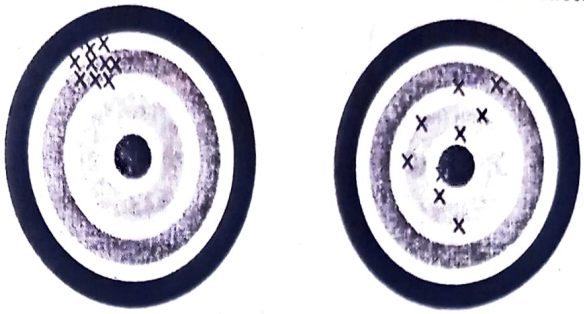
correctness of something when compared to a true or absolute value. Single factor or measurement.

- The **precision** of an experiment, object, or value is a measure of the reliability and consistency. A state of strict exactness - how often something is strictly exact. Multiple measurements or factors are needed.



Precision
Points are close to one another but not near the center.

Accuracy
Points are generally in the center, but have variability.

Fig. 1.14. Precision vs. Accuracy

TWO MARK QUESTIONS WITH ANSWERS

1. ***What are the major types of materials?***

   Solid materials have been conveniently grouped into three basic categories,

   - Metals
   - Ceramics
   - Polymers

2. ***Define line defects.***

   - Line defects are called dislocations and are the edges of surfaces where there is a relative displacement of lattice planes. One type is an edge dislocation, and the other is a screw dislocation.

3. ***What are the benefits of testing?***

   - Safety issues can be identified
   - It provides reliability
   - It is cost effective
   - It offers reassurance

4. ***What are types of material testing?***
   - Materials testing classified into three major categories
     - Mechanical testing (or) Destructive testing (DT)
     - Nondestructive testing.
     - Material characterization testing

5. ***Define NDT.***
   - Nondestructive Testing (NDT) consists of a variety of non-invasive inspection techniques used to evaluate material properties, components, or entire process units. The techniques can also be utilized to detect, characterize, or measure the presence of damage mechanisms (e.g. corrosion or cracks).

6. ***Write contrast between NDT and destructive testing.***

DESTRUCTIVE TEST	NON-DESTRUCTIVE TEST
❖ Tests are usually quantitative measurements of load for failure, significant distortion or damage, or life to failure under given loading and environmental conditions.	❖ Tests are usually quantitative and rarely quantitative. They do not usually measure load for failure or life to failure even indirectly.
❖ The correlation of result is directly given by observer.	❖ Skilled judgment and test or service experience are usually required to interpret test indications.
❖ Destructive tests are not usually to apply on parts in working condition.	❖ Non-destructive tests may often be applied to parts in working assemblies without interruption or service beyond normal maintenance or idle periods.

7. ***What is the test used to test metals?***
   - Major test used for testing metals are destructive one i.e., Test, Shear(Torsion test),Test, Creep Test, Bending test etc

8. ***Why more concentration is needed for selection of materials?***

- Material selection is one of the foremost functions of effective engineering design as it determines the reliability of the design in terms of industrial and economical aspects.
- It is Iterative in nature, there is a strong element of trial and error where an initial design is done and then analyzed, tested, and subjected to trial production. Changes may be made at any stage of the process to satisfy requirements not previously considered or problems just discovered.

9. ***What are factors to be considered during selection materials?***

- Performance
- Mechanical properties
- Wear of materials
- Corrosion
- Ability to manufacture
- Cost
- Reliability and Environmental Resistance
- Reducibility

10. ***What are stages in development of testing?***

- Identify the Need & Define the Problem
- Research the Problem
- Develop possible testing methods
- Evaluate the Alternatives & Select Most Promising methods
- Initial Design
- Construct a prototype
- Test and Evaluate the Prototype
- Communicate the Design
- Redesign

11. ***Define prototype.***

- A prototype, or trial model, is often made and subjected to simulated service testing to demonstrate whether or not a machine or vehicle functions properly.

12. *Differentiate precision and accuracy.*

S.No.	ACCURACY	PRECISION
1.	The accuracy of an experiment, object, or value is a measurement of how closely results agree with accepted value.	The precision of an experiment, object, or value is a measure of the reliability and consistency.
2.	The degree of conformity and correctness of something when compared to a true or absolute value. Single factor or measurement.	A state of strict exactness — how often something is strictly exact. Multiple measurements or factors are needed.

13. *Why development of testing is necessary?*

- A problem can be regarded as a difference between the actual situation and the desired situation. It involves diagnosing the situation so that the focus on the real problem.
- Development of various time, cost, sample and labor minimizing testing techniques.
- The destruction of material reduction technique.
- Scale-up of a testing technology.
- Increase fundamental understanding of materials.
- Improvement of the process/product performance relative to the needs and demands of customers.
- Reduction of existing process spread, which leads to poor capability.

14. *Define ISO.*

- The International Organization for Standardization (ISO) is an international standard-setting body composed of representatives from various national standards organizations.
- ISO is a voluntary organization whose members are recognized authorities on standards, each one representing one country. Members meet annually

at a General Assembly to discuss the strategic objectives of ISO. The organization is coordinated by a central secretariat based in Geneva.

15. *What is the testing standard organization followed in India?*

❖ BIS is the National Standard Body of India established under the BIS Act 2016 for the harmonious development of the activities of standardization, marking and quality certification of goods and for matters connected therewith or incidental there to.

REVIEW QUESTIONS

1. Write a review on types of materials.

   Ans: Section No. 1.1 **Page No:** 1.1

2. What are aspects that you understand from testing of materials?

   Ans: Section No. 1.2 **Page No:** 1.9

3. Write the classification of various material testing.

   Ans: Section No. 1.2 **Page No:** 1.9

4. What are the advantages and disadvantages encountered by various material testing?

   Ans: Section No. 1.2 **Page No:** 1.10

5. Differentiate between NDT and Destructive testing.

   Ans: Section No. 1.2 **Page No:** 1.14

6. Why testing of materials are important?

   Ans: Section No. 1.3 **Page No:** 1.16

7. What are steps to be followed during selection of materials?

   Ans: Section No. 1.4 **Page No:** 1.17

8. What are criteria that affect the selection of materials?

   Ans: Section No. 1.4 **Page No:** 1.19

- Identify critical locations.
- Fatigue tests can also be used to determine the extent that widespread fatigue damage may be a problem.

11. LIMITATIONS

- It fails to recognize the probabilistic nature of fatigue and there is no simple way to relate life predicted by the rule with the characteristics of a probability distribution.
- It does not consider the effect of an overload or high stress which may result in a compressive residual stress that may retard crack growth.

TWO MARK QUESTIONS WITH ANSWERS

1. ***What is advantage of charpy test on izod test?***

- More suitable for low-temperature tests which must be completed within a few seconds from the time of removal of the test piece from the coolant. This is due to easier placement of the Charpy specimen in the tester compared to the Izod.
- Free from compressive stresses around the notch, while gripping of the Izod specimen inside the clamp device produces the compressive stresses around the notch.

2. ***Define true stress–strain and engineering stress–strain.***

- True Stress is Stress value obtained by dividing the instantaneous area into applied load
- True Strain is Provides a more realistic assessment of "instantaneous" elongation per unit length

$$\varepsilon = \int_{L_0}^{L} \frac{dL}{L} = ln \frac{L}{L_0}$$

- **Engineering Stress:** Stress (nominal stress) is defined as the ratio of the applied load to the original cross-sectional area of the specimen

Stress (σ) = applied load / original cross-sectional area

- **Engineering Strain**: Strain is defined as change in length to original length

$$\text{Strain } (e) = \text{change in length / original length}$$

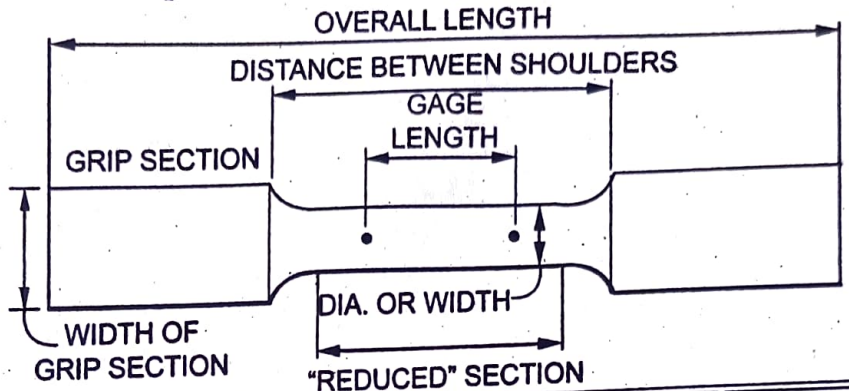
3. ***What are the major mechanical properties of material and its test to determine it?***

Mechanical Property	Destructive Testing Method
❖ Elasticity, Plasticity	❖ Tensile Test, Compression Test, Bending Test, Torsion Test
❖ Stiffness, Material Behaviour Under Static Load	
❖ Creep Behaviour	❖ Creep Rupture Test
❖ Hardness	❖ Brinell, Rockwell, Vickers
❖ Toughness	❖ Impact Test
❖ Fatigue Behaviour, Fatigue Strength	❖ Wöhler Fatigue Test

4. ***What are various failure modes of materials?***
   - Material failure is the loss of load carrying capacity of a material unit. The material failure happens due to two major phenomena,
     - Deformation failure
     - Fracture failure
5. ***How the hardness influence the material properties?***
   - 'Hardness' is a structure-sensitive mechanical property of materials, primarily associated with the surface. It is the resistance of a material to permanent or plastic deformation of its surface.
6. ***List out the different types of Hardness testing machines.***
   - (*i*) Brinell; (*ii*) Meyer; (*iii*) Vickers (macro - and micro-hardness); (*iv*) Rockwell (regular and superficial); (*v*) Knoop (micro hardness); (*vi*) Nano hardness (mostly by Vickers and Berkovich indenters)
7. ***What property of metal does the impact test measure? Give its significance.***
   - The purpose of an impact test is to determine the ability of the material to absorb energy during a collision.

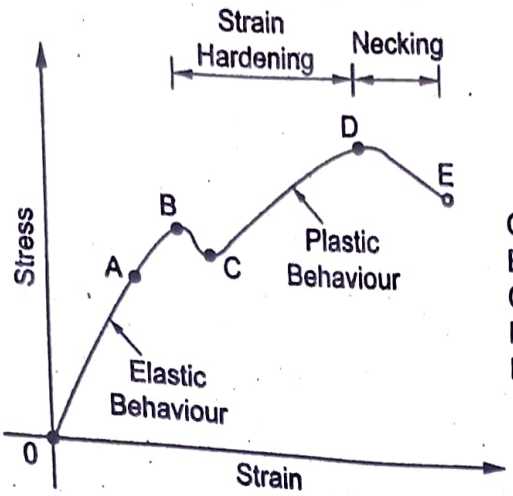
- This energy may be used to determine the
  - Toughness
  - Impact Strength
  - Fracture Resistance
  - Impact resistance or fracture resistance of the material

8. *Sketch a tensile test specimen showing all dimensions in inch.*



All values in inches	Plate type (1.5 in. wide)	Sheet type (0.5 in. wide)	Sub-size specimen (0.25 in. wide)
Gauge length	8.00 ± 0.01	2.00 ± 0.005	1.000 ± 0.003
Width	1.5 + 0.125 – 0.25	0.500 ± 0.010	0.250 ± 0.005
Thickness	0.188 ≤ T	0.005 ≤ T ≤ 0.75	0.005 ≤ T ≤ 0.25
Fillet radius (min.)	1	0.25	0.25
Overall length (min.)	18	8	4
Length of reduced section (min.)	9	2.25	1.25
Length of grip section (min.)	3	2	1.25
Width of grip section (approx.)	2	0.75	3/8

9. *Neatly draw stress–strain curve for a ductile material.*



OA : Proportional Limit
B : Upper Yield Stress Point
C : Lower Yield Stress Point
D : Ultimate Stress Point
E : Fracture

10. *Give the dimensions of Charpy and Izod impact test samples.*

Parameter	Izod impact test	Charphy impact test
Specimen dimension	Length-75 mm Width-10 mm Thickness-10 mm	Length-55 mm Width-10 mm Thickness-10 mm

11. *What are advantages made the choice of Brinell hardness test?*

- A choice can be made between a large numbers of test forces.
- The influence of surface scratches and roughness will be less in the Brinell test than other hardness tests.
- The specimen surface can be rough.
- Suitable for hardness tests on large blanks such as forged pieces, castings and hot-rolled etc
- Measurement is usually not affected by movement of the specimen

12. *What kind of indenter suitable for Vickers hardness?*

- It is made of diamond in the form of a square-based pyramid with an included angle of 136° between opposite faces.

13. *What are properties can be determined from tensile testing?*

- The tension test is the most common method for determining the mechanical properties of materials, such as strength, ductility, toughness, elastic modulus, and strain- hardening capability.

14. ***Define strain hardening and proof stress.***

- **Strain hardening**: This increase in the tensile strength of the material is due to strain hardening which is due to the increased dislocations interactions during the deformation of the tensile test. This is called Strain - hardening.
- **Proof Stress:** The stress that causes a percentage increase in gauge length. It can be found by drawing a line parallel to the straight part of the graph. A value can be taken from the vertical axis.

15. ***Write the classification of impact test based on load application.***

- Impact test classified based on load application applied by means of dropping weight, a swinging pendulum and a rotating flywheel.

16. ***What is the basic principle involved in Charpy and Izod impact test?***

- The Charpy V- notch impact test is the most common fracture toughness test. A notched specimen is broken by a swinging pendulum and the amount of energy required to break the specimen is recorded.
- The Izod impact strength test is a standard method of determining the impact resistance of materials. A pivoting arm is raised to a specific height (constant potential energy) and then released. The arm swings down hitting a notched sample, breaking the specimen.

17. ***Compare Charpy and Izod impact test based on specimen position & point of strike?***

Parameter	Izod impact test	Charphy impact test
Specimen position	Specimen held at vertical	Specimen held at horizontal
Point of strike	At Upper tip of specimen	At Point of notch but in opposite direction

18. ***Define deflection.***

- **Deflection** is the degree to which a element is displaced under a flexural load (due to its deformation).Deflection for three point bending test,

$$\delta_C = \frac{FL^3}{48EI}$$

E = Modulus of Elasticity (or) Young's modulus

I = Area moment of inertia of cross section

19. *What is modulus of rupture in bending nature?*

- Flexural strength, also known as modulus of rupture or bend strength or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test.
- For three point bending test (rectangular cross section)

$$\sigma_f = \frac{3FL}{2bd^2}$$

- For four point bending test where the loading span is 1/2 of the support span (rectangular cross section)

$$\sigma_f = \frac{FL}{bd^2}$$

20. *What is mean by shear relaxation in creep mechanism?*

- Stress relaxation is closely related to creep. In stress relaxation, the stresses resulting from loading of a structural component decrease in magnitude over a period, even though the dimensions of the component remain constant.

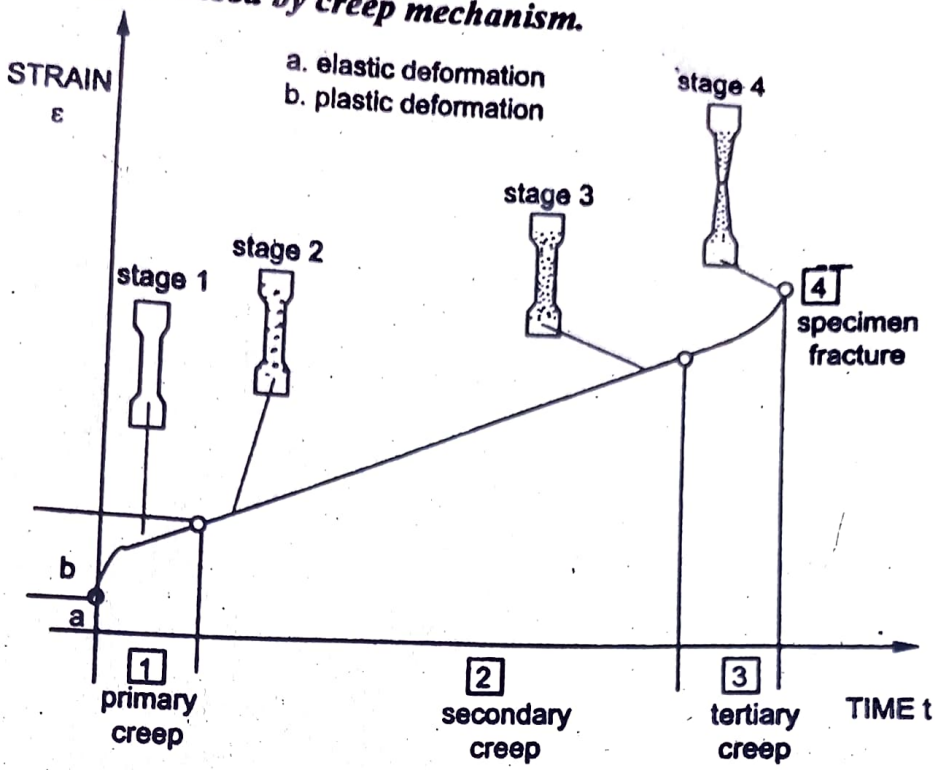
21. *How the steady state creep mechanism will works?*

- Steady-state creep or secondary creep after the primary creep, the creep rate reaches essentially a steady state, in which the creep rate changes little with time. This region of approximately constant creep rate. The steady state is achieved because of an approximate balance between two opposing factors: the strain hardening that tends to reduce the creep rate and the softening or recovery process that tends to increase it.

22. *How will control the creep?*

- Solid solution strengthening
- Particle dispersion strengthening
- Precipitation hardening
- Increasing grain size

23. *Sketch the stage crossed by creep mechanism.*



24. *Define the property of fatigue.*

- When the component is subjected to repeated cyclic stress (due to rotation, bending or vibration) leads to failure even though the stress below the yield strength of material.

25. *What is principle involved in fatigue testing?*

- A fatigue test is used for the determination of the maximum load that a sample can withstand for a specified number of cycles. Cyclic fatigue tests produce repeated loading and unloading in tension, compression, bending, torsion or combinations of these stresses.

26. *What are the methods available to calculate the fatigue life?*

- The stress-life method
- The strain-life method
- The crack growth method
- Probabilistic methods

27. *What is role of SN curve in fatigue mechanism?*

- S-N curves are derived from tests on samples of the material to be characterized, where a regular sinusoidal stress is applied by a testing machine which also counts the number of cycles to failure.

TWO MARK QUESTION WITH ANSWER

1. ***Define NDT.***

- Non-destructive testing (NDT) is a testing and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or defects and discontinuities without causing damage to the original part.

2. ***Write importance of NDT.***

- To ensure product reliability
- To ensure the safety of operation
- To ensure customer satisfaction and to maintain the manufacturer's reputation
- To control manufacturing processes and lower manufacturing costs
- To maintain uniform quality level

3. ***What are the advantages of using NDT?***

1. Reusable
2. Safe
3. Accurate
4. Cost effective
5. Quality control

4. ***What are the major 5 NDT methods?***

The major 5 NDT Methods are:

- Ultrasonic Testing
- Radiography Testing
- Magnetic Particle Testing
- Dye Penetrant Testing
- Eddy Current Testing

5. ***What are stages in NDT testing?***

1. Testing
2. Recording & Reporting
3. Interpretation & Evaluation

6. *Define Borescope.*

- It is optical instrument for remove viewing of objects. Borescope can have various angles of view: 0° direct, 45° fore-oblique, 90° lateral and 110° retro.
- Borescope consist of precision illumination system.
- The size of the visual field usually varies with the diameter, for a given magnification system. The size of the visual field usually varies with the diameter, for a given magnification system.

7. ***What are the factors affecting the choice of NDT method***

- Cost
- Economic criteria.
- Feasibility of NDT methods available.
- Quality assurance level achieved.
- The minimum detectable flaw size, shape, and orientation of the defect
- The sensitivities and limitations of the NDT method
- The type of damage (flaw, defect, discontinuity) mechanism to be inspected.
- Type of material to be tested

8. ***What aids used for visual testing?***

- Magnifying glasses
- Fillet weld gauge-
- Microscopes
- Computer equipment (remote viewing)
- Illuminated magnifier
- Holography

9. ***Define liquid penetrant inspection***

- It is based on the properties of surface wetting and capillary action, which causes a liquid to rise when confined to a small opening. After applying the penetrant and wiping away the excess, the penetrant that rises to the surface can indicate surface-breaking.

10. *What is purpose penetrant in liquid penetrant inspection?*

- The liquid, by capillary action, will penetrate the discontinuities and the excess remaining on the surface will be removed by a suitable cleaning system. It will be highly visible or fluoresce brightly to produce easy to see indications.

11. *What is the role of developer in liquid penetrant inspection?*

- The role of the developer is to pull the trapped penetrant material out of defects and spread it out on the surface of the part so it can be seen by an inspector.

12. *Write the principle of working in magnetic particle testing?*

- This NDT process uses magnetic fields to find discontinuities at or near the surface of ferromagnetic materials. The magnetic field can be created with a permanent magnet or an electromagnet, which requires a current to be applied.
- The magnetic field will highlight any discontinuities as the magnetic flux lines produce leakage, which can be seen by using magnetic particles that are drawn into the discontinuity.

13. *What are type of magnetization in magnetic particle testing?*

Longitudinal magnetization- the magnetic flux flows from pole to pole, we call this longitudinal magnetisation. Discontinuities will be detectable once more at 90° (± 45°) to the flux direction.

Circular magnetization - Circular magnetic field will be produced around the component at right angles to the direction of the electric current which produced it.

14. *What are limitations of using magnetic particle testing?*

- The specimen must be ferromagnetic (e.g. steel, cast iron)
- Paint thicker than about 0.005" must be removed before inspection
- Post cleaning and post demagnetization is often necessary
- Insensitive to internal defects
- Require magnetization and demagnetization of materials to be inspected
- Require power supply for magnetization

- Coating may mask indication
- Material may be burned during magnetization

15. ***What are the major components used in thermography Method?***

- Thermographic camera
- Control unit
- Pc/image processing unit

16. ***Define Pulsed thermography***

It is a classical optical excitation thermography technique. In pulsed thermography, high-energy lamps are often used to produce a uniform heating source on the specimen surface.

17. ***What are the advantages of thermography Method compared to other NDT?***

- Data collection system can record temperature changes with time
- High-speed, portable, and non-contact
- Ability to inspect large areas
- Effective prevention of test scrap
- Contactless testing with low thermal stress

18. ***Define Radiographic Testing.***

- Radiographic Testing (RT) is a non-destructive testing (NDT) method which uses either x-rays or gamma rays to examine the internal structure of manufactured components identifying any flaws or defects.

19. ***How densities of material influence the radiographic testing?***

1. If an object has a high density, ie a thicker object, it absorbs more radiation causing less radiation to hit the film, which produces a lighter image.
2. If an object has a low density, ie when the through section is reduced or there is a lower-density material such as slag (compared to the surrounding material), it will absorb less radiation causing more radiation to hit the film, producing a darker image.

20. ***Define eddy current.***

- An electromagnetic inductor is used to generate a magnetic field. When this field is introduced in the surface of the test piece, it generates so called "eddy currents" in the material.

21. *Difference between Digital Radiography and Conventional Radiography.*

Digital Radiography	Conventional Radiography
It uses a digital detector to display radiographic images on a computer screen almost instantaneously.	It uses a sensitive film which reacts to the emitted radiation to capture an image of the part being tested.
It allows for a much shorter exposure time so that the images can be interpreted more quickly.	The limitation to this technique is that films can only be used once and they take a long time to process.

22. ***What are the types of Eddy current testing?***

- ❖ Pulsed Eddy Current (PEC)
- ❖ Tangential Eddy Current
- ❖ Conventional Eddy Current
- ❖ Eddy Current Array

23. ***How the eddy current used for finding defects in the material?***

- ❖ The electrical currents are called eddy currents because the flow in circles at and just below the surface of the material.
- ❖ Interruptions in the flow of eddy currents, caused by imperfections, dimensional changes, or changes in the materials conductive and permeability properties, can be detected with the proper equipment like probs.

24. ***What are the factors affecting eddy current inspection?***

- ❖ Material conductivity
- ❖ Permeability
- ❖ Frequency
- ❖ Geometry
- ❖ Proximity/Lift-Off
- ❖ Depth of Penetration
- ❖ Eddy Current Testing and Industry

25. ***What are various application of eddy current testing?***

- ❖ Weld Inspection

- ❖ Conductivity Testing
- ❖ Surface Inspection
- ❖ Corrosion Detection

26. *Define ultrasonic testing.*

- ❖ Ultrasonic testing (UT) is a non-destructive testing techniques based on the propagation of ultrasonic waves (high frequency sound waves) are transmitted into materials to detect internal flaws or to characterize materials

27. *What is the principle of working in acoustic emission test?*

- ❖ Acoustic Emission (AE) refers to the generation of transient elastic waves produced by a sudden redistribution of stress in a material.
- ❖ When a structure is subjected to an external stimulus (change in pressure, load, or temperature), localized sources trigger the release of energy, in the form of stress waves, which propagate to the surface and are recorded by sensors.

28. *Differentiate between Radiography, Eddy current and Ultrasonic.*

Parameter	Radiography	Eddy current	Ultrasonic
Source	X ray , δ ray	Magnetic field	Ultrasonic wave made by piezoelectric or laser
Material	All types of engineering materials that do not absorb the whole wavelength of the ray	Only conductive materials, not cellular materials	All type of engineering materials (metals or plastics)
Geometry	Suitable for complex weld geometry	Need for special probes for different geometries	Need for special probes for different geometries

Parameter	Radiography	Eddy current	Ultrasonic
Type of defects and position	Surface and subsurface defects, all types of flaws. Not suitable for very fine defects	Surface and subsurface defects. Not suitable for deep flaws. All types of flaws	Surface and subsurface defects. Suitable for deep flaws. All types of flaws
Advantages	Determine the position and type of defects, ability for automation	Portable. Suitable for poor access areas. No need for paint or coat removing. No consumable Materials	Determine the length, location and type of defects. Portable.
Limitations	Poor resolution. Access to both sides of the part is required. The size of defect is not accurate	Defect direction, conductive materials, clean and smooth enough surface required	Defect direction Sometimes access to both sides or ends of the detail is required
Applications	Crack detection in weld pipeline	Crack detection of coated weld pipeline, inspecting of fatigue crack	Spot welding control, inspection of SAW in pipeline
Weld process (Example)	Electric resistance welding Laser beam welding Electron beam welding Gas metal arc welding	Laser beam welding Gas metal arc welding Gas tungsten arc welding	Resistance spot welding Gas metal arc welding Friction stir welding Laser beam welding Electron beam welding

29. *Define Inherent discontinuities.*

- The discontinuities that originate during the initial casting process (when the metal is casted into ingots for further processing) and also it includes

the discontinuities that are produced when metal is casted as parts of any given shape.

30. ***What are the advantages of using acoustic emission test?***

- ❖ High sensitivity.
- ❖ Early and rapid detection of defects, flaws, cracks etc.
- ❖ Real time monitoring
- ❖ Cost Reduction
- ❖ Defective area location: only critical defects provide sustainable Acoustic Emission sources.

REVIEW QUESTIONS

1. What are the varies advantages of using NDT test?

   Ans: Section No. 3.1 **Page No:** 3.2

2. Compare and contrast the major NDT test with various parameters.

   Ans: Section No. 3.2.12 **Page No:** 3.52

3. Explain the visual test with aids used, advantages and disadvantages.

   Ans: Section No. 3.2.1 **Page No:** 3.5

4. Explain the penetration test with step process and its application.

   Ans: Section No. 3.2.2 **Page No:** 3.10

5. What do you understand by NDT test? And explain the role of Nondestructive testing in manufacture process.

   Ans: Section No. 3.1 **Page No:** 3.1

6. What do you understand by magnetic hysteresis? Explain different magnetization technique using magnetic particle testing with their advantages and disadvantages.

   Ans: Section No. 3.2.5 **Page No:** 3.16

7. Classify the NDT methods. Justify any three methods.

   Ans: Section No. 3.2 **Page No:** 3.3

TWO MARK QUESTIONS WITH ANSWERS

1. *Difference between microscopic and macroscopic observation.*

Microscopic Observation	Macroscopic Observation
Microscopic system is the one with objects or phenomena not visible with the naked eye and magnification instrument is necessary	**Macroscopic** system is the one with objects or phenomena visible with the naked eye and sometimes with magnifying instruments.
Scale of 1 to 100 nanometers and 1 to 1000 micro- meters	Scale of Millimeter to the kilometer scale
Needs very high magnification power	Needs very low magnification of 10x
The structural arrangement of atoms and bonds etc are observed	The appearance and physical arrangement is viewed by naked eye
This simple process can yield a large amount of information about the material such as ❖ The colour of the material ❖ Its lustre (does it display a metallic lustre) ❖ Its shape (whether it displays a regular, crystalline form) ❖ Its composition (is it made up of different phases) ❖ Its structural features (does it contain porosity) etc.	It is necessary because many of the properties of materials are dependent on extremely fine features and defects that are only possible to observe using one of the following techniques in this field.

2. *Define magnification*

❖ Magnification on a microscope refers to the amount or degree of visual enlargement of an observed object or enlargement of image.

- Magnification is measured by multiples, such as 2x, 4x and 10x, indicating that the object is enlarged to twice as big, four times as big or 10 times as big, respectively.

Magnification = Image ÷ Object

3. ***Define resolution.***
   - Resolution is defined as the ability to distinguish two very small and closely-spaced objects as separate entities.
   - Resolution is determined by certain physical parameters that include the wavelength of light, and the light-gathering power of the objective and condenser lenses.
4. ***What are the types lenses used in microscope?***
   - Objective lens
   - Ocular lens (eyepiece)
   - Condenser lens
5. ***Difference between optical and electron microscope.***

Optical Microscope	Electron Microscope
It uses the source of light.	The light source is replaced by a beam of very fast moving electrons
The minor work in specimen preparation	The specimen usually has to be specially prepared and held inside a vacuum air has been pumped out (because electrons do not travel very far in air).
Lens ,light source and reflective mirror is used	The lenses are replaced by a series of coil- shaped electromagnets through which the electron beam travels.
Low resolution and magnification (500x to 1000x)	High resolution and magnification (10000x app.)
Operation type is mechanical	Operation type is electrical
Relatively easy to carry and inexpensive	Relatively large and expensive

6. ***Give some common method of microscopic observation and macroscopic observation.***

Microscopic observation

- Optical Microscope
- Scanning Electron Microscope (SEM)
- Transmission Electron Microscope (TEM)
- Field Ion Microscope
- Scanning Tunneling Microscope

Macroscopic observation

- Mechanical testing, including tensile, compressive, torsional, creep, fatigue, toughness and hardness testing
- Differential thermal analysis
- Dielectric thermal analysis

7. ***Write major contrast between SEM and TEM***

Category	SEM	TEM
Source electrons	Scattered electrons	Transmitted electrons
Process of working	Scattering absorption	Diffraction
Energy	1-30kV	60-300kV
Environment	Air/vacuum	Vacuum
Specimen thickness	Any thickness	Typically less than 150nm
Output	3D image formation	2D projection image of inner structure
Magnification	2 million level magnification	50 million level magnification.
Image formation	Electron are captured and countered by detector image on PC	Direct image on fluorescent screen or PC screen with LCD
Amount of sample	Huge amount of sample	Minimum sample amount

8. ***Write principle of SEM and TEM***

- A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons.
- In **TEM**, an image is formed from the interaction of the electrons with the sample as the beam is transmitted through the specimen. The image is then magnified and focused onto an imaging device, such as a fluorescent screen, a layer of photographic film, or a sensor such as a scintillator attached to a charge-coupled device.

9. ***Why specimen preparation is important in microscopic technique.***

- Specimen preparation is important in any microscopic technique with proper preparation methods facilitating examination and interpretation of microstructural features.
- Improper preparation methods may obscure features, and even create artifacts that may be misinterpreted.

10. ***State the uses of scattered electrons in TEM .***

- **X-rays**-element and mineral information.
- **Secondary Electrons**-Secondary electron image for surface morphology
- **Backscattered Electrons**-This feature can be used to observe the topography of the surface.

11. ***State Difference between Diffraction and Inference.***

Inference	Diffraction
Interference is due to the super position of two different waves from coherent source	Diffraction is super position of secondary wavelets
Fringes width is constant	Fringes width are vary
Have same intensity	Have varying intensity

12. ***State Diffraction Principle.***

- **Bragg's law** is which determines the angles of coherent and incoherent scattering from a crystal lattice. When X-rays are incident on a particular atom, they make an electronic cloud move just like an electromagnetic wave.

13. ***Write the methods of Diffraction.***

1. Electron diffraction
2. Neutron diffraction
3. X-ray diffraction

14. ***Define spectroscopy.***

- Spectroscopy deals with the production, measurement, and interpretation of spectra arising from the interaction of electromagnetic radiation with matter.
- Spectroscopic methods are very informative and widely used for both quantitative and **qualitative analyses.**

15. ***What are the methods of Spectroscopy?***

- Ultraviolet-visible spectroscopy (UV-vis)
- Electron Spin Resonance spectroscopy
- Atomic spectroscopy
- infrared spectroscopy and Raman spectroscopy
- Mass spectrometry
- Nuclear spectroscopy(nuclear magnetic resonance)

16. ***Difference between Raman and IR spectroscopy.***

Raman spectroscopy	Infrared spectroscopy
It is due to the scattering of light by vibrating molecules	It is the result of absorption of light by vibrating molecules.
The vibration is active if it causes to change in polarizability	The vibration is active if it causes to change in dipole moment
The molecule need not possess a permanent dipole moment	The vibration concerned change in dipole moment due to vibration
Water can be used as solvent	Water cannot be used as intense absorption of IR
Sample preparation is not elaborate. Any state of sample is used	Sample preparation is elaborate. Gaseous sample can be rarely used. It diffused in

Raman spectroscopy	Infrared spectroscopy
ves an indication of covalent racter of molecule	Gives an ionic character in the molecule
st of instrument is high	Comparatively inexpensive
ak in intensity	Strong in intensity
tical system: Glass, quartz	Optical system: NaCl, KBr
cord by using a beam of nochromatic radiation	Record by using a beam of radiation having a large number of frequencies

17. *Write about types in IR spectroscopy.*

There are four types of instruments for infrared absorption measurements available:

- Dispersive grating spectrophotometers for qualitative measurements .
- Non dispersive photometers for quantitative determination of organic species in the atmosphere .
- Reflectance photometers for analysis of solids .
- Fourier transform infrared (FT-IR) instruments for both qualitative and quantitative measurements.

18. *Write about sample preparation in IR spectroscopy.*

- Sampling techniques for IR spectroscopy
- Gas sample - In sample tube of 10 cm length fitted with IR transparent holder
- Liquids - The think film formed between NaCl plates
- Solid - Pellet or as a Nujol mull (Nujol is a viscous mineral oil (hydrocarbon)) in which the solid is finely suspended

19. *Write objectives of material characterization.*

- To measure accurately the physical properties of materials
- To measure accurately the chemical properties of materials
- To determine accurately the structure of a material at atomic and microscopic level structures

TWO MARK QUESTIONS WITH ANSWERS

1. ***Define thermal analysis***

Thermal analysis is a form of analytical technique most commonly used in the branch of materials science where changes in the properties of materials are examined with respect to temperature.

2. ***List out various thermal properties***

- ❖ Thermo-Elastic Effect
- ❖ Specific heat
- ❖ Thermal expansion
- ❖ Thermal stress
- ❖ Thermal conductivity

3. ***What is meant by Dilatometer?***

A dilatometer is a scientific instrument that measures volume changes caused by a physical or chemical process. A familiar application of a dilatometer is the mercury-in-glass thermometer, in which the change in volume of the liquid column is read from a graduated scale.

4. ***Define Thermogravimetric analysis***

The Thermogravimetric analysis (TGA) is a type of thermo analytical testing performed on materials to determine changes in weight in relation to changes in temperature.

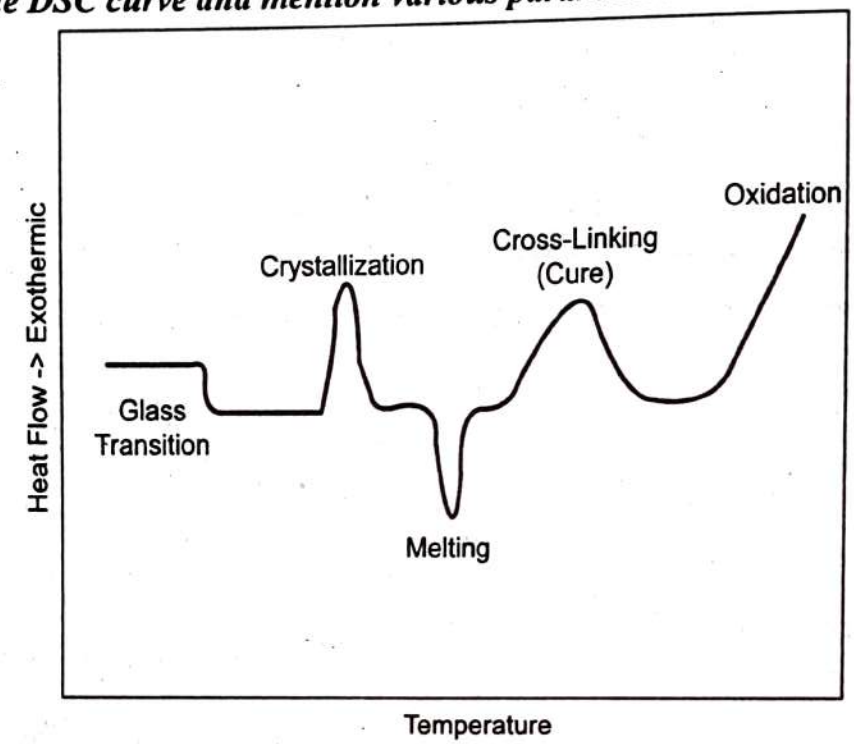
5. ***What is principle of working in Differential scanning calorimetry?***

Differential scanning calorimetry (DSC) is based on the principle; sample and reference are maintained at the same temperature, even during a thermal event (in the sample). The energy required maintaining zero temperature different between the sample and the reference is measured.

6. ***Write the methods of Differential scanning calorimetry***

- ❖ Heat flux DSC
- ❖ Power compensated DSC
- ❖ Modulated DSC
- ❖ Hyper DSC
- ❖ Pressure DSC

7. *Draw the DSC curve and mention various parameters in curve.*



8. *Define Differential thermal analysis.*

Differential thermal analysis (DTA) is a thermo-analytical technique which is used for thermal analysis where thermal changes can be studied. It is used to determine the oxidation process, decomposition, and loss of water or solvent.

9. *Write about detector used in Differential thermal analysis.*

Differential Temperature Detector (Thermogram), the main function of this detector is to measure differential temperature.

10. *Write limitation of Differential Temperature Detector*

1. There is lot of uncertainty in transition reactions and heat of fusions upto 20-50%
2. Destructive limited range of samples time consuming usually not qualitative.

11. *Define LVDT.*

Linear Variable Differential Transformer is a common type of electromechanical transducer that can convert the rectilinear motion of an object to which it is coupled mechanically into a corresponding electrical signal.

12. *Write the usage of LVDT in Differential thermal analysis*

Every displacement in pushrod of Differential thermal analysis is transformed into an analog signal by the LVDT, converted to digital form and then recorded in the computer system, and finally presented by the software as a dimensional change versus time or temperature.

13. ***Compare the merits and demerits of TMA, DSC, TGA.***

Technique	Employed for	Merits	Demerits
Thermomechanical analysis	Glass transition temperature, softening point, coefficient of linear thermal expansion	Straightforward method with high accuracy and applicable for all polymers	High cost
Differential scanning calorimetry	Crystalllinity, oxidation time, glass transition temperature	Limited for chlorinated polymers	High cost, qualitative result
Thermogravimetric analysis	Polymer additives, ash content, carbon black content, decomposition temperature	Straightforward method with high accuracy for all polymers	Qualitative

14. ***Write various advantages in Differential thermal analysis***

- ❖ Compactness and lightness
- ❖ Low operation voltage
- ❖ Measures large deformation
- ❖ Large actuation force
- ❖ Measures measure relaxation effects

15. ***Mention the various components of Dynamic Mechanical Analyser***

- ❖ Transducer Sensor (Linear Variable Displacement Transducer (LVDT)
- ❖ Drive shaft or probe

- ❖ Drive motor
- ❖ Stepper motor

16. *Difference between Drive motor and Stepper motor of DMA*

- ❖ Drive motor is a linear motor for probe loading which provides load for the applied force
- ❖ Stepper motor is controls the specimen dimension and measurement

17. *What are benefits of using DMA?*

- ❖ Very soft and hard samples are measured.
- ❖ Allows accurate temperature measurement.
- ❖ It can provide major and minor transitions of materials
- ❖ It is also more sensitive.
- ❖ It is able to quickly scan and calculate the modulus for a range of temperatures.

18. *Differentiate between TGA, DTA, DSC*

TGA	DTA	DSC
TGA is Thermogravimetric analysis	DTA is Differential thermal analysis	DSC is Differential scanning calorimetry
The change mass with change of temperature is analysed.	Temperature difference developed between the sample and reference is measured identically.	Heat flow is measured against temperature at particular time
Sample can be used as solid substance.	Sample can be used as solid substance.	Sample can be used as liquid substance.

19. *What are purposes of chemical analysis*

- ❖ Chemical Trace Analysis
- ❖ Elemental Trace Analysis
- ❖ Failure Analysis
- ❖ Contamination Analysis
- ❖ Materials Analysis and Testing
- ❖ Material Verification

20. *Define chromatography technique*

Chromatography is a technique for the separation of a mixture. The mixture is dissolved in a fluid called the mobile phase, which carries it through a structure holding another material called the stationary phase. The various constituents of the mixture travel at different speeds, causing them to separate.

21. *Define Wet Chemistry*

Wet Chemistry, also called wet chemical analysis, generally refers to chemistry performed on samples in the liquid phase. Since wet chemistry analysis is performed on liquid samples, this type of element analysis can often be performed on samples too small for other instrumental methods.

22. *How X Ray is utilized in XRF spectroscopy?*

X-ray fluorescence (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by being bombarded with high-energy X-rays or gamma rays.

23. *What are the types of XRF spectroscopy?*

- Energy Dispersive XRF (Direct and polarized excitation)
- Wavelength Dispersive XRF

24. *What are the limitations of XRF spectroscopy?*

- XRF analyses cannot distinguish variations among isotopes of an element.
- XRF analyses cannot distinguish ions of the same element in different valence states.
- Instrumentation is fairly expensive

25. *Define inductively coupled plasma.*

An inductively coupled plasma (ICP) or transformer coupled plasma (TCP) is a type of plasma source in which the energy is supplied by electric currents which are produced by electromagnetic induction, that is, by time-varying magnetic fields.

26. *Define Nebulizer*

Nebulizers are devices that convert a liquid into an aerosol that can be transported to the plasma. This process is one of the critical steps in ICP-OES. The ideal sample introduction system would be one that delivers the

entire sample to the plasma in a form that the plasma could reproducibly desolvate, vaporize, atomize and ionize, and excite. Types of Nebulizers,

- Pneumatic nebulizer
- Babington nebulizer
- Ultrasonic nebulizer

27. ***Compare contrast between ICP OES and ICP MS***

ICP OES	ICP MS
Inductively coupled plasma optical emission spectroscopy (ICP-OES)	Inductively coupled plasma mass spectrometry (ICP-MS)
Measurement of excited atoms and ions at the wavelength characteristics for the specific elements being measured	Measures an atom's mass by mass spectrometry
Detection limit for ICP-MS can extend to parts per trillion (ppt)	Detection limit for ICP-OES is parts per billion (ppb)
ICP-OES has much higher tolerance for TDS (up to 30%)	ICP-MS has much lower tolerance for TDS (about 0.2%) although there are ways to increase the tolerance.

28. ***Define Torches in ICP OES***

- It contains a ring-shaped toroidal plasma is formed, where the sample aerosol passes centrally through the hot plasma.
- The burner consists of three con- centric quartz tubes. The aerosol is led with its carrier gas through the central tube.

29. ***List out types of dispersing unit.***

- **Prism or diffraction gratings** - The grating provides dispersion of the wavelength range of interest over a given angular range.
- **Monochromators** - Multi-element determinations using a monochromator must be sequential, as the monochromator can observe only one line at a time owing to single secondary slit.