Assignment

Basic Mechanical Engg (BT-203)

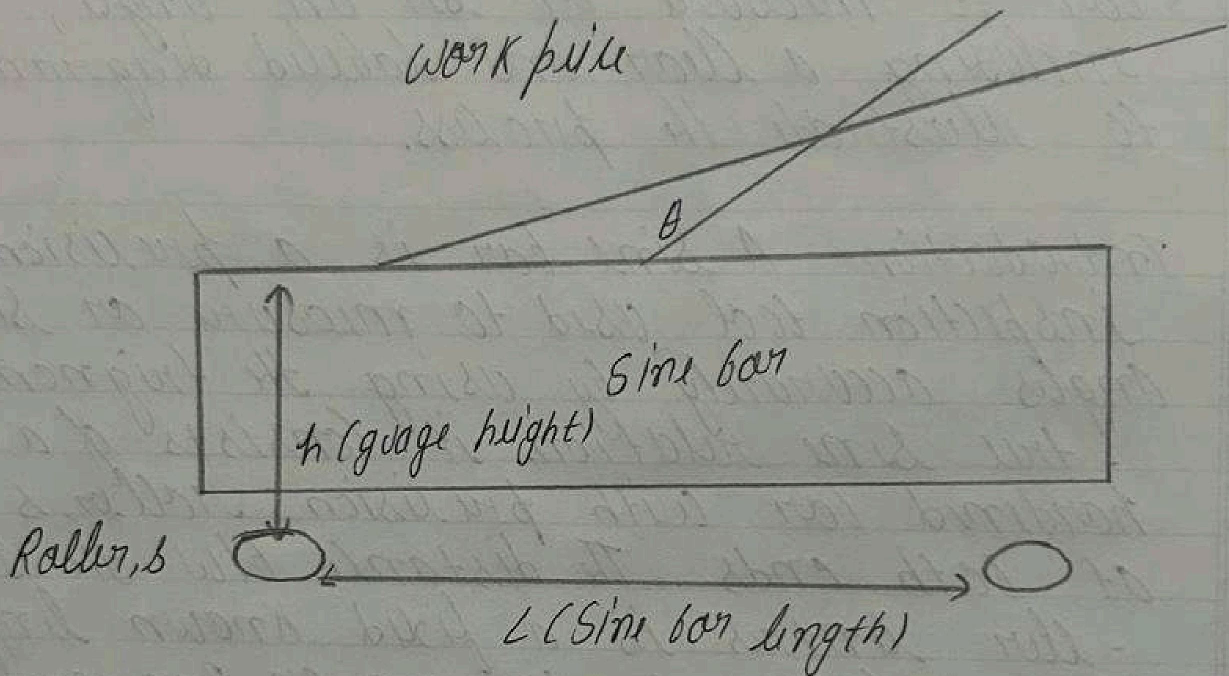
Q1 Describe the procedure for using a sine bar to measure or set an angle, including a clear and labelled diagram to illustrate the process.

Ans Introduction- A sine bar is a precision inspection tool used to measure or set angles accurately by using the trignometric sine relation. it consists of a hardened bar with precision roller,s at both ends. The distance b/w the roller centres is a fixed known length (L), commonly 100 mm or 200 mm.

Principle- The sine bar uses the relation $\sin\theta = h/L$ where θ is the angle to be measured or set, h is the gauge (slip) block stack height under one roller, and L is the distance b/w the roller centres (sine bar length). Rearranged

$$\theta = \sin^{-1}(h/L)$$

Equipment required- 1. Sine bar
2. Slip gauges 3. Precision Surface plate
4. Dial Indicator and workpiece
5. Vernier height gauge.


work piece
θ
Sine bar
h (guage height)
Roller,s
L (Sine bar length)

Procedure to set an angle using a Sine bar :-

1. Clean the Surface plate, Sine bar, Slip gauges and the work piece to remove dust and oil.
2. Place the Sine bar on the Surface plate so that both roller,s sit firmly and stably.
3. Calculate the required gauge height h using $h = L \times \sin\theta$ (use θ in degrees and calculator in degrees)
4. Select slip gauge blocks to make up the calculated height h. use combination of Standard gauge blocks for accuracy.
5. Place the row of Slip gauges under the roller on the side where height is required.
6. Place the workshop on the top face of the Sine bar ensuring it rests properly and is alligned.
7. Verify the set angle by running a dial Indicator along the work piece surface or using a height gauge to check the slope. make the fine adjustments by adding / removing gauge blocks.
8. once set clamp the workpiece and proceed with machining or inspection while maintaining

the angle.

Q2 Describe the Principles and applications of radiation and optical Pyrometers for temperature measurement.

Ans Principle of Radiation Pyrometer

(i) Every hot body emits thermal radiation according to its temperature.

(ii) Radiation Pyrometers measure temperature based on the intensity of total radiation (infrared, + visible + ultraviolet) emitted by the object.

(iii) The Stefan - Boltzmann law governs the Principle. $E = \sigma T^4$

Where

E = radiant Energy per unit area

σ = Stefan Boltzmann Constant

(iv) Thus, higher the temperature, greater is the radiated emmited.

Principle of optical Pyrometer.

(i) optical Pyrometers measure brightness of radiation at a particular wavelength, usually in the visible spectrum.

(ii) They work on wien,s law of radiation which relates monochromatic radiation intensity to temperature.

(iii) The method involves comparing the brightness of a filament lamp with the brightness of the hot body being measured.

(iv) When the filament disappears against the background of the hot body, the corresponding temperature can be read from a calibrated scale.

Applications of Radiation and Optical Pyrometers.

1. Metallurgy - for measuring temperature of molten metals and furnaces.

2. Ceramics and glass industry - for kiln and furnace temperature monitoring.

3. Power plants - For monitoring boiler tube temperature.

4. Aerospace and automotive - For turbine blade and engine exhaust measurements.

5. Research laboratories - where precise, non contact and high temperature measurement is required.

Q3 Explain construction, working and prin-ciple of vernier caliper.

Ans Principle of vernier calliper- The vernier calliper works on the principle of vernier scale, invented by Pierrer vernier

(i) The Principle states that :-
"when two scales are slightly different in divisions, the difference between them can be used to measure very small lengths precisely"

(ii) In a vernier calliper, the main scale is fixed, and the vernier scale slides over it.

(iii) The least count (LC) is the smallest value that can be measured and it is given by-

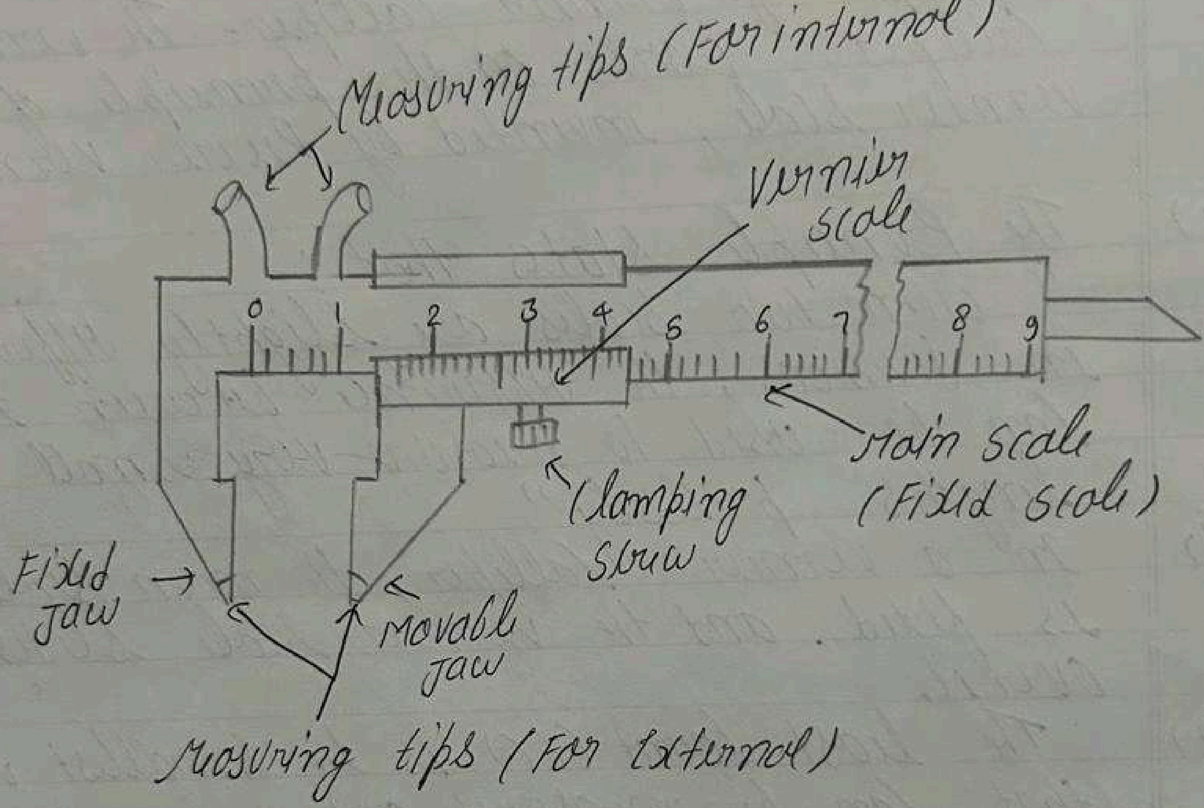
LC = 1 main scale division - 1 vernier scale division.

Construction of vernier calliper

The main parts of vernier calliper are:-

1. main scale- A long steel strip graduated in cm and mm.
2. vernier scale- A small sliding scale attached parallel to the main scale, capable moving along it.

Vernier Scale



3. Fixed jaw- Attached at one end of the main scale.
4. Movable jaw- Attached to the vernier scale, moves with it,
5. External measuring jaws- used to measure external diameter or length of objects.
6. Internal measuring jaws- Smaller jaws at the top to measure internal diameter of pipes or holes.
7. Depth rod- A thin rod used to measure depths of containers.
8. Lock screw- To hold the vernier scale in position after adjustment.

Working of Vernier Caliper

1. External measurement - The object is placed b/w the external jaws, and the main scale reading is noted just before the vernier zero. The coinciding vernier division is then multiplied by the least count and added to the main reading.
2. Internal measurement - The internal jaws are inserted into the hollow object. The same reading method (main scale + vernier scale coinciding × LC) is followed.

3. Depth measurement - The depth rod is inserted into the hole until the main scale rests on the surface. The reading is again taken using the main and vernier scales.

Total reading = Main scale reading + (Vernier coincidence X least count)

Q4 Explain with sketch the construction and working of micrometer. Explain how least count is found are reading is taken, What is zero error?

Ans Construction of micrometer - It consists of

1. Frame - C-shaped rigid body that holds all parts.
2. Anvil - Fixed and against which the object is placed.
3. Spindle - movable screw that move forward / backward by rotation.
4. Sleeve - Fixed scale marked in mm and half-mm.
5. Thimble - Rotating cylindrical part with circular scale. (50 or 100 divisions)
6. Ratchet - Ensures uniform pressure while tightening.

7. Lock Nut - Locks the spindle in position after measurement.

Working of micrometer

(i) The object is placed b/w the anvil & spindle.
(ii) The ~~thimble~~ ratchet is used to apply uniform pressure.
(iii) The thimble is rotated until the spindle touches the object.
(iv) The main scale reading (on sleeve) and the circular scale reading (on thimble) are combined to get the final measurement.

Least count of micrometer

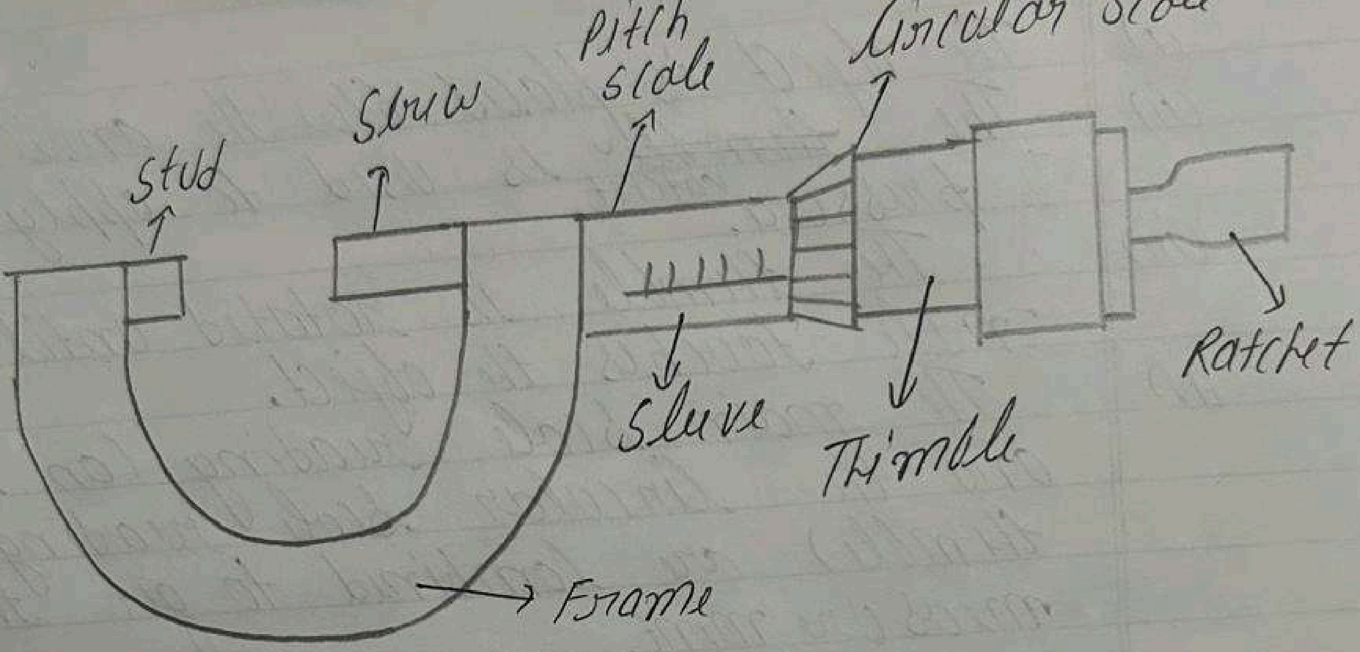
1. Pitch of screw = distance moved by spindle in one complete rotation (usually 0.5mm)

2. Number of divisions on circular scale = 50
Therefore,

$$LC \text{ (least count)} = \frac{\text{Pitch}}{\text{No of divisions}} = \frac{0.5}{50} = 0.01\,mm$$

Taking Reading

1. Note the main scale reading on the sleeve,
2. Note the circular scale division that coincides with the reference line.


Stud
Screw
Pitch scale
Circular Scale
Ratchet
Sleeve
Thimble
Frame

Micro - meter

3. multiply the circular scale division by least count.
4. Total Reading = main scale Reading + (circular scale reading × LC)

Zero Error

If the zero mark of the thimble does not coincide with reference line when the anvil and spindle are in contact, a zero error occurs.

The zero error must always be added or subtracted from the observed reading to get the correct measurement.

Q5 Explain various types of Errors in measurement and state how they can take care of.

Ans When we measure any physical quantity, the measured value may not be exactly equal to the true value, The difference between the measured value and the true value is called an error.

Types of Errors.

1. Gross Error- caused due to human mistake such as incorrect reading, wrong ~~no~~ recording, or improper use of Instruments.

Example- misreading a scale

Cure- Avoided by taking proper care, repeating readings and practicing careful handling.

2. Systematic Errors- These occurs due to faults in instruments, wrong calli-bration, or consistent mistakes in the method.
Types- Instrumental, observational or Environmental Error.

Cure- Can be minimized by proper callibration, correct experiment set up, and applying corrections.

3. Random Errors- These occurs due to unpredictable variations, like small fluctuations in temperature or human reaction time.
Cure- Reduced by taking a large num-ber of observations and calculating the mean value.

4. Absolute, Relative and Percentage Errors

(i) Absolute Error- Difference b/w true value and measured value.
(ii) Relative Error- Ratio of absolute error to true value.

Percentage error- Relative Error X 100

Care- Repeated measurements and using Precise instruments help reduce these errors.

Q6 Explain the classification of engineering materials highlighting the different categories and their key characteristics.

Ans Engineering materials are substances used in manufacturing and construction processes to design machines, structures, and devices. They are selected based on properties like strength, durability, cost and application.

1. Metals

(i) Ferrous metals- Contain iron as the main element. Examples - Cast Iron, Steel.

Characteristics- High strength, ductility good conductivity, Prone to corrosion.

(ii) Non-Ferrous metals- Do not contain iron Examples- Aluminium, copper etc

Characteristics- light weight, corrosion resistant, good thermal and electrical conductivity.

2. Polymers

Examples - Plastics, rubber, nylon etc

Characteristicks - light weight, corrosion resistant, low strength compared to metals easily moldable, low cost.

3. Ceramics

Examples - Glass, porcelain, cement, refractory materials.

Characterstics - Hard, brittle, high compressive strength, resistant to heat and corrosion, poor electrical and thermal conductors.

4. Composites

Examples - Fiber glass, carbon - Fiber, com - posites, reinforced plastics.

Characterstics - Combination of two or more materials, high strength to weight ratio corrosion resistance.

5. Smart materials.

Examples - Shape memory alloys, Piezo electric materials.

Characterstics- Properties change with external conditions (temperature, stress, electric field), widely used in modern engineering applications.

Q7 Compare various mechanical properties based on its application.

Ans Mechanical properties of material deter-mine their suitability for different engineering applications. The most important properties include strength, hardness, toughness, elasticity, ductility, malleability and fatigue resi-stance.

1. Strength- It is the ability of a materi-al to withstand applied load without failure. High-strength materi-als like steel are used in construc-tion of bridges, buildings and machi-nery parts where load bearing capacity is essential.

2. Hardness- Hardness is the resistance to wear and scratching. materials like tools steel, tungsten carbide, and diamond are used for cutting tools, drills, and dies because they must resist abrosion.

3. Toughness- Toughness is the capacity to absorb Energy before fracture. it is important in automotive parts, railway tracks, and armor plates where resistance to sudden shocks or impact is required.

4 Elasticity - Elasticity is the ability of a material to regain its original shape after deformation, Springs, Sus-pension system, and elastic fasteners use materials like spring steel and rubber for this property.

5. Ductility- Ductility allows a material to be drawn into wires without brea-king. Copper and aluminium are widely used in electrical cables and wires due to their ductility and conduc-tivity.

6. malleability- It is the property of being hammered or rolled into thin sheets Gold, silver and alluminium are used in sheet metal applications.

7. Fatigue resistance- Fatigue Strength is crucial for components subjected to cyclic loading. Aircraft wings, turbine blades and crankshafts require material like titanium alloys an-d special steels with high Fatigue resistance

Q8 Explain the impact of various alloy -ing elements on the properties and behaviour of Steel.

Ans Steel is the alloy of iron and carbon, but to improve its mechanical, thermal, and chemical properties various alloying elements are added in specific proportions.

1. Carbon (C) → The most important element in Steel. An increase in carbon content improves hardness and strength but reduces ductility and weldability.

2. Manganese (Mn) → Acts as a deoxidizer and improves strength and toughness. It also enhances hardenability and wear resistance while reducing brittleness caused by sulfur.

3. Chromium (Cr) → Improves hardness, tensile strength, and toughness. It also resistance to corrosion and oxidation. Chromium ~~resistance to corrosion~~ is the key element in stainless steel, it also enhances wear hardness and harden -ability.

4. Nickel (Ni) → Increases toughness and impact strength, especially at low tem

-perature. Nickel also improves corrosion resistance and gives steel good sur-face finish.

5. Molybdenum (Mo) → Enhances strength at high temperatures, increase hardenab-ility, and improves resistance to corrosion and creep. often used in tool steels and high-strength alloys.

6. Vanadium- Refines grain size, increases hardness and enhances wear resistance, vanadium carbides provide excellent strength and toughness.

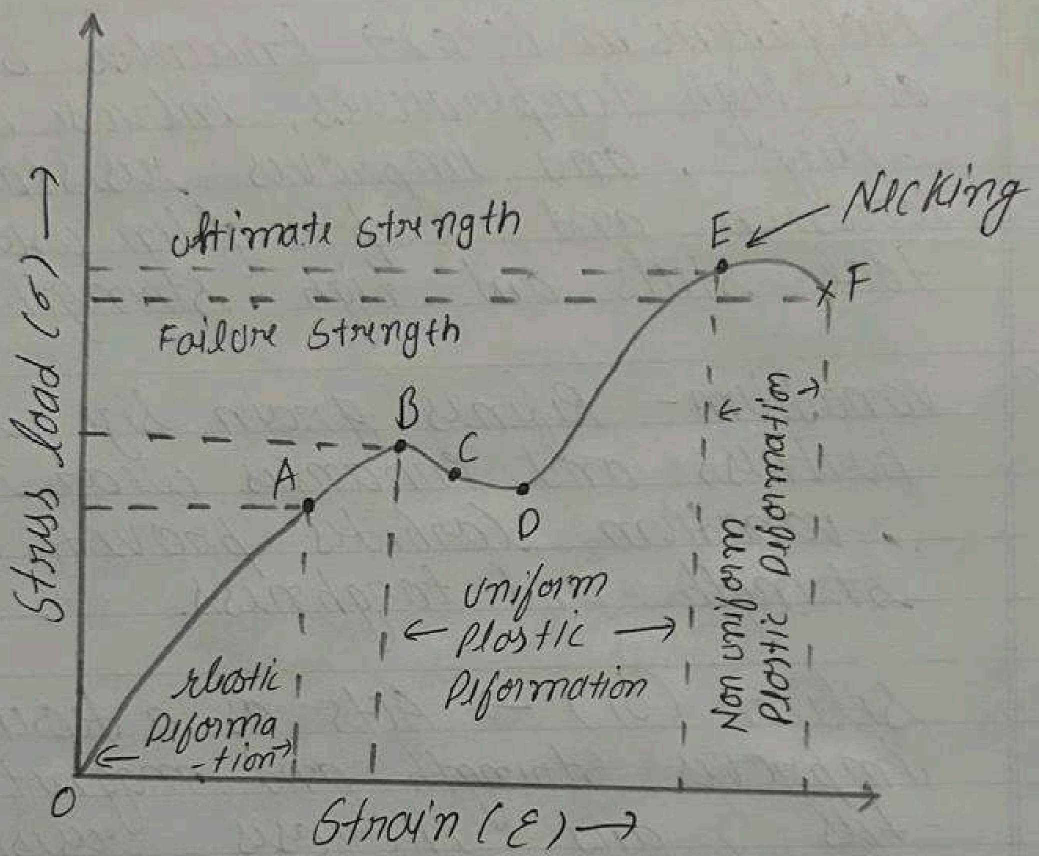
7. Silicon (Si) → Acts as a deoxidizer, improves strength and magnet proper-ties, and increases resistance to scaling at high temperature.

Q9 Comparison of stress strain diagram of ductile and brittle of engineering material.

Ans Ductile materials - Such as mild steel, copper and aluminium, can under-go large plastic.
Deformation before fracture. their stress strain curve typically shows:-

1. Proportional limit - Where stress directly proportional to strain

For Ductile



A = Proportional limit
B = Elastic limit
C = Yeild Point
D = Lower yeild Point
E = Ultimate Stress Point
F = Breaking point

2. Elastic limit - material returns to original Shape if load is removed.

3. Yield Point - sudden elongation at nearly constant Stress.

4. Strain hardening region - Stress increases with Strain due to dislocation resistance.

5. Ultimate tensile Strength (UTS) - maximum Stress material can bear.

6. Fracture point - occurs after Significant plastic deformation and necking.

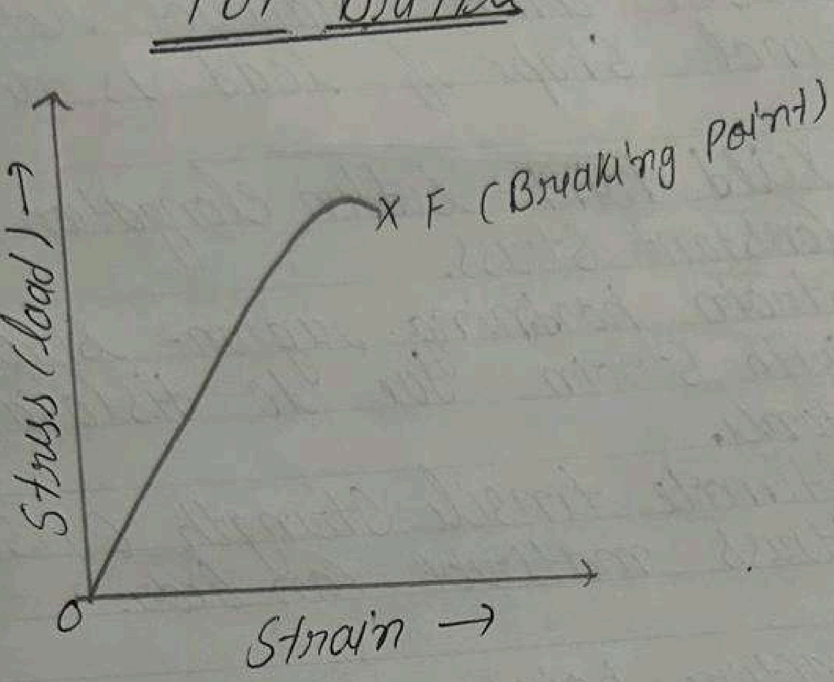
Thus, Brittle materials Exhibit a long curve with a large area under it, showing high toughness and energy absorption.

Brittle materials - Such as Cast Iron, glass and ceramics, show very little plastic deformation before breaking. Their Stress Strain curve has:-

1. Elastic region only - Almost linear up to fracture.
2. No yielding or Strain hardening region.
3. Fracture occurs suddenly after the elastic limit with almost no warning.

The curve is Short and Steep, indicating

For Brittle



high strength but low toughness.

Q10 Explain the Iron-Carbon Phase diagram and discuss its significance in under-standing the microstructures and properties of steel and cast iron.

Ans The Iron-Carbon (Fe-C) Phase diagram is one of the most important tools in materials science, it represents the changes in phases of iron with varying carbon content (0-6.67%) and temperature. The diagram expl-ains the formation of important microstructures such as ferrite, auste-nite, cementite, pearlite, bainite, and martensite, which govern the properties of steels and cast irons.

1. Steel (0-2% C) :-

(i) Low carbon steel (< 0.25 % C) → Ductile, tough, used in structural applications.

(ii) Medium carbon steel (0.25 - 0.6 % C) → higher strength, used in cutting tools, machinery.

(iii) High carbon steel (0.6 - 1.5 % C) → hard, wear-resistant, used in cutting tools.

2. Cast Iron (2-4.3% C) :-

(i) Contains cementite and graphite, making it hard but brittle.

(ii) Grey cast iron → good machinability and damping.

(iii) White Cast Iron → hard and wear-resistant.

Significance :-

1. Helps in selecting proper heat treatment (annealing, quenching, tempering).
2. Explains how microstructures form and influence mechanical properties.
3. Guides alloy design for engineering applications.

Thus, the Fe-C Phase diagram is essential for understanding and controlling the microstructure mechanical behaviour and industrial use of steels and cast irons.