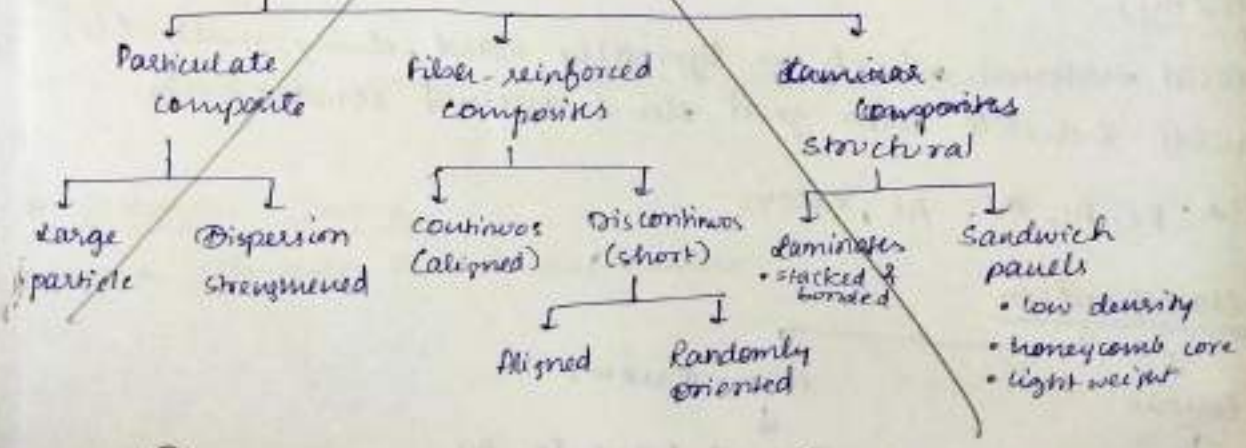
Composites

→ Composites materials are materials made from two or more constituent materials with significantly different physical / chemical properties, that when combined, produce a material with char. different from the individual components.

→ Typical engg. composites materials include:

- composite building materials such as cement, concrete
- reinforced plastics just as fibre-reinforced polymer
- metal composites

→ 3 Types (Based on type of reinforcements)



(6)

Applications of Ceramics

→ Aerospace : space shuttle tiles, thermal barriers
→ Consumer Uses: glassware, window, pottery
→ Automotive : catalytic converters, ceramic filters
→ medical (Bio ceramics): orthopedic joint replacement
→ military: structural comp. for ground, air & naval vehicles
→ Computers: insulators, resistors, s/c

Properties of ceramics (7)

→ Hard, brittle
→ Wear-resistant
→ Refractory
→ Thermal & Electrical Insulators
→ Non-magnetic
→ Oxidation Resistant
→ Prone to thermal shock and
→ Chemically stable

Ceramics

→ Ceramic materials are inorganic, non-metallic materials made from compounds of a metal and a non-metal.
→ They are formed by the action of heat & subsequent cooling.

crystalline ← | → non-crystalline

→ Some ceramics are semiconductors. Most of these are transition metal oxides that are II-VI s/cs, such as zinc oxides.

**→ Some ceramics exhibit high temperature super-conductivity under extremely low temperatures

(5) Applications of Polymers

→ Plastics, proteins such as hair, nails, tortoise shells.
→ Cellulose in paper & trees, DNA, rubber

Q: write the diff. b/w Thermosetting & Thermoplastics Polymers.

(4)

Thermosetting Plastics	Thermoplastics
→ 3-D net of primary covalent bonds with cross-linking b/w chain	→ linear polymers without cross-linking and branching
→ upon heating, they retain their strength and prolonged heating causes roasting of polymers and ultimately de-polymerisation.	→ upon heating the 2° bonds b/w individual chains break, the polymers become soft & on cooling hard & rigid cuz 2° bonds re-establish themselves
→ Harder, stronger & more brittle.	→ strong and less brittle.
→ Diff to fill an intricate mold with such plastics.	→ can fill complicated mold easily.
→ can't be recycled.	→ can be recycled
→ Ex: polyesters, silicones, Bakelite, etc.	→ PVC, Nylons, polyethylene
→ Appl: manufacture of telephones, elec objects, appliance handles, etc.	→ Appl: Plastic walls, floor tiles, reflectors, plastic lenses, etc

General chas of Polymers (3)

1) Polymers have long chain structures
2) All polymers have one thing common i.e- Carbon which bonds H, N, X or other organic/inorganic substances.

3) Although polymers structure may be crystalline in simple materials but generally they are non-crystalline solids at room temperatures. Polymers pass through a viscous stage during formation.

4) Polymers have light weight & they can be easily fabricated & shaped.

5) They are poor conductors of elec. & their thermal conductivity is also low.

6) Moreover, polymers are resistant to chem. attack & decay.

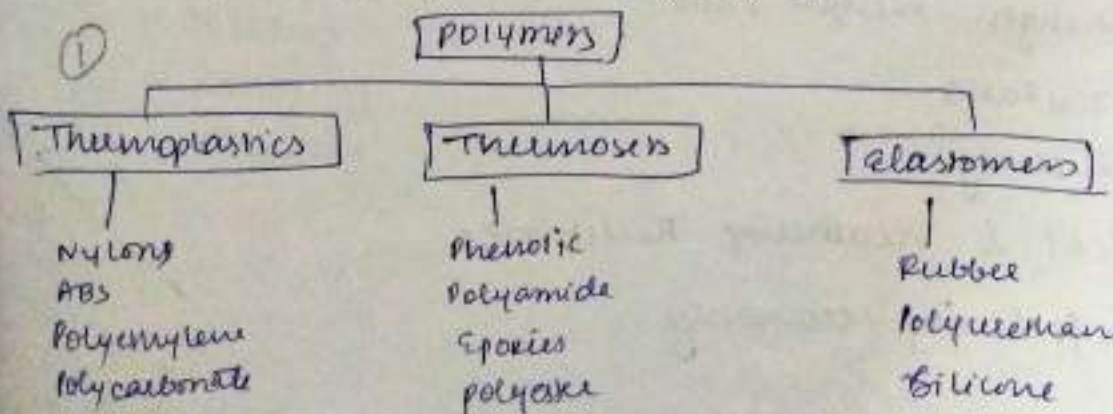
#Polymers (2)

→ A compound of high mol. wt. derived either by add^{n} of any smaller molecules, as polyethylene, or by condensation of many smaller molecules with elim. of water, alcohol or the like as nylon.

→ Natural : amber, wool, silk, natural rubber.

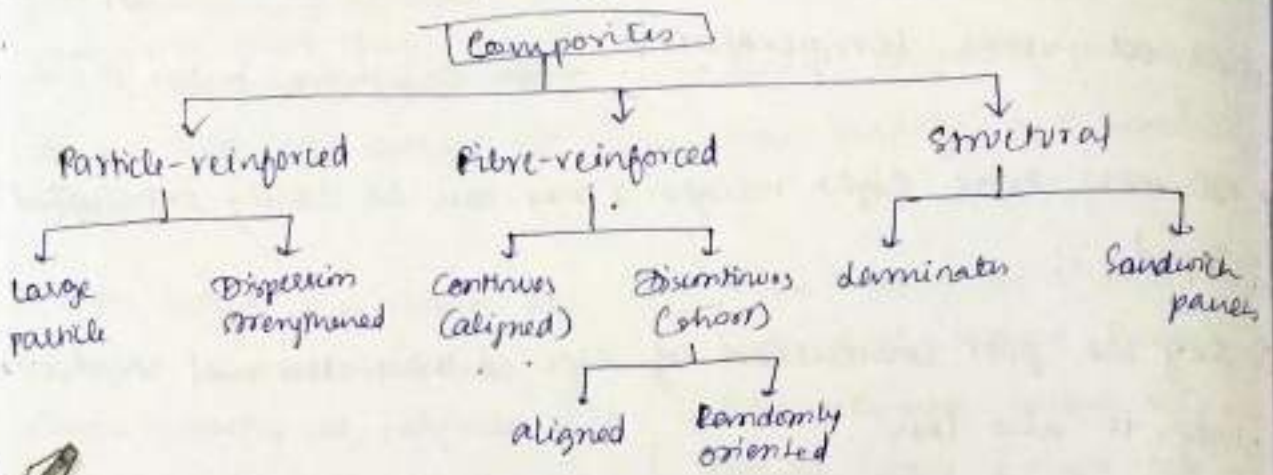
→ synthetic : synthetic rubber, Phenol formaldehyde resin, neoprene, nylon, PVC, Si, etc.

(1)



22 # Classification of Composites

(based on type of reinforcement)



Composite materials are materials made from 2/more constituent materials with significantly diff. physical/chem. prop., that when combined, produce a material with char. diff from individual components

Q. with a neat diag/flowchart explain in detail the class. of composite materials.

Scheme - diag/flowchart (5m)
Detailed expl (5m)

Properties

→ High strength - weight ratio
→ Fire resistance
→ Translucency
→ chemical & Weathering Resistance
→ manufacturing economy

Physical Properties

→ Can be reversible / irreversible.

→ A substance may seem different, but the way atoms link is same.

→ Solubility → ability to dissolve .. Ex - sugar in water

→ MP, BP

→ Density

→ Colour

Chemical Properties

→ change in the identity of matter

→ Ex - • Corrosion Resistance -
- Combustability
- Toxicity
- Reactivity - How readily a substance combines chem. with other substances
- Flammability -
- Burning / Combustion
- Corroding / Rusting
- Molding
- Decaying
- Digesting

22) **

Mechanical Properties

→ used to det the ~~stability~~ suitability for a particular application

→ General properties of matter:

- Hardness: resistance to penetration
- Brittleness: failure at shock loads
- Ductility: drawn out into wires
- malleability: beaten into sheets

#

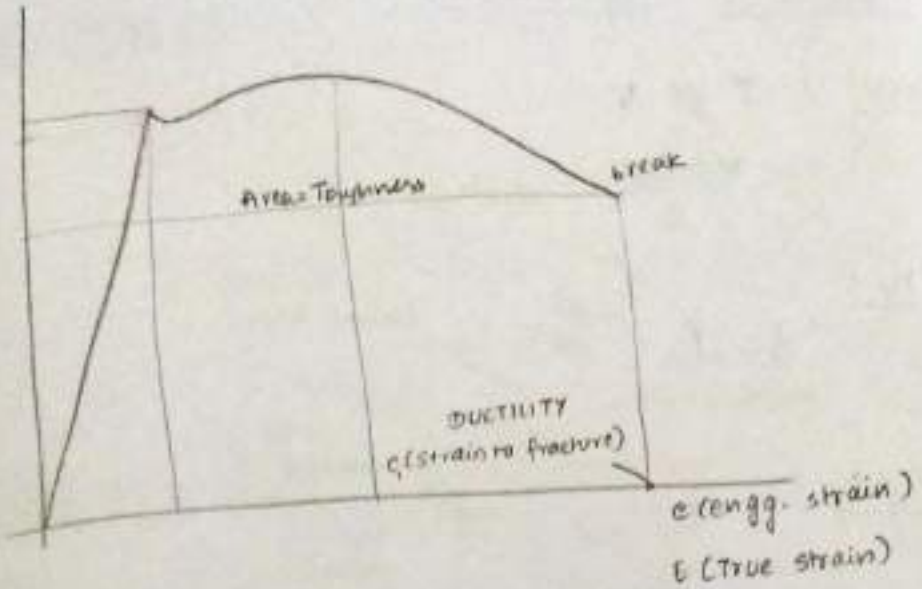
* modulus of elasticity: The initial slope of the curve, related directly to the strength of atomic bonds.

* Yield Strength: The point at which a consistent and measurable amount of permanent strain remains in the specimen.

* Ductility: The total elongation of the specimen due to plastic deformation, neglecting the elastic stretching.

* Toughness: Total area under the curve which measures the energy absorbed by the specimen in the process of breaking.

Q Explain with a neat sketch the stress-strain diag for a mild steel.



Thermal Properties

→ The specific heat is the amount of heat / unit mass req. to raise the temperature by 1°C.

$$C = \frac{Q}{m \Delta T}$$

C: specific heat

→ Coefficient of Thermal Expansion (CTE) : defined as the frac. ↑ in the length / unit to rise in temp.

$$\alpha_V = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)$$

→ Thermal conductivity:

Rate at which heat passes through a specified material exp. as amt of heat that flows per unit time through a unit area with temp. gradient of 1°/unit dist.

→ opp. face is maintained at a temp diff. of 1°.

22/5 Electrical & Electronic Conductivity

→ Ohm's law : $I \propto V$

$V = IR$

→ Resistivity :

$\rho = \frac{R}{}$

→ Conductivity :

#

Optical Properties

→ ~~material~~ interaction with ~~ems~~ EM radiation in the visible

→ classified into-

- Transparent: capable of transmitting light with relatively little loss absorption & reflection.
- Translucent: light is transmitted diffusely i.e- not clearly distinguishable.
- Opaque: impervious to the transmission of visible light. They absorb all energy from light photons.