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B.Sc. IV SEM

PERSPECTIVES OF MODERN PHYSICS & BASIC ELECTRONICS

- Brief and Intensive Notes
- Multiple Choice Questions

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SYLLABUS

Subject: Physics	
Year: Second	**Semester:** Fourth
Course Code: B010401T	Course Title: **Perspectives of Modern Physics & Basic Electronics**
Unit	**Topics**
I	**Relativity-Experimental Background** Structure of space & time in Newtonian mechanics and inertial & non-inertial frames. Galilean transformations. Newtonian relativity. Galilean transformation and Electromagnetism. Attempts to locate the Absolute Frame: Michelson-Morley experiment and significance of the null result. Einstein's postulates of special theory of relativity.
II	**Relativity-Relativistic Kinematics** Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations (4-vector formulation included). Consequences of Lorentz Transformation Equations (derivations & examples included): Transformation of Simultaneity (Relativity of simultaneity); Transformation of Length (Length contraction); Transformation of Time (Time dilation); Transformation of Velocity (Relativistic velocity addition); Transformation of Acceleration; Transformation of Mass (Variation of mass with velocity). Relation between Energy & Mass (Einstein's mass & energy relation) and Energy & Momentum
III	**Inadequacies of Classical Mechanics** Particle Properties of Waves: Spectrum of Black Body radiation, Photoelectric effect, Compton effect and their explanations based on Max Planck's Quantum hypothesis. Wave Properties of Particles: Louis de Broglie's hypothesis of matter waves and their experimental verification by Davisson-Germer's experiment and Thomson's experiment.

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IV	**Introduction to Quantum Mechanics** Matter Waves: Principal of linear superposition, Mathematical representation, Wavelength, Concept of Wave group, Group velocity, Phase velocity and relation between Group & Phase velocities. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function.
V	**Transistor Biasing** Faithful amplification & need for biasing. Stability Factors and its calculation for transistor biasing circuits for CE configuration: Fixed Bias (Base Resistor Method), Emitter Bias (Fixed Bias with Emitter Resistor), Collector to Base Bias (Base Bias with Collector Feedback) &, Voltage Divider Bias. Discussion of Emitter-Follower configuration.
VI	**Amplifiers** Classification of amplifiers based on Mode of operation (Class A, B, AB, C & D), Stages (single & multi stage, cascade & cascade connections), Coupling methods (RC, Transformer, Direct & LC couplings), Nature of amplification (Voltage & Power amplification). Theory & working of RC coupled voltage amplifier (Uses of various resistors & capacitors, and Frequency response) and Transformer coupled power amplifier. Calculation of Amplifier Efficiency (power efficiency) for Class A Series-Fed, Class A Transformer Coupled, Class B Series-Fed and Class B Transformer Coupled amplifiers, Use of heat sink & Power dissipation
VII	**Feedback & Oscillator Circuits** Feedback Circuits: Effects of positive and negative feedback. Voltage Series, Voltage Shunt, Current Series and Current Shunt feedback connection types and their uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion, Noise and Band Width for Voltage Series negative feedback and their comparison between different negative feedback

	connection types. Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for selfsustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators (Tuned oscillator circuits): Hartley & Colpitt oscillators.
VIII	**Introduction to Fiber Optics** Basics of Fiber Optics, step index fiber, graded index fiber, light propagation through an optical fiber, acceptance angle & numerical aperture, qualitative discussion of fiber losses and applications of optical fibers.

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Unit I

Unit 1: Relativity - Experimental Background

Galilean Relativity: Principles and Applications

Galilean relativity is a fundamental concept in classical mechanics that describes the relationship between the motion of objects in different reference frames. It was first formulated by Galileo Galilei and later refined by Isaac Newton within the framework of Newtonian mechanics. This principle is essential in understanding how physical laws remain unchanged under a transformation between inertial reference frames.

Principle of Relativity

The principle of relativity states that the fundamental laws of physics are the same in all inertial reference frames. This means that no experiment conducted within an inertial frame can distinguish whether it is at rest or moving with a constant velocity relative to another inertial frame.

Galilean Transformations

Galilean transformations describe how the coordinates of an event change when observed from two different inertial reference frames moving at a constant velocity relative to each other. If one frame moves with velocity **v** relative to another, the transformation equations are:

- **Position:** $x' = x - vt$
- **Time:** $t' = t$
- **Velocity:** $v' = v - u$

where (x, t) are coordinates in the original frame, (x', t') are coordinates in the moving frame, and u is the velocity of an object in the original frame.

Implications of Galilean Relativity

1. **Addition of Velocities** The velocity of an object relative to one frame can be determined by simply adding or subtracting the velocity of the moving frame. This is given by:

   $$\mathbf{v' = v - u}$$

This principle is intuitive and applies to everyday experiences, such as the motion of passengers inside a moving train.

2. **Newtonian Mechanics Consistency** Galilean relativity aligns with Newton's laws of motion, particularly the second law (F = ma). Since acceleration remains unchanged under Galilean transformations, the equations of motion remain valid in all inertial frames.
3. **Invariance of Physical Laws** The form of Newton's equations and conservation laws (momentum, energy) do not change when shifting from one inertial frame to another using Galilean transformations.

Limitations of Galilean Relativity

While Galilean relativity is effective at low velocities, it fails when dealing with objects moving at speeds close to the speed of light. The major limitations include:

- **Failure to Explain Light's Behavior:** Unlike mechanical motion, the speed of light remains constant in all reference frames, which contradicts the classical addition of velocities.
- **Non-Applicability to Electromagnetism:** Maxwell's equations governing electromagnetism do not remain invariant under Galilean transformations.
- **Replaced by Special Relativity:** Albert Einstein introduced the theory of special relativity in 1905, modifying the transformation equations to Lorentz transformations, which account for the constancy of the speed of light and relativistic time dilation.

Applications of Galilean Relativity

Despite its limitations, Galilean relativity is widely applicable in scenarios where velocities are much lower than the speed of light. Some of its applications include:

- **Navigation and Transport:** Understanding the motion of vehicles, ships, and airplanes relative to Earth.
- **Engineering and Physics Experiments:** Designing structures and machines under Newtonian mechanics.
- **Astronomy (Pre-Relativity Era):** Describing planetary motion using Newtonian mechanics before the advent of relativity.

Conclusion

Galilean relativity forms the foundation of classical mechanics and provides a simple yet powerful way to analyze motion in different reference frames. While it is limited by its inability to handle relativistic effects, it remains a cornerstone of physics for most practical applications where speeds are non-relativistic. Its principles laid the groundwork for future developments in modern physics, leading to the more comprehensive framework of special relativity.

Objective Type Questions

1. For a person at rest on the ground, the path of a particle on the rim of a slowly moving wheel of a car will appear to be a:

(a) circle

(b) cycloid

(c) parabola

(d) straight-line

Answer: (b) cycloid

Explanation: For an observer at rest on the ground, a particle on the rim of a slowly moving wheel follows a path that combines circular motion (relative to the wheel) with the wheel's forward translational motion, resulting in a cycloid.

2. For a person situated at the centre of the wheel of a slowly moving car, the path of a particle on the rim of the wheel will appear to be a:

(a) hyperbola

(b) Circle

(c) parabola

(d) straight-line

Answer: (b) circle

Explanation: From the center of the wheel, the particle's motion is purely circular relative to that point, as the wheel's translational motion does not affect the relative path.

3. Galilean transformations relate coordinates between:

(a) two inertial frames

(b) two non-inertial frames

(c) one inertial and one non-inertial frame

(d) none of the above

Answer: (a) two inertial frames

Explanation: Galilean transformations connect coordinates between two inertial frames, which are frames moving at constant velocity relative to each other where Newton's laws hold.

4. The path of a projectile as seen by an observer at rest on the earth will appear to be a:

(a) parabola

(b) circle

(c) straight-line

(d) ellipse

Answer: (a) parabola

Explanation: A projectile under gravity follows a parabolic trajectory as seen by an observer at rest on Earth, due to constant horizontal velocity and vertical acceleration.

5. The path of a projectile as seen by an observer situated at another projectile will appear to be:

(a) cycloid

(b) ellipse

(c) straight-line

(d) parabola

Answer: (c) straight-line

Explanation: For an observer on another projectile with the same velocity, the relative motion is zero, making the path appear as a straight line.

6. The earth is an:

(a) inertial frame

(b) non-inertial frame

(c) sometimes inertial and sometimes non-inertial frame

(d) none of the above

Answer: (b) non-inertial frame

Explanation: Earth's rotation introduces accelerations (e.g., Coriolis and centrifugal forces), making it a non-inertial frame where Newton's first law does not strictly hold.

7. An inertial frame is:

(a) accelerated

(b) decelerated

(c) moving with uniform velocity or at rest

(d) may be accelerated, decelerated or moving with uniform velocity

Answer: (c) moving with uniform velocity or at rest

Explanation: An inertial frame has no acceleration, so it is either at rest or moving with uniform velocity, satisfying Newton's first law.

8. A frame moving with uniform velocity relative to an inertial frame is:

(a) inertial frame

(b) non-inertial frame

(c) inertial at daytime and non-inertial at night

(d) non-inertial at daytime and inertial at night

Answer: (a) inertial frame

Explanation: A frame moving with uniform velocity relative to an inertial frame remains inertial, as it experiences no acceleration.

9. Which of these quantities remain invariant under Galilean transformations?

(a) acceleration

(b) velocity

(c) momentum

(d) both **(b)** and **(c)**

Answer: (a) acceleration

Explanation: Acceleration is invariant under Galilean transformations (same in all inertial frames), while velocity and momentum change with relative motion.

10. The Foucault's pendulum demonstrates that:

(a) sun is inertial frame

(b) moon is inertial frame

(c) earth is non-inertial frame

(d) earth is inertial frame

Answer: (c) earth is non-inertial frame

Explanation: Foucault's pendulum precesses due to Earth's rotation, proving Earth is non-inertial as inertial frames do not exhibit such effects.

11. Galilean transformations violate:

(a) the first postulate of special relativity

(b) the second postulate of special relativity

(c) both the postulates of special relativity

(d) none of the postulates of special relativity

Answer: (b) the second postulate of special relativity

Explanation: Galilean transformations assume absolute time and do not preserve the constancy of light speed, violating the second postulate of special relativity.

12. Which of the following conservation principles remains invariant under Galilean transformations?

(a) law of conservation of energy

(b) law of conservation of momentum

(c) **(a)** and **(b)**

(d) none of the above

Answer: (c) (a) and **(b)**

Explanation: In classical mechanics, both energy and momentum conservation are invariant under Galilean transformations.

13. Michelson-Morley experiment was based upon:

(a) Interference of light

(b) diffraction of light

(c) polarisation of light

(d) refraction of light

Answer: (a) Interference of light

Explanation: The Michelson-Morley experiment relied on light interference to detect motion through the aether, yielding a null result.

14. The idea of absolute (or fundamental) frame of reference was given by:

(a) Epstein

(b) Galileo

(c) Newton

(d) Michelson

Answer: (c) Newton

Explanation: Newton introduced the concept of absolute space and time, implying a fundamental frame of reference.

15. Frames for which the law of inertia is valid are called:

(a) inertial

(b) rotational

(c) non-inertial

(d) none of these

Answer: (a) inertial

Explanation: Frames where Newton's first law (law of inertia) holds are defined as inertial frames.

16. Pseudo force appears to be acting on a particle in the:

(a) inertial frame

(b) non-inertial frame

(c) both inertial and non-inertial frames

(d) none of these

Answer: (b) non-inertial frame

Explanation: Pseudo forces (e.g., centrifugal force) appear in non-inertial frames due to acceleration, not in inertial frames.

17. Pseudo force acting on a particle in a non-inertial frame depends on:

(a) acceleration of the particle itself

(b) acceleration of the frame

(c) difference of particle and frame accelerations

(d) sum of particle and frame accelerations

Answer: (b) acceleration of the frame

Explanation: Pseudo forces in a non-inertial frame are proportional to the frame's acceleration, not the particle's motion.

18. The reference frames where fundamental laws of physics are invariant are called:

(a) rotational frames

(b) inertial frames

(c) accelerated frames

(d) frames attached to earth

Answer: (b) inertial frames

Explanation: Fundamental laws of physics remain invariant in inertial frames, per the classical principle of relativity.

19. Which of these is not invariant under Galilean transformations?

(a) velocity

(b) electric field

(c) current density

(d) all of these

Answer: (a) velocity

Explanation: Velocity transforms under Galilean transformations ($v' = v - u$), while electric fields are not part of this framework.

20. Which of these quantities remain invariant under Galilean transformations?

(a) charge density

(b) velocity

(c) current density

(d) electric field

Answer: (a) charge density

Explanation: Charge density is invariant in classical mechanics under Galilean transformations, unlike velocity or electromagnetic quantities.

21. Which of these statements is incorrect about Newtonian mechanics?

(a) no upper limit on the speed attainable by particles

(b) Newtonian mechanics works well for

(c) space and time are two separate entities

(d) space has a fixed orientation

Answer: (b) Newtonian mechanics works well for

Explanation: The option is incomplete, but Newtonian mechanics applies to low speeds and macroscopic scales; other options reflect relativistic concepts.

22. The three-dimensional space of Newtonian mechanics is:

(a) Vector space

(b) Minkowski space

(c) Absolute space

(d) Euclidean space

Answer: (d) Euclidean space

Explanation: Newtonian mechanics assumes a three-dimensional Euclidean space, not Minkowski space (relativity).

23. The most satisfactory explanation of negative results of Michelson-Morley experiment was given by:

(a) Michelson

(b) Lorentz and Fitzgerald

(c) Einstein based on constancy of c

(d) Newton

Answer: (c) Einstein based on constancy of c

Explanation: Einstein's special relativity, with the constant speed of light, explained the Michelson-Morley null result, unlike classical theories.

24. Correct relation in Galilean transformation for relative motion along +y-axis is:

(a) y' = y - vt

(b) y' = y + vt

(c) y' = y

(d) $y' = y - \frac{v}{t}$

Answer: (c) y' = y

Explanation: For motion along the y-axis, Galilean transformations leave perpendicular coordinates (y) unchanged.

25. The trajectory of a particle on the rim of a wheel moving at constant velocity, as seen by an observer at rest on the ground, is a:

(a) Spiral

(b) Hypocycloid

(c) Epicycloid

(d) Cycloid

Answer: (d) Cycloid

Explanation: Same as Q1: the combination of circular and translational motion yields a cycloid for a ground observer.

26. If a projectile is launched horizontally from a moving vehicle, as seen by an observer in the vehicle, its path appears to be:

(a) A parabola

(b) A straight line

(c) A circle

(d) A hyperbola

Answer: (b) A straight line

Explanation: From the vehicle's frame, a horizontally launched projectile has no relative vertical motion, appearing as a straight line.

27. A non-inertial frame is one that is:

(a) Moving at constant velocity

(b) Accelerating

(c) At rest

(d) Rotating at a constant speed

Answer: (b) Accelerating

Explanation: A non-inertial frame is accelerating or rotating, where Newton's first law does not hold without pseudo forces.

28. The Galilean transformation equations assume:

(a) The speed of light is constant in all frames

(b) Space and time are absolute

(c) Time dilation occurs

(d) Length contraction occurs

Answer: (b) Space and time are absolute

Explanation: Galilean transformations treat space and time as absolute, unlike special relativity's relative framework.

29. The Earth is approximately an inertial frame for:

(a) High-speed experiments

(b) Large-scale astronomical events

(c) Local everyday mechanics

(d) None of these

Answer: (c) Local everyday mechanics

Explanation: Earth approximates an inertial frame for small-scale, low-speed daily phenomena, despite its rotation.

30. The Galilean transformation does not hold true for:

(a) Newton's laws of motion

(b) Electromagnetic waves

(c) Classical mechanics

(d) Fluid dynamics

Answer: (b) Electromagnetic waves

Explanation: Galilean transformations fail for electromagnetic waves, where special relativity's constant c applies.

31. Which of the following is true in an inertial frame?

(a) Pseudo forces are always present

(b) Newton's first law holds

(c) Acceleration due to gravity is zero

(d) Time flows at different rates

Answer: (b) Newton's first law holds

Explanation: In an inertial frame, objects move uniformly or remain at rest unless acted upon, per Newton's first law.

32. An object in free fall appears to be at rest when viewed from:

(a) An observer in another free-falling frame

(b) An observer on Earth

(c) An observer in an inertial frame

(d) An observer at the center of the Earth

Answer: (a) An observer in another free-falling frame

Explanation: In free fall, relative acceleration is zero, so the object appears at rest to another free-falling observer.

33. The principle of relativity in classical mechanics states that:

(a) The laws of physics are different in all frames

(b) The laws of physics are the same in all inertial frames

(c) Space and time are relative

(d) Motion is absolute

Answer: (b) The laws of physics are the same in all inertial frames

Explanation: This is the classical principle of relativity, foundational to Galilean transformations.

34. Which of these transforms incorrectly under Galilean transformations?

(a) Time

(b) Length

(c) Electric field

(d) Momentum

Answer: (c) Electric field

Explanation: Electric fields transform under relativistic conditions, not Galilean mechanics, which focuses on mechanical quantities.

35. Newtonian mechanics fails at:

(a) High speeds close to the speed of light

(b) Large distances

(c) Small velocities

(d) Macroscopic scales

Answer: (a) High speeds close to the speed of light

Explanation: Newtonian mechanics fails at relativistic speeds, where special relativity corrects for effects like time dilation.

36. Which frame of reference is considered a preferred frame in Newtonian mechanics?

(a) The center of mass frame

(b) The Earth's surface

(c) An absolute space

(d) Any inertial frame

Answer: (c) An absolute space

Explanation: Newtonian mechanics assumes an absolute space as a universal reference, unlike relativity.

37. Which of the following transformations hold true under Galilean relativity?

(a) $x' = x + vt$

(b) $y' = y - vt$

(c) $z' = z + 2vt$

(d) $t' = t + v$

Answer: (a) $x' = x + vt$

Explanation: This is the standard Galilean transformation for position along the x-axis with relative velocity v.

38. Which of the following remains unchanged in Galilean transformations?

(a) Speed of light

(b) Acceleration

(c) Time dilation

(d) Length contraction

Answer: (b) Acceleration

Explanation: Acceleration remains unchanged under Galilean transformations, unlike velocity.

39. The velocity addition rule in Galilean transformation is given by:

(a) $u' = u + v$

(b) $u' = u - v$

(c) $u' = u/v$

(d) $u' = uv$

Answer: (a) $u' = u + v$

Explanation: Galilean velocity addition simply adds the velocities of the object and frame.

40. The Michelson-Morley experiment was designed to detect:

(a) Time dilation

(b) Length contraction

(c) The motion of Earth through the aether

(d) The speed of sound in air

Answer: (c) The motion of Earth through the aether

Explanation: The Michelson-Morley experiment aimed to detect Earth's motion through a hypothetical aether, finding no evidence.

41. The Lorentz transformation differs from the Galilean transformation because it includes:

(a) The constancy of acceleration

(b) The relativity of simultaneity

(c) The non-invariance of time

(d) The expansion of space

Answer: (b) The relativity of simultaneity

Explanation: Lorentz transformations account for the relativity of simultaneity, absent in Galilean transformations.

42. Which of the following statements about Foucault's pendulum is correct?

(a) It does not work in space

(b) It provides evidence for the Earth's rotation

(c) It requires an inertial frame to function

(d) It demonstrates time dilation

Answer: (b) It provides evidence for the Earth's rotation

Explanation: Foucault's pendulum precesses due to Earth's rotation, a non-inertial effect.

43. A pseudo force is necessary in:

(a) Inertial frames

(b) Non-inertial frames

(c) Both inertial and non-inertial frames

(d) Relativistic mechanics

Answer: (b) Non-inertial frames

Explanation: Pseudo forces are introduced in non-inertial frames to explain observed motion.

44. The acceleration transformation under Galilean transformation is given by:

(a) a' = a

(b) a' = a + v

(c) a' = a - v

(d) a' = 0

Answer: (a) a' = a

Explanation: Acceleration is invariant under Galilean transformations, as time is absolute.

45. Which of these conservation principles is affected by Galilean transformations?

(a) Conservation of energy

(b) Conservation of momentum

(c) Conservation of charge

(d) None of the above

Answer: (d) None of the above

Explanation: Conservation laws (energy, momentum, charge) hold under Galilean transformations in classical mechanics.

46. If a person is moving in a train with a velocity v and throws a ball with velocity u, the velocity of the ball with respect to an observer on the ground is:

(a) u − v

(b) u + v

(c) u/v

(d) u × v

Answer: (b) u + v

Explanation: Galilean velocity addition gives the ball's velocity relative to the ground as the sum of the train's and ball's velocities.

47. A frame in which Newton's first law is not valid is called:

(a) An inertial frame

(b) A non-inertial frame

(c) A Galilean frame

(d) A Lorentz frame

Answer: (b) A non-inertial frame

Explanation: Newton's first law fails in a non-inertial frame due to acceleration or rotation.

48. Newtonian mechanics assumes that:

(a) The speed of light is absolute

(b) Space and time are independent

(c) Length contraction occurs

(d) Time dilation occurs

Answer: (b) Space and time are independent

Explanation: Newtonian mechanics treats space and time as separate, absolute entities.

49. The idea that space and time are absolute is a concept from:

(a) Special relativity

(b) Newtonian mechanics

(c) Quantum mechanics

(d) General relativity

Answer: (b) Newtonian mechanics

Explanation: Absolute space and time are key assumptions of Newtonian mechanics.

50. The Foucault pendulum proves that:

(a) The Earth is an inertial frame

(b) The Sun is an inertial frame

(c) The Earth rotates

(d) The Earth does not rotate

Answer: (c) The Earth rotates

Explanation: Foucault's pendulum's precession directly demonstrates Earth's rotation.

51. In Galilean relativity, the speed of light is:

(a) Constant in all frames

(b) Variable depending on motion

(c) Infinite

(d) Independent of motion

Answer: (b) Variable depending on motion

Explanation: In Galilean relativity, light speed varies with the source's motion, unlike special relativity's constant c.

52. The principle of relativity states that:

(a) The speed of light is constant in all frames

(b) Laws of physics are the same in all inertial frames

(c) Space and time are absolute

(d) All motion is absolute

Answer: (b) Laws of physics are the same in all inertial frames

Explanation: This is the classical principle of relativity underpinning Galilean mechanics.

53. The Newtonian concept of absolute time means that:

(a) Time flows differently in different frames

(b) Time flows at the same rate in all frames

(c) Time depends on motion

(d) Time does not exist

Answer: (b) Time flows at the same rate in all frames

Explanation: Newtonian mechanics assumes absolute time, uniform across all frames.

Unit II

Unit 2: Relativity - Relativistic Kinematics

Special Theory of Relativity

The special theory of relativity was introduced by Albert Einstein in 1905, revolutionizing physics by redefining our understanding of space and time. This theory applies to inertial frames, where the laws of physics remain the same and the speed of light is a universal constant.

Inertial and Non-Inertial Frames

Special relativity specifically deals with problems in inertial frames, meaning reference frames moving at constant velocity with respect to each other. Non-inertial frames, which involve acceleration, are handled in general relativity.

Lorentz Transformations

To describe the relationships between space and time coordinates in different inertial frames moving relative to each other at a constant velocity, Lorentz transformations are used. These transformations reduce to Galilean transformations when the relative velocity between the frames approaches zero.

Length Contraction

According to special relativity, an object in motion relative to an observer experiences a contraction in its length, but only in the direction of motion. This effect becomes significant at relativistic speeds (close to the speed of light). The apparent length of an object decreases as observed by a stationary observer.

Time Dilation

A moving clock appears to tick slower when observed from a stationary reference frame. This phenomenon, known as time dilation, means that the proper lifetime of a particle or object is measured in its own rest frame. The observed lifetime increases in a moving frame due to time dilation.

Velocity Addition in Special Relativity

When two objects move toward each other at relativistic speeds, their relative velocity is not simply the sum of their individual velocities but follows the relativistic velocity addition formula. This ensures that no object can exceed the speed of light.

Energy-Mass Equivalence

Einstein's famous equation, $\mathbf{E = mc^2}$, states that mass and energy are equivalent. A mass of 1 kg corresponds to an enormous amount of energy, approximately $\mathbf{9 \times 10^{16}}$ **Joules**. Massless particles, such as photons, must always travel at the speed of light.

Momentum of Massless Particles

For a massless particle like a photon, momentum is given by the equation $\mathbf{p = E/c}$. Unlike classical mechanics, where momentum is defined as mass times velocity, relativistic momentum takes into account the energy of massless particles.

Pair Production

For the creation of an electron-positron pair, the minimum energy required is 1.02 MeV. This is the energy threshold for a gamma-ray photon to produce an electron and a positron.

Relativistic Mass Increase

As an object's speed approaches the speed of light, its relativistic mass increases. When the velocity of a moving particle reaches a specific value, its mass doubles compared to its rest mass.

Shape Distortion at Relativistic Speeds

Objects moving at relativistic speeds undergo apparent shape distortions due to length contraction. A square moving at high speeds appears as an ellipse, while a cube appears as a cuboid.

Simultaneity in Relativity

Simultaneity is relative and depends on the observer's frame of reference. Two events that are simultaneous in one frame may not be simultaneous in another.

Space-Time Intervals

The classification of space-time intervals depends on the relationship between spatial distance and time separation:

- **Space-like Interval:** When the spatial distance is greater than the time interval multiplied by the speed of light.
- **Time-like Interval:** When the time interval multiplied by the speed of light is greater than the spatial distance.
- **Light-like (Singular) Interval:** When the space-time interval is zero, meaning the events are connected by a light signal.

Minkowski Space

Minkowski space is a four-dimensional space combining three spatial dimensions and one time dimension. Lorentz transformations can be understood as hyperbolic rotations in Minkowski space, with angles involving imaginary numbers.

Lorentz Transformation Properties

Lorentz transformations are:

- **Linear**
- **Orthogonal transformations**
- **Space and time are placed on equal footing**
- **Not equivalent to parabolic rotation**

Length Contraction and Percentage Reduction

The percentage contraction in the length of an object moving at relativistic speeds depends on its velocity. For example, at **0.9c**, a rod's length contracts by approximately **43%**.

Experimental Evidence of Time Dilation

Particles such as muons, which have a short proper lifetime, are observed to live longer when moving at relativistic speeds, confirming time dilation.

Conclusion

Special relativity fundamentally alters our understanding of space, time, and motion. It introduces concepts like length contraction, time dilation, energy-mass equivalence, and the relativity of simultaneity. These principles have been experimentally verified and are essential in modern physics, including particle physics and cosmology.

Okay, here's the text content with brief explanations for each heading:

Objective Type Questions

1. Special theory of relativity was given by Einstein in the year:

(a) 1911

(b) 1905

(c) 1896

(d) 1892

Answer: (b) 1905

Explanation: Einstein published his special theory of relativity in 1905, revolutionizing physics.

2. Special theory of relativity deals with problems in:

(a) Inertial frames

(b) Non-inertial frames

(c) Both inertial and non-inertial frames

(d) None of the above

Answer: (a) Inertial frames

Explanation: Special relativity applies to inertial frames, where physical laws and the speed of light are consistent.

3. The correct transformations between two inertial frames that are consistent with both of the postulates of special relativity are:

(a) Legendre transformations

(b) Galilean transformations

(c) Lorentz transformations

(d) Canonical transformations

Answer: (c) Lorentz transformations

Explanation: Lorentz transformations satisfy both postulates of special relativity: invariance of laws and constancy of c.

4. The Lorentz transformations reduce to Galilean transformations when v tends to:

(a) zero

(b) infinity

(c) one

(d) half

Answer: (a) zero

Explanation: As v approaches 0, Lorentz transformations reduce to Galilean transformations ($v \ll c$).

5. The contraction in the length of an object due to relative motion between the object and the observer takes place:

(a) along the direction of motion

(b) perpendicular to the direction of motion

(c) both along and perpendicular to the direction of motion

(d) at 45° to the direction of motion

Answer: (a) along the direction of motion

Explanation: Length contraction occurs only in the direction parallel to relative motion, per special relativity.

6. A moving object, to a stationary observer, appears to be:

(a) increased in length

(b) no change in length

(c) decreased in length

(d) nothing can be said definitely

Answer: (c) decreased in length

Explanation: A moving object contracts in length along its motion direction as seen by a stationary observer.

7. The apparent length of a meter rod, when it is moving at a speed 0.8c relative to an observer, will be:

(a) 1 m

(b) 0.5 m

(c) 0.8 m

(d) 0.6 m

Answer: (d) 0.6 m

8. A moving clock appears to a stationary observer:

(a) slow

(b) fast

(c) keeping correct time

(d) none of the above

Answer: (a) slow

Explanation: Time dilation causes a moving clock to tick slower as observed by a stationary observer.

9. The proper lifetime of muons is their lifetime in the:

(a) Moving frame at a speed

(b) Moving frame at a speed c

(c) Rest frame

(d) Frame moving at a speed of

Answer: (c) Rest frame

Explanation: Proper lifetime is the time measured in the particle's own rest frame.

10. The proper lifetime of muons is 2.2 μs, and they move at a speed of 0.998c relative to the lab (earth) frame. Their lifetime in the lab frame would be:

(a) 2.2×10^{-6} s

(b) 1.0×10^{-6} s

(c) 34.38×10^{-6} sec

(d) zero

Answer: (c) 34.38×10^{-6} sec

11. Two particles are moving in opposite directions each with a velocity of 0.9c relative to a stationary observer. The speed of one particle relative to the other will be:

(a) 0.994 c

(b) 0.715 c

(c) 1.8 c

(d) 1.2 c

Answer: (a) 0.994 c

12. When a velocity c is added to another velocity c relativistically, the resultant velocity will be:

(a) 0.5 c

(b) 0.75 c

(c) 2 c

(d) c

Answer: (d) c

Explanation: Relativistically, adding c to c yields c, as no speed exceeds the speed of light.

13. One kilogram of mass is equivalent to an energy of:

(a) 9×10^{16} Joules

(b) 3×10^{16} Joules

(c) 1.6×10^{-19} Joules

(d) 3×10^{8} Joules

Answer: (a) 9×10^{16} Joules

14. Massless particles must move with a velocity of:

(a) 0.1c

(b) 0.5c

(c) 2c

(d) c

Answer: (d) c

Explanation: Massless particles, like photons, must travel at the speed of light, c.

15. The momentum of massless particles is given by:

(a) E/c

(b) E^2 / c

(c) 2E/c

(d) $E^2 / 2c$

Answer: (a) E/c

16. The rest mass energy of electrons is:

(a) 1.6×10^{-19} Joules

(b) 9×10^{16} Joules

(c) 0.51 MeV

(d) 1.02 MeV

Answer: (c) 0.51 MeV

17. The minimum energy required for a gamma-ray photon for the creation of an electron and a positron is:

(a) 0.51 MeV

(b) 1.02 MeV

(c) 2 MeV

(d) 5 MeV

Answer: (b) 1.02 MeV

18. The speed at which the mass of a moving particle becomes double its rest mass, is:

(a) $\sqrt{3\,c}$

(b) $\sqrt{2\,c}$

(c) $\frac{c}{2}$

(d) $\frac{\sqrt{3}}{2}c$

Answer: (d)

19. The percentage contraction in the length of a rod when it is moving at a speed of 0.8c in a direction inclined at 60° to its length will approximately be:

(a) 9

(b) 21

(c) 4

(d) 14

Answer: (d) 14

20. The shape of a square moving at relativistic speed relative to a stationary observer appears to be:

(a) circle

(b) ellipse

(c) point

(d) rectangle

Answer: (b) ellipse

Explanation: A square contracts along the motion direction, distorting into an ellipse for a stationary observer.

21. A circle is moving at relativistic speed relative to a stationary observer. Its shape appears to be:

(a) ellipse

(b) straight line

(c) square

(d) circle

Answer: (a) ellipse

Explanation: A circle contracts along one axis due to motion, appearing as an ellipse.

22. The length of a space ship is measured to be exactly half of its proper length by an observer. The relative velocity of the observer is:

(a) $\frac{1}{2}c$

(b) $\frac{\sqrt{2}}{3}c$

(c) $\frac{\sqrt{3}}{2}c$

(d) $\frac{1}{\sqrt{2}}\,c$

Answer: (c)

23. If the total energy of a particle of mass m is equal to twice its rest energy, the magnitude of the particle's relativistic momentum is:

(a) $\frac{mc}{2}$

(b) $\frac{mc}{\sqrt{2}}$

(c) mc

(d) $\sqrt{3}\,mc$

Answer: (d)

24. If a charged pion that decays in 10^{-8} sec in its own rest frame is to travel 30 meters in the laboratory before decaying, the pion's speed must be most nearly:

(a) 0.43 x 10^8 m/sec

(b) 2.84 x 10^8 m/sec

(c) 2.90 x 10^8 m/sec

(d) 2.98 x 10^8 m/sec

Answer: (c) 2.90 x 10^8 m/sec

25. A train 100 m in length when at rest is moving with velocity of 0.8c. Its length as seen by a stationary observer is:

(a) 40 m

(b) 60 m

(c) 100 m

(d) 120 m

Answer: (b) 60 m

26. In the laboratory, the lifetime of a particle moving with velocity 2.8 x 10^8 m/sec is found to be 2.5 x 10^{-7} sec. Its proper lifetime is:

(a) 3 x 10^{-8} sec

(b) 0.9 x 10^{-7} sec

(c) 3.5 x 10^{-7} sec

(d) 2.0 x 10^{-6} sec

Answer: (b) 0.9 x 10^{-7} sec

27. A particle leaving a cyclotron has a total relativistic energy of 10 GeV and a relativistic momentum of 9 GeV/c. What is the rest mass of this particle?

(a) 0.25 GeV/c^2

(b) 1.20 GeV/c^2

(c) 4.36 GeV/c^2

(d) 6.00 GeV/c^2

Answer: (c) 4.36 GeV/c^2

28. A tube of water is travelling at $\frac{1}{2c}$ relative to the lab frame when a beam of light travelling in the same direction as the tube, enters it. What is the speed of light in the water relative to the lab frame?

(The index of refraction of water is 4/3).

(a) $\frac{1}{2c}$

(b) $\frac{2}{3c}$

(c) $\frac{5}{6c}$

(d) $\frac{10}{11c}$

Answer: (d)

29. The speed of an electron having kinetic energy 2 MeV will be:

(a) 2.93 x 10^8 m/sec

(b) 3 x 10^8 m/sec

(c) 1.0 x 10^8 m/sec

(d) 1.5 x 10^8 m/sec

Answer: (a) 2.93 x 10^8 m/sec

30. A π^+-meson decays into a μ^+-meson and a neutrino with a mean lifetime of about 2.5 x 10^{-8} sec in a frame in which it is at rest. If velocity of the π^+-mesons in the laboratory frame be 0.9c, then expected lifetime in this frame is:

(a) 5.7 x 10^{-8} sec

(b) 2.5 x 10^{-8} sec

(c) 3.1 x 10^{-8} sec

(d) none of these

Answer: (a) 5.7 x 10^{-8} sec

31. An electron has a velocity 0.8c. Its energy will be:

(a) 3.6 MeV

(b) 0.85 MeV

(c) 31 MeV

(d) 0.031 MeV

Answer: (b) 0.85 MeV

32. Rest mass of an electron is m_o and its velocity is c/ $\sqrt{2}$. Its momentum is:

(a) $\frac{m_o c}{\sqrt{2}}$

(b) $m_o c$

(c) $\sqrt{2}\, mo\ c$

(d) none of these

Answer: (b) m_o c

33. The speed of a rocket relative to an observer for which its length appears to be contracted to 99% of its length at rest would be:

(a) 0.04 c

(b) 0.14 c

(c) 0.24 c

(d) 0.7 c

Answer: (b) 0.14 c

34. The length of a rod, of length 5 m in a frame of reference which is moving with velocity 0.6c in a direction making 30° angle with the rod is nearly:

(a) 4.3 m

(b) 3.4 m

(c) 2.43 m

(d) 2.34 m

Answer: (a) 4.3 m

35. For space-like interval, we must have:

(a) $\frac{r_{12}}{c} > (t_2 - t_1)$

(b) $\frac{r_{12}}{c} < (t_2 - t_1)$

(c) $\frac{r_{12}}{c} = (t_2 - t_1)$

(d) none of these

Answer: (a) $\frac{r_{12}}{c} > (t_2 - t_1)$

36. Minkowski space is:

(a) two-dimensional

(b) three-dimensional

(c) four-dimensional

(d) infinite-dimensional

Answer: (c) four-dimensional

Explanation: Minkowski space combines three spatial dimensions and one time dimension.

37 Lorentz transformations are equivalent to a rotation of axes in Minkowski, space through an angle:

(a) $\cos^{-1}\frac{iv}{c}$

(b) $\sin^{-1}\frac{iv}{c}$

(c) $\sin^{-1}\frac{v}{c}$

(d) $\tan^{-1}\frac{iv}{c}$

Answer: (d) $\tan^{-1}\frac{iv}{c}$

38. Which of these statements is incorrect with regard to Lorentz transformation?

(a) orthogonal transformations

(b) space and time are placed on equal footing

(c) are linear

(d) equivalent to parabolic rotation

Answer: (d) equivalent to parabolic rotation

Explanation: Lorentz transformations are hyperbolic, not parabolic, rotations in Minkowski space.

39. Space-time interval is time-like when :

(a) $(t_2 - t_1) > \frac{r_{12}}{c}$

(b) $(t_2 - t_1) = \frac{r_{12}}{c}$

(c) $(t_2 - t_1) < \frac{r_{12}}{c}$

(d) $t_2 - t_1 = 0$

Answer: (c) $(t_2 - t_1) < \frac{r_{12}}{c}$

40. Space-time interval is light-like when :

(a) $r_{12}^2 < c^2 (t_2 - t_1)^2$

(b) $r_{12}^2 = c^2 (t_2 - t_1)^2$

(c) $r_{12}^2 > c^2 (t_2 - t_1)^2$

(d) none of the above

Answer: (b) $r_{12}^2 = c^2 (t_2 - t_1)^2$

41. Space-time interval is called singular if it is:

(a) space-like

(b) time-like

(c) light-like

(d) none of these

Answer: (c) light-like

Explanation: A singular interval typically refers to light-like (null) separation.

42. Two events are simultaneous in the two inertial frames of reference in relative motion if they occur at:

(a) same place and time

(b) same place but different time

(c) different place but same time

(d) different place and time

Answer: (c) different place but same time

Explanation: Simultaneity in relativity depends on the frame; events at different places can be simultaneous in one frame.

43. Simultaneity is a:

(a) absolute concept

(b) relative concept

(c) sometimes absolute and sometimes relative

(d) absolute in inertial frames and relative in non-inertial frames

Answer: (b) relative concept

Explanation: Simultaneity is relative in special relativity, varying between inertial frames.

44. Which of these is not invariant under Lorentz transformations?

(a) space-time interval

(b) acceleration

(c) $E^2 - p^2c^2$

(d) velocity

Answer: (d) velocity

45. According to special relativity, how does the length of a moving object appear to an observer in a different inertial frame?

(a) Longer than its proper length

(b) Shorter than its proper length

(c) Same as its proper length

(d) Infinite

Answer: (b) Shorter than its proper length

Explanation: Due to relativistic length contraction, an observer moving relative to an object will measure its length as shorter than its proper length.

46. For an object, the proper length is:

(a) Maximum length

(b) Zero

(c) Minimum length

(d) Infinite

Answer: (a) Maximum length

Explanation: Proper length is the length measured in the object's rest frame, the maximum value.

47. For Lorentz transformations:

(a) sin θ = i

(b) sin θ = -i

(c) sin θ = i

(d) None of these

Answer: (c) sin θ = i

Explanation: Lorentz transformations involve imaginary rotations in complex form.

48. The percentage contraction in the length of a rod moving at a speed of 0.9c along its own length is approximately:

(a) 10

(b) 43

(c) 29

(d) 57

Answer: (b) 43

49. A cube moving at a relativistic speed relative to a stationary observer appears as:

(a) Sphere

(b) Cuboid

(c) Flat plane

(d) Trapezium

Answer: (b) Cuboid

Explanation: A cube contracts along the motion direction, appearing as a cuboid.

50. The length contraction effect in special relativity is observed:

(a) In all directions of motion

(b) Only in the direction of motion

(c) Perpendicular to the direction of motion

(d) Independent of motion

Answer: (b) Only in the direction of motion

Explanation: Length contraction occurs only along the direction of relative motion.

Unit III

Unit 3: Inadequacies of Classical Mechanics

Black Body Radiation and Wien's Displacement Law

- **Relationship between peak wavelength and temperature:** Wien's Displacement Law states that the peak wavelength of radiation emitted by a black body is inversely proportional to its absolute temperature. This helps determine the temperature of an object based on its emitted light.
- **Stefan-Boltzmann Law and power emitted per unit area:** This law relates the total energy radiated per unit surface area of a black body to the fourth power of its absolute temperature. It explains how hotter objects emit significantly more radiation.
- **Determining spectral range of black body radiation:** By applying Wien's Displacement Law, we can identify the portion of the electromagnetic spectrum (e.g., infrared, visible, ultraviolet) where a black body's radiation intensity is highest at a given temperature.

Compton Scattering

- **Interaction of photons with electrons:** Compton scattering describes the collision between a photon and a free electron, resulting in the photon losing some energy and changing direction.
- **Conservation of energy and momentum:** The principles of energy and momentum conservation are crucial in analyzing Compton scattering, as they dictate the changes in photon and electron energies and momenta.
- **Compton shift formula and scattering angle:** The Compton shift formula ($\Delta\lambda$=mch $(1-\cos\phi)$) quantifies the change in photon wavelength based on the scattering angle (ϕ), demonstrating the particle-like behavior of light.
- **Photon energy loss and wavelength increase:** In Compton scattering, the photon loses energy, which corresponds to an increase in its wavelength.
- **Particle nature of light demonstration:** The Compton effect provides strong evidence for the particle (photon) nature of light, as it cannot be explained by classical wave theory.
- **Ratio of momenta of electron and scattered photon:** the ratio of the momenta of the scattered electron and photon is related to their respective scattering angles, derived from energy and momentum conservation.

Photoelectric Effect - Basics

- **Work function and threshold frequency:** The work function is the minimum energy required to eject an electron from a metal surface, and the threshold frequency is the corresponding minimum frequency of light.
- **Stopping potential, intensity, and frequency of light:** Stopping potential is the potential required to stop the emission of photoelectrons. Light intensity determines the number of photoelectrons, while frequency determines their kinetic energy.
- **Photon nature of light:** The photoelectric effect supports the photon theory of light, where light is composed of discrete energy packets (photons).
- **Relationship between work function and threshold frequency:** The work function (W) is related to the threshold frequency ($\nu 0$) by the equation $W=h\nu 0$, where h is Planck's constant.
- **Number of photoelectrons and light intensity:** The number of photoelectrons emitted is directly proportional to the intensity of the incident light.
- **Kinetic energy of photoelectrons and light frequency:** The kinetic energy of emitted photoelectrons is directly proportional to the frequency of the incident light, above the threshold frequency.

Photoelectric Effect - Calculations and Applications

- **Photoelectric equation and kinetic energy calculations:** The photoelectric equation ($KEmax=h\nu-W$) allows us to calculate the maximum kinetic energy of emitted photoelectrons.
- **Stopping potential and maximum kinetic energy:** The stopping potential (Vs) is related to the maximum kinetic energy by $KEmax=eVs$, where e is the electron charge.
- **Relationship between wavelength and photon energy:** The energy of a photon is inversely proportional to its wavelength, given by $E=hc/\lambda$.
- **Effects of wavelength and intensity on stopping potential and photoelectric current:** Wavelength affects the kinetic energy and stopping potential, while intensity affects the photoelectric current.
- **Calculation of threshold wavelength and work function:** These values can be determined using the photoelectric equation and the relationship between frequency and wavelength.
- **Graphs of kinetic energy vs. frequency:** The graph of photoelectron kinetic energy versus light frequency is a straight line, with the slope representing Planck's constant.

Photon Properties

- **Rest mass of photons:** Photons have zero rest mass, meaning they only exist when moving at the speed of light.
- **Dynamic mass of photons:** Photons possess dynamic mass due to their energy and momentum, given by m=h/cλ.
- **Validity of E=pc equation:** The equation E=pc (where E is energy, p is momentum, and c is the speed of light) is valid only for photons, not for particles with rest mass.

De Broglie Wavelength

- **De Broglie wavelength formula:** The De Broglie wavelength (λ=h/p) relates the wavelength of a particle to its momentum (p), demonstrating the wave-particle duality of matter.
- **Relationship between wavelength and momentum:** The De Broglie wavelength is inversely proportional to momentum.
- **Wavelength and kinetic energy relationship:** The De Broglie wavelength is inversely proportional to the square root of the kinetic energy of a particle.
- **Comparison of wavelengths for different particles:** For a given kinetic energy, heavier particles have shorter De Broglie wavelengths.
- **Momentum and wavelength relation:** Particles with same de broglie wavelenght have same momentum.

<u>**Objective Type Questions**</u>

1. The black body spectrum of an object A is such that its radiant intensity (i.e., intensity per unit wavelength interval) is maximum at a wavelength of 200 nm. Another object B has the maximum radiant intensity at 600 nm. The ratio of power emitted per unit area by A to that of B is:

(a) 1/81

(b) 1/9

(c) 9

(d) 81

Answer: (d) 81

2. A photon of frequency v stikes an electron of mass *m* initially at rest. After scattering at an angle ϕ the photon loses half of its energy. If the electron recoils at an angle θ, which of the following is true?

(a) Cos ϕ = (1 - mc^2 / hv)

(b) Sin ϕ = (1- mc^2 / hv)

(c) The ratio of the magnitudes of momenta of the recoiled electron and scattered photon is Cos ϕ/Cos θ

(d) Change in photon wavelength is (h / mc) (1 - 2cosϕ)

Answer: (c)

Explanation: Compton scattering involves momentum conservation. The ratio of the magnitudes of the momenta of the recoiled electron and scattered photon can be derived from conservation laws

3. A photon of frequency v strikes an electron of mass m initially at rest. After scattering at an angle ϕ the photon loses half of its energy. If the electron recoils at an angle θ, which of the following is correct?

(a) Cos θ = 1(1 - mc^2 / hv)

(b) Sin ϕ = 1(1 - mc^2 / hv)

(c) The ratio of the magnitudes of momenta of the recoiled electron and scattered photon is Sin ϕ/sin θ

(d) Change in photon wavelength is (h / mc) (1 2 cos ϕ)

Answer: (c)

4. A γ-ray photon emitted from a^{137} Cs source collides with an electron at rest. If the Compton shift of the photon is 3.25 x 10^{-13} m, then the scattering angle is close to:

(a) 45°

(b) 60°

(c) 30°

(d) 90°

Answer: (d) 90°

5. The spectrum of radiation emitted by a black body at a temperature 1000 K peaks in the:

(a) Visible range of frequencies

(b) Infrared range of frequencies

(c) Ultraviolet range of frequencies

(d) Microwave range of frequencies

Answer: (b) Infrared range of frequencies

6. If the wavelength of electromagnetic radiation is doubled, the energy of photons:

(a) Remains the same

(b) Doubled

(c) Halved

(d) Infinite

Answer: (c) Halved

7. When a photon collides with an electron, its wavelength after collision:

(a) Increases

(b) Decreases

(c) Remains the same

(d) Infinite

Answer: (a) Increases

Explanation: In Compton scattering, the photon loses energy, increasing its wavelength.

8. For a photo sensitive metal surface, work function is 3.3×10^{19} J. The threshold frequency is:

(a) 5×10^{14}

(b) 5×10^{13}

(c) 25×10^{14}

(d) 2.5×10^{14}.

Answer: (a) 5×10^{14}

9. The number of photo electron emitted for a light of frequency v, higher than the threshold frequency v_0 is proportional to:

(a) Threshold frequency (v_0)

(b) Intensity of light

(c) Frequency of light

(d) $\nu - \nu_0$.

Answer: (b) Intensity of light

Explanation: The number of photoelectrons is proportional to the number of incident photons, which depends on intensity.

10. Work function of a material in a photoelectric effect:

(a) is same for all metals

(b) depends on the frequency of incident light

(c) depends on the intensity of incident light

(d) is different for different material

Answer: (d) is different for different material

Explanation: Work function varies with material properties, not frequency or intensity of light.

11. Maximum kinetic energy of electrons emitted in photoelectric effect increases on:

(a) increasing intensity of light

(b) decreasing intensity of light

(c) decreasing frequency of light

(d) decreasing wavelength of light

Answer: (d) decreasing wavelength of light

12. The work function of a metal surface is 6.2 eV. The threshold wavelength of the metal will be:

(a) 200 nm

(b) 300 nm

(c) 400 nm

(d) 100 nm

Answer: (a) 200 nm

13. The minimum energy required to remove an electron is called:

(a) stopping potential

(b) kinetic energy

(c) work function

(d) none of these

Answer: (c) work function

Explanation: Work function is the minimum energy needed to eject an electron from a metal surface.

14. The minimum energy required to remove an electron is called:

- **(a)** stopping potential
- **(b)** kinetic energy
- **(c)** work function
- **(d)** none of these.

Explanation: Photon energy must exceed the work function for photoelectric emission.

15. If threshold frequency of a metal surface is increased, the work function:

(a) remains the same

(b) increases

(c) decreases

(d) None of these

Answer: (b) increases

16. The photoelectric effect is described as the emission of electrons from the surface of a metal when:

(a) it is heated to a high temperature

(b) electrons of suitable velocity impinge on it

(c) light of suitable wavelength falls on it

(d) it is placed in a strong magnetic field

Answer: (c) light of suitable wavelength falls on it

Explanation: Photoelectric effect requires photons of sufficient energy (suitable wavelength) to eject electrons.

17. Photoelectric effect supports:

(a) Newton's corpuscular nature of light

(b) Huygen's wave theory of light

(c) Maxwell's electromagnetic theory of light

(d) Einstein's quantum theory of light

Answer: (d) Einstein's quantum theory of light

Explanation: Einstein explained the photoelectric effect using quantized photons.

18. Work function of a metal is:

(a) minimum energy required to free an electron from surface against Coulomb's forces

(b) minimum energy required to free a nucleon

(c) minimum energy required to eject an electron from electronic orbit

(d) minimum energy to ionise an atom

Answer: (a) minimum energy required to free an electron from surface against Coulomb's forces

Explanation: Work function is the energy to overcome surface binding forces.

19. Photoelectrons emitted from a metallic surface are those which are:

(a) present inside the nucleus

(b) are orbiting very near to nucleus

(c) are generated by the decay of neutrons within the nucleus

(d) free to move within interatomic spacing

Answer: (d) free to move within interatomic spacing

Explanation: Photoelectrons are conduction electrons free within the metal.

20. In photoelectric effect:

(a) light energy is converted into heat energy

(b) light energy is converted into electric energy

(c) light energy is converted into sound energy

(d) electric energy is converted into light energy

Answer: (b) light energy is converted into electric energy

Explanation: Photoelectric effect converts photon energy into electron kinetic energy.

21. Which of the following phenomena support the quantum nature of light?

(a) Interference

(b) Diffraction

(c) Polarisation

(d) Compton effect

Answer: (d) Compton effect

Explanation: Compton scattering demonstrates light's particle (quantum) nature, unlike wave phenomena.

22. For light of wavelength 5000 Å the photon energy is nearly 2.5eV. For X-rays of wavelength 1Å, the photon energy will be close to:

(a) 2.5/ 5000 eV

(b) 2.5/ $(5000)^2$ eV

(c) 2.5 x 5000 eV

(d) 2.5 x $(5000)^2$ eV.

Answer: (c) 2.5 x 5000 eV

23. In photoelectric effect when photons of energy *hv* fall on a photosensitive surface (work function hv_0) electrons are emitted from the metallic surface with a kinetic energy. It is possible to say that:

(a) all ejected electrons have same kinetic energy equal to $hv - hv_0$

(b) the ejected electrons have a distribution of kinetic energy from zero to $(hv - hv_0)$

(c) the most energetic electrons have kinetic energy equal to hv

(d) all ejected electrons have kinetic energy hv_0.

Answer: (b)

24. The rest mass of a photon of wavelength \(\lambda \) is:

The rest mass of a photon of wavelength λ, is:

(a) zero

(b) h /cλ

(c) h /λ

(d) hc/λ

Answer: (a) zero

Explanation: Photons have zero rest mass, per special relativity.

25. The dynamic mass of a photon of wavelength λ is:

(a) zero

(b) h /cλ

(c) h /λ

(d) hc/λ

Answer: (b) h /cλ

26. In photoelectric effect the number of photoelectrons emitted is proportional to:

(a) intensity of incident beam

(b) frequency of incident beam

(c) velocity of incident beam

(d) work function of photocathode

Answer: (a) intensity of incident beam

Explanation: Number of photoelectrons depends on the number of incident photons, proportional to intensity.

27. The threshold frequency of potassium is 3 x 10^{14} Hz. The work function is:

(a) 1.0 x 10^{-19}J

(b) 2x 10^{-19}J

(c) 4x 10^{-19}J

(d) 0.5 x 10^{-19} J.

Answer: (b) 2x 10^{-19}J

28. The threshold wavelength for photoelectric emission from a material is 5200 Å. Photoelectrons will be emitted when this material is illuminated with monochromatic radiation from a:

(a) 50 watt infrared lamp

(b) 1000 watt infrared lamp

(c) 1 watt ultraviolet lamp

(d) 1 watt infrared lamp

Answer: (c) 1 watt ultraviolet lamp

29. Sodium surface is illuminated by ultraviolet and visible radiation successively and the stopping potential determined. This stopping potential is:

(a) equal in both cases

(b) more with ultraviolet light

(c) more with visible light

(d) varies randomly

Answer: (b) more with ultraviolet light

Explanation: Ultraviolet light has higher frequency (energy), increasing the stopping potential.

30. The strength of a photoelectric current depends upon:

(a) frequency of incident radiation

(b) intensity of incident radiation

(c) angle of incident radiation

(d) distance between anode and cathode

Answer: (b) intensity of incident radiation

Explanation: Photoelectric current is proportional to the number of photons, i.e., intensity.

31. Photoelectrons are being obtained by irradiating zinc by a radiation of 3100 Å. In order to increase the kinetic energy of ejected photoelectrons:

(a) the intensity of radiation should be increased

(b) the wavelength of radiation should be increased

(c) the wavelength of radiation should be decreased

(d) both wavelength and intensity of radiation should be increased

Answer: (c) the wavelength of radiation should be decreased

Explanation: Shorter wavelength increases photon energy, thus increasing electron kinetic energy.

32. In a photoelectric experiment the stopping potential for the incident light wavelength 4000 Å is 2 volts. If the wavelength be changed to 3100 Å, the stopping potential will be:

(a) 2 V

(b) < 2 V

(c) zero

(d) > 2 V

Answer: (d) > 2 V

33. In a photoelectric experiment the wavelength of the incident radiation is reduced from 6000 Å to 4000 Å while the intensity of radiation remains the same; then:

(a) the cut-off potential will decrease

(b) the cut-off potential will increase

(c) the photoelectric current will increase

(d) the kinetic energy of the emitted electrons will decrease

Answer: (b) the cut-off potential will increase

Explanation: Shorter wavelength increases photon energy, raising the stopping (cut-off) potential.

34. In photoelectric effect, the work function of a metal is 3.5 eV. The emitted electrons can be stopped by applying a potential of -1.2 V:

(a) the energy of the incident photons is 4.7 eV

(b) the energy of incident photons is 2.3 eV

(c) if higher-frequency photons be used, the photoelectric current will rise

(d) when the energy of photons is 3.5 eV, the photoelectric current will be maximum

Answer: (a) the energy of the incident photons is 4.7 eV

35. The work function for a metal is 3 eV. To emit a photoelectron of energy 2 eV from the surface of this metal, the wavelength of the incident light should be:

(a) 6187 Å

(b) 4125 Å

(c) 12375 Å

(d) 2475 Å

Answer: (b) 4125 Å

36. Ultraviolet radiation of 6.2 eV falls on an aluminium surface (work function 4.2 eV). The kinetic energy (in joule) of the fastest electron emitted approximately:

(a) 3×10^{-21}

(b) 3×10^{-19}

(c) 3×10^{-17}

(d) 3×10^{-15}.

Answer: (b) 3×10^{-19}

37. The work function of a substance is 3.3 eV. Its threshold frequency will be-

(a) 8×10^{14}Hz

(b) 5×10^{33} Hz

(c) 8×10^{10} Hz

(d) 4×10^{11} Hz

Answer: (a) 8×10^{14}Hz

38. The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately:

(a) 540 nm

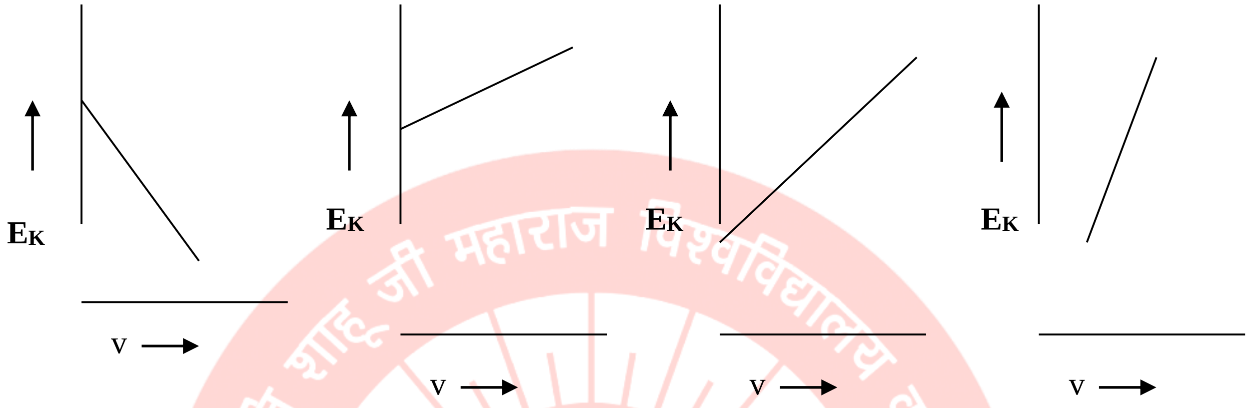
(b) 400 nm

(c) 310 nm

(d) 220 nm

Answer: (c) 310 nm

39. According to Einstein's photoelectric equation, the graph between the kinetic energy (E_K) of photoelectrons ejected and the frequency (v) of incident radiation is:



(a) **(b)** **(c)** **(d)**

Answer: (d)

40. The work function of a surface of a photosensitive material is 6.2 eV. The wavelength of the incident radiation for which the stopping potential is 5 V lies in:

(a) ultraviolet region

(b) visible region

(c) infrared region

(d) X-ray region

Answer: (a) ultraviolet region

41. The potential difference that must be applied to stop the fastest photoelectrons emitted by a nickel surface, having work function 5.01 eV, when ultraviolet light of wavelength 200 nm falls on it, is:

(a) -1.2 V

(b) -2.4 V

(c) 1.2 V

(d) 2.4 V

Answer: (d) 2.4 V

42. When monochromatic radiation of intensity I falls on a metal surface, number of photoelectrons and their maximum kinetic energy are N and T respectively. If the intensity of radiation is 2*I*, the number of emitted electrons and their maximum kinetic energy are respectively:

(a) $2N$ and T

(b) $2N$ and $2T$

(c) N and T

(d) N and $2T$.

Answer: (a) $2N$ and T

Explanation: Doubling intensity doubles the number of photons ,but T depends on frequency, not intensity.

43. According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal versus frequency of incident radiation gives a straight line, whose slope:

(a) depends on the nature of metal

(b) depends on the intensity of radiation

(c) depends both on intensity of the radiation and the metal used

(d) is the same for all metals and is independent of the intensity of the radiation

Answer: (d) is the same for all metals and is independent of the intensity of the radiation

44. A photon has energy E = 100 eV which is equal to kinetic energy of proton. If λ_1 is the wavelength of proton and λ_2 the wavelength of photon, then $\frac{\lambda_1}{\lambda_2}$ is directly proportional to:

(a) $E^{1/2}$

(b) $E^{-1/2}$

(c) E

(d) E^2

Answer: (b) $E^{-1/2}$

45. The work function of a substance is 4.0 eV. The minimum energy of light photons that can cause photoelectron emission from this substance is:

(a) 1.0 eV

(b) 16 eV

(c) 4.0 eV

(d) 2 eV

Answer: (c) 4.0 eV

Explanation: Minimum energy to emit photoelectrons equals the work function, 4.0 eV.

46. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it, is 4 eV. The stopping potential is:

(a) 2 V

(b) 4 V

(c) 6 V

(d) 10 V

Answer: (b) 4 V

47. If E is energy and p is momentum, then equation E = pc is valid:

(a) for an electron as well as for a photon

(b) for an electron but not for a photon

(c) for a photon but not for an electron

(d) neither for an electron nor for a photon

Answer: (c) for a photon but not for an electron

48. The de Broglie wavelength of an electron accelerated through a p.d. *V* is directly proportional to V^n . Then *n* must be equal to (*n* = ?)

(a) 1

(b) -1

(c) 0.5

(d) -0.5

Answer: (d) -0.5

49. For a given kinetic energy, which of the following has the smallest de Broglie wavelength?

(a) Electron

(b) Proton

(c) Deuteron

(d) α- particle

Answer: (d) α- particle

50. If an electron and a photon propagate in the form of waves having wavelength, it implies that they have same:

(a) speed

(b) momentum

(c) energy

(d) all of the above

Answer: (b) momentum

Unit IV

Unit 4: Introduction to Quantum Mechanics

Matter Waves and de Broglie's Hypothesis

- The concept of matter waves was introduced by **de Broglie** in 1924.
- The **Davisson and Germer experiment** (1927) verified the existence of matter waves through **electron diffraction**.
- Matter waves are **probability waves**, not physical waves.
- The **de Broglie wavelength** is given by the formula: where *h* is Planck’s constant and *p* is momentum.

Properties of Matter Waves

- The **group velocity** of matter waves is equal to the particle's velocity.
- The **phase velocity** (vp), **group velocity** (vg), and **speed of light** (c) are related by:
- The **wave function** () describes the state of a quantum system and must be **finite, single-valued, and continuous**.
- The probability of finding a particle between **x** and **x + dx** is given by:
- **Normalization condition**: The total probability must be 1:

Quantum Mechanics vs. Classical Mechanics

- **Classical mechanics** applies to **macroscopic** systems.
- **Quantum mechanics** applies to **microscopic** systems like atoms and subatomic particles.
- Classical mechanics is a **special case** of quantum mechanics.

Schrödinger Equation and Quantum States

- The **time-independent Schrödinger equation**:
- The **wave function ()** represents the **probability amplitude** of a quantum particle.
- The **matrix form** of quantum mechanics was developed by **Heisenberg**, while the **wave mechanics** version was developed by **Schrödinger**.

Wave-Particle Duality

- **Wave-particle duality** was demonstrated through:

- **Photoelectric effect** (Einstein)
- **Double-slit experiment** (Young and later experiments with electrons)
- **Compton effect** (X-ray scattering by electrons)

Heisenberg's Uncertainty Principle

- It states that: This means that the **position (x) and momentum (p) of a particle cannot be precisely known at the same time**.

Quantum Tunneling

- **Quantum tunneling** allows a particle to pass through a **potential barrier** even if its energy is less than the barrier height.
- This phenomenon is used in **scanning tunneling microscopes** and **nuclear fusion in the Sun**.

Atomic Structure and Quantum Numbers

- The **principal quantum number (n)** determines the **energy level** of an electron in an atom.
- The **Pauli exclusion principle** states that no two electrons in an atom can have the same **set of quantum numbers**.

Photon Energy and Planck's Constant

- The **energy of a photon** is given by: where is frequency.
- The unit of **Planck's constant (h)** is **Joule-second (J.s)**.

Experimental Evidence for Quantum Theory

- **Davisson-Germer experiment** confirmed the wave nature of **electrons**.
- The **double-slit experiment** shows an **interference pattern** for **particles** when not observed.
- **Quantum mechanics predicts probability distributions**, not exact trajectories.

Objective Type Questions

1. Existence of matter wave was first experimentally verified by:

(a) de Broglie

(b) Davisson and Germer

(c) Schrödinger

(d) Heisenberg

Answer: (b) Davisson and Germer

Explanation: Their 1927 electron diffraction experiment confirmed de Broglie's matter wave hypothesis.

2. Matter waves are:

(a) Electromagnetic waves

(b) Transverse waves

(c) Longitudinal waves

(d) Probability waves

Answer: (d) Probability waves

Explanation: Matter waves represent probability amplitudes, not physical waves.

3. The concept of matter wave was proposed by:

(a) Heisenberg

(b) de Broglie

(c) Schrödinger

(d) Laplace

Answer: (b) de Broglie

Explanation: De Broglie introduced the matter wave concept in 1924.

4. Correct relation for matter wave is:

(a) $\lambda = h \times p$

(b) $\lambda = \frac{h}{p}$

(c) $\lambda = h + p$

(d) $\lambda = h - p$

Answer: (b) $\lambda = \frac{h}{p}$

5. The group velocity of matter waves associated with a moving particle is:

(a) same as phase velocity

(b) less than particle velocity

(c) equal to particle velocity

(d) greater than particle velocity

Answer: (c) equal to particle velocity

Explanation: Group velocity of a matter wave equals the particle's velocity.

6. Phase velocity (v_p), group velocity (v_g) and speed of light (c) are related as:

(a) $v_p v_g = c^2$

(b) $v_p = c v_g$

(c) $v_g = c v_p$

(d) $v_p + v_g = c$

Answer: (a) $v_p v_g = c^2$

7. The quantity that varies periodically in a matter wave is called:

(a) Displacement

(b) Phase velocity

(c) Wave function

(d) Group velocity

Answer: (c) Wave function

Explanation: The wave function \(\psi \) varies periodically and describes the quantum state.

8. An acceptable wave function associated with a moving particle must be:

(a) finite, single valued and discontinuous

(b) finite, multiple valued and continuous

(c) finite, single valued and continuous

(d) infinite, single valued and continuous

Answer: (c) finite, single valued and continuous

Explanation: A valid wave function must be well-behaved: finite, single-valued, and continuous.

9. The probability of finding a particle between *x* and *x* + *dx* is :

(a) Ψ dx

(b) Ψ^* dx

(c) $\Psi\Psi^*$ dx

(d) $\Psi\Psi^*$

Answer: (c) $\Psi\Psi^*$ dx

10. For two functions Ψ_m and Ψ_n to orthogonal :

(a) $\int_{\infty}^{\infty} \Psi^{*}{}_{m}\, \Psi_{n}\, dx = 0$

(b) $\int_{\infty}^{\infty} \Psi^{*}{}_{m}\, \Psi_{n}\, dx = 1$

(c) $\int_{\infty}^{\infty} \Psi^{*}{}_{m}\, \Psi_{n}\, dx = \delta_{mn}$

(d) $\int_{\infty}^{\infty} \Psi^{*}{}_{m}\, \Psi_{n}\, dx = \infty$

Answer: (a) (a) $\int_{\infty}^{\infty} \Psi^{*}{}_{m}\, \Psi_{n}\, dx = 0$

Explanation: Orthogonal functions have zero overlap integral.

11. Classical mechanics deals with:

(a) macroscopic systems

(b) microscopic systems

(c) both microscopic and macroscopic systems

(d) atomic systems

Answer: (a) macroscopic systems

Explanation: Classical mechanics applies to large-scale systems.

12. Which of these is correct?

(a) Classical mechanics is applied to macroscopic systems

(b) Quantum mechanics is applied to microscopic systems

(c) Classical mechanics is a special case of quantum mechanics

(d) all of these

Answer: (d) all of these

Explanation: All statements are true: classical for macro, quantum for micro, and classical as a limit of quantum.

13. Which of these functions can be taken as a wave function?

(a) sin *x*

(b) tanh *x*

(c) tan *x*

(d) cot *x*

Answer: (a) sin x

Explanation: sin x is finite, single-valued, and continuous.

14. Phase velocity is:

(a) *wk*

(b) *w / k*

(c) *dw / dk*

(d) w^2k

Answer: (b) *w / k*

15. The correct relation between v_p and v_g is:

(a) $v_g = v_p - \frac{dv_p}{d\lambda}$

(b) $v_g = v_p + \frac{dv_p}{d\lambda}$

(c) $v_g = v_p - \lambda \frac{dv_p}{d\lambda}$

(d) $v_g = v_p + \lambda \frac{dv_p}{d\lambda}$

Answer: (a) $v_g = v_p - \frac{dv_p}{d\lambda}$

16. A Schrödinger equation is __________ form of quantum mechanics:

(a) matrix

(b) wave

(c) vector

(d) none of these

Answer: (b) wave

Explanation: Schrödinger's equation is the wave mechanics form of quantum theory.

17. Matrix form of quantum mechanics was developed by:

(a) P.A.M Dirac

(b) Wolfgang Pauli

(c) Werner Heisenberg

(d) Erwin Schrödinger

Answer: (c) Werner Heisenberg

Explanation: Heisenberg developed matrix mechanics in 1925.

18. Which of these scientists established that wave mechanics and matrix mechanics versions of quantum mechanics are equivalent to each other?

(a) Schrödinger

(b) Heisenberg

(c) Pauli

(d) Dirac

Answer: (a) Schrödinger

Explanation: Schrödinger proved the equivalence in 1926.

19. Time-independent Schrödinger equation is:

(a) $\frac{\partial^2 \Psi}{\partial x^2} + \frac{2m}{\hbar^2}(E - V)\Psi = 0$

(b) $\frac{\partial^2 \Psi}{\partial x} + \frac{2m}{\hbar^2}(E - V)\Psi = 0$

(c) $\frac{\partial^2 \Psi}{\partial x^2} + \frac{2m}{\hbar^2}(E + V)\Psi = 0$

(d) $\frac{\partial \Psi}{\partial x} + \frac{2m}{\hbar^2}(E + V)\Psi = 0$

Answer: (a)

20. The constant $\hbar$ is:

(a) $2\pi h$,

(b) πh

(c) $h / 2\pi$

(d) $2\pi h / \lambda$

Answer: (c) $h / 2\pi$

21. For a non-dispersive medium:

(a) v_p is same for all wavelengths

(b) v_p is different for different wavelengths

(c) v_p is definitely zero for all wavelengths

(d) v_p is greater than v_g

Answer: (a) v_p is same for all wavelengths

Explanation: In a non-dispersive medium, phase velocity is constant across wavelengths.

22. The wavelength of a matter wave associated with a particle is inversely proportional to:

(a) Its momentum

(b) Its energy

(c) Its velocity

(d) Its frequency

Answer: (a) Its momentum

23. The de Broglie wavelength of a moving particle is:

(a) $\lambda = h / mv$

(b) $\lambda = mv / h$

(c) $\lambda = h / p$

(d) $\lambda = p / h$

Answer: (c) $\lambda = h / p$

24. The concept of wave-particle duality was introduced by:

(a) Planck

(b) Einstein

(c) de Broglie

(d) Heisenberg

Answer: (c) de Broglie

Explanation: De Broglie introduced wave-particle duality for matter in 1924.

25. The phase velocity of a matter wave is given by:

(a) $v_p = \lambda / T$

(b) $v_p = \lambda f$

(c) $v_p = f / \lambda$

(d) $v_p = h / p$

Answer: (b) $v_p = \lambda f$

26. The probability of finding a particle in a given region is proportional to:

(a) The square of the wave function

(b) The integral of the wave function

(c) The amplitude of the wave function

(d) The phase of the wave function

Answer: (a) The square of the wave function

27. What does the wave function Ψ(x,t) represent?

(a) Probability amplitude of a particle's position

(b) Probability of a particle's position

(c) Energy of the particle

(d) Velocity of the particle

Answer: (a) Probability amplitude of a particle's position

28. The Schrödinger equation describes:

(a) The motion of classical particles

(b) The evolution of wave functions

(c) The behavior of electromagnetic waves

(d) The transformation of momentum

Answer: (b) The evolution of wave functions

29. The momentum of a particle associated with a matter wave is related to the wavelength by:

(a) $p=\hbar/\lambda$

(b) $p=h/\lambda$

(c) $p=\lambda/h$

(d) $p=\lambda h$

Answer: (b) $p=h/\lambda$

30. What is the condition for the normalization of the wave function?

(a) The integral of Ψ^2 over all space equals 1

(b) The integral of Ψ over all space equals 1

(c) The square of the wave function must be negative

(d) The wave function must be zero at infinity

Answer: (a) The integral of Ψ^2 over all space equals 1

31. The Heisenberg uncertainty principle states that:

(a) The position and momentum of a particle can be known precisely at the same time

(b) The position and energy of a particle can be known precisely at the same time

(c) The position and momentum of a particle cannot both be known precisely simultaneously

(d) The position and velocity of a particle cannot both be known precisely simultaneously

Answer: (c) The position and momentum of a particle cannot both be known precisely simultaneously

32. In wave mechanics, the group velocity is associated with:

(a) The velocity of the wave crest

(b) The rate of change of the amplitude of the wave packet

(c) The speed of the wavefront

(d) The speed of light in vacuum

Answer: (c) The speed of the wavefront

33. The particle-like behavior of matter is demonstrated by:

(a) Interference patterns in double-slit experiments

(b) The constant velocity of light

(c) Refraction of light

(d) The Doppler shift of sound waves

Answer: (b) The double-slit experiment

34. The probability of a particle being located in a specific region of space is related to:

(a) The square of the wave function's magnitude

(b) The wave function itself

(c) The potential energy in the region

(d) The time evolution of the wave function

Answer: (a) The square of the wave function's magnitude

35. The principal quantum number 'n' in an atom determines:

(a) The energy level of the electron

(b) The angular momentum of the electron

(c) The shape of the orbital

(d) The spin of the electron

Answer: (a) The energy level of the electron

36. The Pauli exclusion principle states that:

(a) Two electrons can occupy the same orbital with different spins

(b) Two electrons can never occupy the same orbital

(c) No two particles can have the same quantum numbers

(d) Particles behave both as waves and particles

Answer: (a) Two electrons can occupy the same orbital with different spins

Explanation: Pauli exclusion allows two electrons per orbital with opposite spins.

37. The particle-wave duality is demonstrated by:

(a) The photoelectric effect

(b) The double-slit experiment

(c) The Compton effect

(d) All of the above

Answer: (d) All of the above

Explanation: Photoelectric, double-slit, and Compton effects all demonstrate wave-particle duality.

38. The concept of quantum tunneling is based on:

(a) The wave nature of particles

(b) The ability of particles to be in two places at once

(c) The uncertainty principle

(d) The quantization of energy

Answer: (a) The wave nature of particles

Explanation: Quantum tunneling arises from the wave function penetrating barriers.

39. The energy of a photon is directly proportional to its:

(a) Wavelength

(b) Frequency

(c) Mass

(d) Speed

Answer: (b) Frequency

Explanation: Photon energy \(E = h \nu \), proportional to frequency.

40. The de Broglie wavelength is associated with the motion of:

(a) Electrons

(b) Protons

(c) All matter

(d) Only light

Answer: (c) All matter

Explanation: De Broglie wavelength applies to all moving particles with mass.

41. In a double-slit experiment with particles, the interference pattern is observed when:

(a) The particles are not observed

(b) The particles are observed

(c) The particles travel at high speed

(d) The particles are in a vacuum

Answer: (a) The particles are not observed

Explanation: Interference occurs when particle paths are not measured; observation collapses the wave function.

42. The wave function of a particle must be:

(a) Continuous and differentiable

(b) Discontinuous

(c) Infinite at some points

(d) Singular

Answer: (a) Continuous and differentiable

Explanation: Wave functions must be smooth (continuous and differentiable) except at specific discontinuities.

43. The phenomenon in which an electron can pass through a potential barrier, even though it doesn't have enough energy to overcome the barrier, is known as:

(a) Quantum tunneling

(b) Photoelectric effect

(c) Wave-particle duality

(d) The Compton effect

Answer: (a) Quantum tunneling

Explanation: Tunneling allows particles to pass through barriers due to wave properties.

44. The quantization of energy levels in an atom is a result of:

(a) The particle-wave duality

(b) The Schrödinger equation

(c) The Heisenberg uncertainty principle

(d) The Pauli exclusion principle

Answer: (b) The Schrödinger equation

Explanation: Quantized energy levels arise from solutions to the Schrödinger equation.

45. A photon has:

(a) Zero mass and zero energy

(b) Zero mass and finite energy

(c) Finite mass and finite energy

(d) Finite mass and zero energy

Answer: (b) Zero mass and finite energy

Explanation: Photons have zero rest mass but carry energy \(E = h \nu \).

46. What does de Broglie's hypothesis state?

(a) Matter has both wave and particle properties

(b) Only light has wave properties

(c) Electrons move in fixed orbits

(d) Atoms do not exhibit wave behavior

Answer: (a) Matter has both wave and particle properties

Explanation: De Broglie's hypothesis posits dual nature for all matter.

47. What is the wavelength of a particle with momentum p ?

(a) $\lambda = h / mv$

(b) $\lambda = mv / h$

(c) $\lambda = h / p$

(d) $\lambda = p / h$

Answer: (c) $\lambda = h / p$

48. Which experiment confirmed the wave nature of electrons?

(a) The double-slit experiment

(b) The Davisson-Germer experiment

(c) The photoelectric effect experiment

(d) Rutherford's gold foil experiment

Answer: (b) The Davisson-Germer experiment

Explanation: Electron diffraction in 1927 confirmed wave nature.

49. What is the unit of Planck's constant ' h' ?

(a) Joule-second (J·s)

(b) Newton-meter (N·m)

(c) Electron-volt (eV)

(d) Hertz (Hz)

Answer: (a) Joule-second (J·s)

Explanation: Planck's constant 'h' has units of energy times time.

50. What is the significance of a wave function in quantum mechanics?

(a) It describes the probability amplitude of a particle

(b) It gives the exact position of a particle

(c) It determines the energy of a system directly

(d) It predicts the exact velocity of a particle

Answer: (a) It describes the probability amplitude of a particle

Unit V

Unit 5: Transistor Biasing

Load Line and Operating Point

- The load line represents the relationship between collector current (IC) and collector-emitter voltage (VCE).
- The operating point (Q-point) is the zero-signal values of IC and VCE, ensuring proper transistor operation.
- The Q-point should ideally be at the center of the load line for maximum voltage swing and minimal distortion.

Biasing in Transistors

- Common biasing methods include fixed bias, collector bias, emitter bias, and voltage divider bias.
- Voltage divider bias is the most stable, reducing sensitivity to variations in transistor parameters.
- The stability factor (S) should be low for better Q-point stability.
- Emitter feedback bias and collector-to-base bias also enhance stability.

Stability Factor and Thermal Stability

- Stability factor (S) measures the variation in collector current (IC) due to changes in transistor parameters.
- A low stability factor improves transistor performance.
- Thermal stability is improved by using an emitter resistor, which provides negative feedback.

Regions of Transistor Operation

- In the active region, the emitter-base junction is forward biased, and the collector-base junction is reverse biased.
- The transistor operates in the active region for amplification and in saturation or cutoff for switching applications.
- The Q-point should be in the active region for proper amplification.

Types of Transistor Configurations

- **Common-Emitter (CE) Amplifier**: High gain, moderate input impedance, and used for amplification.
- **Common-Base (CB) Amplifier**: Low input impedance, high voltage gain, used in high-frequency applications.
- **Common-Collector (CC) Amplifier (Emitter Follower)**: High input impedance, unity voltage gain, used for impedance matching.

Amplifier Characteristics and Design

- The collector current (IC) is controlled by the base-emitter voltage (VBE).
- The output resistance of a CE amplifier is high, while the input resistance is moderate.
- Emitter degeneration (adding an emitter resistor) improves stability but reduces gain.
- The bypass capacitor in a CE amplifier bypasses AC signals to ground, improving gain.

Frequency Response and Cutoff Frequency

- The cutoff frequency is the point where the gain falls to 70.7% of its maximum value.
- Amplifiers should maintain a stable Q-point for consistent performance across frequencies.

Transistor Parameters and Material Properties

- Silicon (Si) transistors have a VBE of approximately 0.7V, while Germanium (Ge) transistors have a VBE of about 0.1V.
- The emitter is the most heavily doped region in a BJT to ensure efficient charge carrier injection.

Clipping and Distortion in Amplifiers

- If the Q-point shifts toward cutoff, the negative half of the output is clipped.
- If the Q-point shifts toward saturation, the positive half is clipped.
- Proper biasing and positioning of the Q-point prevent signal distortion.

Applications of Biasing and Feedback Mechanisms

- Biasing stabilizes the Q-point, ensuring linear operation.
- Feedback mechanisms like emitter feedback improve stability and reduce distortion.

- Voltage divider bias is widely used for its stability and minimal parameter sensitivity.

This structured content provides a clear understanding of transistors, biasing, and amplification principles.

OBJECTIVE TYPE QUESTIONS

1. A Load line is a graph between:

(a) I_C and V_{CC}

(b) I_C and V_{BE}

(c) I_E and V_{EE}

(d) I_C and V_{CE}

Answer: (d) I_C and V_{CE}

Explanation: A load line is a graphical representation of the relationship between collector current (I_C) and collector-emitter voltage (V_{CE}) for a given circuit, typically drawn on a transistor's characteristic curve.

2. Which bias circuit is predominantly used in linear circuits?

(a) Fixed bias

(b) Collector bias

(c) Emitter bias

(d) Voltage divider bias

Answer: (d) Voltage divider bias

Explanation: Voltage divider bias is widely used in linear circuits due to its excellent stability against variations in transistor parameters and temperature, providing a stable Q-point.

3. For good stability of Q point stability factor S must be:

(a) High

(b) Very high

(c) Low

(d) Negative

Answer: (c) Low

Explanation: A low stability factor (S) indicates less variation in collector current (IC) with changes in parameters like β or temperature, ensuring better Q-point stability.

4. Stability factor S is given as:

(a) $\frac{\delta I_B}{\delta I_{CBO}}$

(b) $\frac{\delta I_C}{\delta I_{CBO}}$

(c) $\frac{\delta I_B}{\delta I_C}$

(d) $\frac{\delta I_{CBO}}{\delta I_C}$

Answer: (b) $\frac{\delta I_C}{\delta I_{CBO}}$

5. Expression for stability factor is:

(a) S = $\frac{1-\beta}{1-\beta\,(\frac{\delta I_B}{\delta I_C})}$

(b) S = $\frac{1-\beta}{1+\beta\,(\frac{\delta I_B}{\delta I_C})}$

(c) S = $\frac{1+\beta}{1-\beta\,(\frac{\delta I_B}{\delta I_C})}$

(d) S = $\frac{1+\beta}{1+\beta\,(\frac{\delta I_B}{\delta I_C})}$

Answer: (c) S = $\frac{1+\beta}{1-\beta\,(\frac{\delta I_B}{\delta I_C})}$

6. Operating point represents:

(a) I_C and V_{CE} values when signal applied

(b) Zero signal values of I_C and V_{CE}

(c) Zero signal values of I_B and I_C

(d) I_B and I_C values when signal is applied

Answer: (b) Zero signal values of I_C and V_{CE}

Explanation: The operating point (Q-point) represents the DC values of I_C and V_{CE} when no input signal is applied, defining the transistor's quiescent state.

7. Which of the following bias has most stable Q point:

(a) Fixed bias

(b) Emitter feedback bias

(c) Collector to base bias

(d) Voltage divider bias

Answer: (d) Voltage divider bias

Explanation: Voltage divider bias offers the most stable Q-point due to its use of a resistor network that compensates for transistor parameter variations.

8. In amplifier, maximum peak to peak output voltage swing is obtained when Q point of circuit is located:

(a) near saturation point

(b) near cutoff point

(c) at the center of load line

(d) anywhere on load line

Answer: (c) at the center of load line

Explanation: Positioning the Q-point at the center of the load line allows maximum symmetrical output voltage swing without clipping, optimizing amplifier performance.

9. Q Point in voltage amplifier is selected in the middle of load line because:

(a) It gives better stability

(b) Circuit needs smaller supplier

(c) Biasing circuit needs less number of resistors

(d) It gives distortion output

Answer: (a) It gives better stability

Explanation: A centered Q-point on the load line ensures maximum undistorted output swing and stability against signal variations.

10. The negative part of amplifier output in CE amplifier clips if Q point moves to:

(a) Towards saturation point

(b) Towards cut off point

(c) Toward center of load line

(d) None of these

Answer: (b) Towards cut off point

Explanation: If the Q-point shifts toward cutoff, the transistor cannot conduct fully for the negative half-cycle, causing clipping of the negative output in a CE amplifier.

11. In a CE transistor amplifier in which bias is not stabilised I_C varies with:

(a) β

(b) V_{BE}

(c) I_{CB0}

(d) All of these

Answer: (d) All of these

Explanation: In an unstabilized CE amplifier, I_C varies with V_{BE} (base-emitter voltage), I_{CB0} (leakage current), and β (current gain), as these parameters affect biasing.

12. In a single battery fixed bias circuit using a transistor of β=50, stability factor will be:

(a) 50

(b) 51

(c) 100

(d) 101

Answer: (b) 51

13. Most heavily doped region in BJT is:

(a) Base

(b) Collector

(c) Emitter

(d) Equal doping in all regions

Answer: (c) Emitter

Explanation: The emitter is the most heavily doped region in a BJT to ensure efficient injection of charge carriers into the base.

14. BJT is a.......... device:

(a) Voltage operated

(b) Current operated

(c) Both Voltage and Current Operated

(d) None of these

Answer: (b) Current operated

Explanation: A BJT is a current-controlled device, where base current (IB) controls the collector current (IC).

15. In active region of BJT:

(a) Both E-B & C-B forward biased

(b) Both E-B & C-B reverse biased

(c) E-B Forward & C-B reverse Biased

(d) None of these

Answer: (c) E-B Forward & C-B reverse Biased

Explanation: In the active region, the emitter-base junction is forward-biased (conducting), and the collector-base junction is reverse-biased (non-conducting).

16. V_{BE} for Ge transistor is:

(a) 0.5 V

(b) 0.7 V

(c) 0.1 V

(d) 1.0 V

Answer: (c) 0.1 V

17. For a Si transistor, V_{BE} is:

(a) 0.3 V

(b) 0.7 V

(c) 0.5 V

(d) 1.1 V

Answer: (b) 0.7 V

Explanation: For a silicon (Si) transistor, V_{BE} is typically 0.7 V, the threshold for forward bias.

18. In an emitter follower, output is taken from:

(a) Emitter

(b) Base

(c) Collector

(d) None of these

Answer: (a) Emitter

Explanation: In an emitter follower (common-collector configuration), the output is taken from the emitter, following the base voltage.

19. Emitter follower is:

(a) CC amplifier

(b) CE amplifier

(c) CB amplifier

(d) CC amplifier with zero collector load

Answer: (a) CC amplifier

Explanation: An emitter follower is a common-collector (CC) amplifier, characterized by high input impedance and unity voltage gain.

20. The stability factor is, S = 1 + β. The biasing method is:

(a) Emitter feedback bias

(b) Fixed bias

(c) Voltage divider bias

(d) Collector feedback bias

Answer: (b) Fixed bias

21. The purpose of biasing in a transistor amplifier is to:

(a) Stabilize the operating point

(b) Maximize the input signal

(c) Minimize distortion

(d) All of the above

Answer: (d) All of the above

Explanation: Biasing stabilizes the Q-point, minimizes distortion by keeping the transistor in the active region, and supports signal amplification.

22. Which of the following biasing circuits provides the most stable Q-point?

(a) Voltage divider bias

(b) Fixed bias

(c) Emitter bias

(d) Collector bias

Answer: (a) Voltage divider bias

Explanation: Voltage divider bias provides the most stable Q-point due to its resistor network compensating for variations.

23. In a voltage divider bias circuit, the resistors used to set the biasing are connected between:

(a) V_{CC} and ground

(b) Base and collector

(c) Emitter and ground

(d) Base and emitter

Answer: (a) V_{CC} and ground

Explanation: In voltage divider bias, resistors are connected between V_{CC} and ground to set the base voltage.

24. The Q-point of a transistor amplifier should be located in the:

(a) Saturation region

(b) Cut-off region

(c) Active region

(d) None of the above

Answer: (c) Active region

Explanation: The Q-point must be in the active region for linear amplification, avoiding saturation or cutoff.

25. The term "load line" refers to the graph between:

(a) I_C and V_{CE}

(b) V_{BE} and I_C

(c) I_C and I_B

(d) I_C and V_{CC}

Answer: (a) I_C and V_{CE}

Explanation: The load line plots I_C versus V_{CE}, showing the transistor's operating range.

26. In a common-emitter amplifier, the transistor operates in which of the following regions?

(a) Saturation and active

(b) Active and cutoff

(c) Cutoff and saturation

(d) None of the above

Answer: (b) Active and cutoff

Explanation: A CE amplifier typically operates in the active region but may enter cutoff or saturation depending on the signal.

27. For the stability of a transistor amplifier, the best value for the stability factor S is:

(a) Low

(b) High

(c) Zero

(d) Negative

Answer: (a) Low

Explanation: A low stability factor ensures minimal IC variation, enhancing amplifier stability.

28. The purpose of using emitter degeneration in a transistor amplifier is to:

(a) Increase gain

(b) Improve stability

(c) Increase output impedance

(d) Decrease linearity

Answer: (b) Improve stability

Explanation: Emitter degeneration (adding an emitter resistor) provides negative feedback, stabilizing the Q-point.

29. In a common-emitter amplifier, the input signal is applied to the:

(a) Collector

(b) Emitter

(c) Base

(d) All of the above

Answer: (c) Base

Explanation: In a CE amplifier, the input signal is applied to the base to control the collector current.

30. The voltage at the emitter of a common-emitter amplifier is:

(a) Always lower than the base voltage

(b) Always higher than the base voltage

(c) Equal to the base voltage

(d) None of the above

Answer: (a) Always lower than the base voltage

31. The collector current in a common-emitter amplifier is mainly controlled by:

(a) The base voltage

(b) The emitter current

(c) The collector voltage

(d) The base-emitter voltage

Answer: (d) The base-emitter voltage

Explanation: I_C is primarily controlled by V_{BE}, as it determines the base current in a BJT.

32. In a transistor, the most heavily doped region is:

(a) Base

(b) Emitter

(c) Collector

(d) Collector-emitter junction

Answer: (b) Emitter

Explanation: The emitter is the most heavily doped to facilitate carrier injection.

33. The purpose of a bypass capacitor in a common-emitter amplifier is to:

(a) Stabilize the Q-point

(b) Provide feedback

(c) Bypass the AC signal to ground

(d) Increase the voltage gain

Answer: (c) Bypass the AC signal to ground

Explanation: A bypass capacitor shunts AC signals to ground, bypassing the emitter resistor to maintain gain.

34. In a common-base amplifier, the input impedance is:

(a) High

(b) Low

(c) Zero

(d) Infinite

Answer: (b) Low

Explanation: A common-base amplifier has low input impedance due to the forward-biased emitter-base junction.

35. In a transistor amplifier, the output is typically taken from the:

(a) Base

(b) Emitter

(c) Collector

(d) None of the above

Answer: (c) Collector

Explanation: In most transistor amplifiers (e.g., CE), the output is taken from the collector.

36. The gain of a transistor amplifier is mainly determined by:

(a) The emitter resistor

(b) The collector resistor

(c) The biasing resistors

(d) All of the above

Answer: (b) The collector resistor

37. The input resistance of a common-emitter amplifier is:

(a) High

(b) Low

(c) Zero

(d) Infinite

Answer: (a) High

Explanation: CE amplifiers have moderate to high input resistance, typically in the kΩ range.

38. The output resistance of a common-emitter amplifier is:

(a) High

(b) Low

(c) Zero

(d) Infinite

Answer: (a) High

Explanation: CE amplifiers have high output resistance, often determined by the collector resistor.

39. Which of the following is NOT a type of transistor amplifier configuration?

(a) Common-base

(b) Common-emitter

(c) Common-collector

(d) Common-anode

Answer: (d) Common-anode

Explanation: Common-anode is not a transistor configuration; the valid ones are CB, CE, and CC.

40. The cut off frequency of a transistor amplifier is:

(a) The frequency at which the gain is zero

(b) The frequency at which the power is zero

(c) The frequency at which the phase shift is 180°

(d) The frequency at which the impedance is infinite

Answer: (Not fully clear; likely (a))

Explanation: Cutoff frequency is where gain drops significantly (e.g., to 0.707 of max), not necessarily zero gain.

41. A transistor amplifier in which the emitter current is directly fed back to the base is called:

(a) Common-emitter amplifier

(b) Emitter feedback amplifier

(c) Voltage divider bias amplifier

(d) Common-collector amplifier

Answer: (b) Emitter feedback amplifier

Explanation: Emitter current feedback to the base stabilizes the Q-point via negative feedback.

42. In a transistor amplifier, the thermal stability of the Q-point is improved by:

(a) Using a higher value of R

(b) Increasing the bias current

(c) Using an emitter resistor

(d) Decreasing the base-emitter voltage

Answer: (c) Using an emitter resistor

Explanation: An emitter resistor provides negative feedback, improving thermal stability.

43. In a common-emitter amplifier, the emitter resistor is used to:

(a) Stabilize the Q-point

(b) Increase gain

(c) Decrease output resistance

(d) None of the above

Answer: (a) Stabilize the Q-point

Explanation: The emitter resistor stabilizes the Q-point by counteracting variations in IC.

44. In an emitter follower circuit, the voltage gain is:

(a) Greater than 1

(b) Less than 1

(c) Equal to 1

(d) Zero

Answer: (c) Equal to 1

Explanation: An emitter follower (CC) has a voltage gain of approximately 1, acting as a buffer.

45. Which biasing method provides the most stable Q-point?

(a) Fixed bias

(b) Emitter feedback bias

(c) Collector-to-base bias

(d) Voltage divider bias

Answer: (d) Voltage divider bias

Explanation: Voltage divider bias is the most stable due to its robust resistor network.

46. Where should the Q-point be placed for maximum output voltage swing in an amplifier?

(a) Close to the saturation region

(b) Close to the cutoff region

(c) At the center of the load line

(d) Anywhere on the load line

Answer: (c) At the center of the load line

Explanation: A centered Q-point maximizes the symmetrical output voltage swing.

47. Why is the Q-point in a voltage amplifier placed in the middle of the load line?

(a) It provides better stability

(b) It reduces the power supply requirement

(c) It minimizes the number of resistors in the biasing circuit

(d) It produces a distorted output

Answer: (a) It provides better stability

Explanation: A centered Q-point ensures stability and maximum undistorted output.

48. In a common-emitter (CE) amplifier, what happens if the Q-point shifts towards cutoff?

(a) The negative half of the output signal is clipped

(b) The positive half of the output signal is clipped

(c) The output signal remains unaffected

(d) The gain of the amplifier increases

Answer: (a) The negative half of the output signal is clipped

Explanation: Shifting toward cutoff limits conduction for the negative cycle, causing clipping.

49. What is a transistor amplifier called when the emitter current is fed back to the base?

(a) Common-emitter amplifier

(b) Emitter feedback amplifier

(c) Voltage divider bias amplifier

(d) Common-collector amplifier

Answer: (b) Emitter feedback amplifier

Explanation: Emitter current feedback to the base enhances stability.

50. How can the thermal stability of the Q-point in a transistor amplifier be improved?

(a) By using a higher value of resistance

(b) By increasing the bias current

(c) By adding an emitter resistor

(d) By decreasing the base-emitter voltage

Answer: (c) By adding an emitter resistor

Explanation: An emitter resistor improves thermal stability via negative feedback.

51. Which component is commonly used in a transistor circuit to improve DC stability?

(a) Collector resistor

(b) Emitter resistor

(c) Coupling capacitor

(d) Bypass capacitor

Answer: (b) Emitter resistor

Explanation: The emitter resistor enhances DC stability by providing feedback.

52. What is the purpose of biasing in a transistor amplifier?

(a) To amplify the input signal

(b) To establish a stable operating point

(c) To reduce the transistor's power consumption

(d) To increase the transistor's switching speed

Answer: (b) To establish a stable operating point

Explanation: Biasing sets the Q-point for proper transistor operation in the active region.

Unit VI

Unit 6: Amplifier

Amplifier Coupling Methods

- **Direct Coupling:** This method directly connects the output of one stage to the input of the next, bypassing the need for any coupling components. This results in the widest possible frequency response, extending from DC (zero frequency) to very high frequencies. However, it can be challenging to implement due to the need to isolate DC offsets between stages.
- **Transformer Coupling:** This method uses a transformer to transfer the signal from one stage to the next. The transformer provides several advantages:
  - **Impedance Matching:** It can effectively match the output impedance of one stage to the input impedance of the next, maximizing power transfer.
  - **DC Isolation:** The transformer isolates the DC component of the signal, preventing it from affecting the subsequent stage.
  - **Efficient Power Transfer:** Transformers can efficiently transfer power, making them suitable for high-power applications.
  - **Image:** (A diagram of a transformer-coupled amplifier would be helpful here)
- **RC Coupling:** This is the most common coupling method, especially in audio amplifiers. It uses a resistor and a capacitor to connect the stages.
  - **Simplicity:** RC coupling is relatively simple to implement.
  - **Reasonable Frequency Response:** It provides a good balance of low-frequency and high-frequency response.
  - **Image:** (A diagram of an RC-coupled amplifier would be helpful here)
- **LC Coupling:** This method uses an inductor and a capacitor to couple the stages. It is less common than RC coupling and offers some advantages in specific applications, but it can be more complex to design and may have limitations in frequency response.

Amplifier Fundamentals

- **Amplification:** This is the process of increasing the strength of a signal without altering its shape or characteristics. Amplifiers are essential components in many electronic systems, from audio systems to communication devices.
- **Gain:** Gain is a measure of how much a signal is amplified. It can be expressed as voltage gain, current gain, or power gain.

- **Voltage Gain:** The ratio of the output voltage to the input voltage.
- **Current Gain:** The ratio of the output current to the input current.
- **Power Gain:** The ratio of the output power to the input power.

- **Decibel (dB) Gain:** Decibels are a logarithmic unit used to express gain. They provide a convenient way to represent large gains in a more compact form.
- **Bandwidth:** The bandwidth of an amplifier is the range of frequencies over which the amplifier provides a relatively constant gain. It is typically defined as the range of frequencies between the lower and upper cutoff frequencies, where the gain has dropped by 3 dB from its maximum value.
- **Operating Point (Q-point):** The Q-point is the DC operating point of the amplifier, which determines the transistor's bias conditions. It is crucial for proper amplifier operation and affects factors like distortion and efficiency.
- **Distortion:** Distortion occurs when the output signal of an amplifier is not an accurate replica of the input signal. It can be caused by various factors, such as non-linearity in the active device, overloading, or improper biasing.
- **Coupling Purpose:** The primary purpose of coupling in an amplifier is to transfer the signal from one stage to the next while blocking the DC component. This is essential because the DC component of one stage can adversely affect the operation of the next stage.

Amplifier Classes and Efficiency

- **Class A Amplifiers:** In Class A amplifiers, the transistor conducts for the entire cycle of the input signal. This results in low distortion but also low efficiency (typically around 25-50%).
- **Class B Amplifiers:** In Class B amplifiers, each transistor conducts for only half of the input cycle. This significantly improves efficiency (up to 78.5%) but can introduce crossover distortion. Push-pull configurations are commonly used to minimize this distortion.
- **Class C Amplifiers:** In Class C amplifiers, the transistor conducts for less than half of the input cycle. This results in very high efficiency (up to 90%) but also high distortion. Class C amplifiers are typically used in RF applications where high efficiency is more critical than low distortion.

- **Class AB Amplifiers:** Class AB amplifiers operate between Class A and Class B, providing a compromise between efficiency and distortion.
- **Collector Efficiency:** Collector efficiency is a measure of how efficiently the amplifier converts DC power from the supply to AC output power. It is an important parameter, especially for power amplifiers.
- **Q-point Placement:** The placement of the Q-point on the load line significantly affects the amplifier's performance, including its efficiency, distortion, and power output.

Amplifier Characteristics and Performance

- **Frequency Response:** The frequency response of an amplifier describes how its gain varies with the frequency of the input signal. It is influenced by factors such as the coupling method, the active device used, and the values of the components in the circuit.
- **Impedance Matching:** Impedance matching is crucial for efficient power transfer between stages. In transformer-coupled amplifiers, the transformer is specifically designed to match the output impedance of one stage to the input impedance of the next.
- **Load Resistance:** The load resistance connected to the output of an amplifier significantly affects its gain and bandwidth.
- **Emitter Resistor:** In common-emitter amplifiers, the emitter resistor can affect the voltage gain. Increasing the emitter resistor generally reduces the voltage gain but can improve stability.
- **Input Signal Frequency:** The frequency of the input signal can affect the amplifier's gain, especially at the extremes of its frequency response.
- **Current Gain:** Current gain is a measure of how much the amplifier amplifies the input current. It is an important parameter for some types of amplifiers.
- **Negative Feedback:** Negative feedback is a technique that can be used to improve the stability, linearity, and bandwidth of an amplifier. It involves feeding a portion of the output signal back to the input, with the feedback signal being inverted.
- **Saturation Region:** When an amplifier is driven too hard, it can enter the saturation region. In this region, the output signal is clipped, leading to significant distortion.

Multistage Amplifiers

- **Cascaded Gain:** In a multistage amplifier, the overall gain is the product of the gains of the individual stages.
- **Stage Gain:** The gain of each individual stage in a multistage amplifier can vary depending on the design and the specific requirements of the application.
- **High Power Amplifier Systems:** High-power amplifier systems often use transformer coupling to efficiently transfer power between stages and to match the output impedance of the amplifier to the load impedance.

Components and their effect.

- **Coupling Capacitors:** Coupling capacitors are used in RC coupling to block the DC component of the signal while allowing the AC signal to pass. The value of the coupling capacitor affects the lower cutoff frequency of the amplifier. A larger capacitor value will allow lower frequencies to pass.

OBJECTIVE TYPE QUESTIONS

1. Best frequency response is shown by........... coupling:

(a) RC
(b) Transformer
(c) Direct
(d) None of them

Answer: (c) Direct

Explanation: Direct coupling provides the best frequency response, extending from DC to high frequencies without capacitor or transformer limitations.

2. Transformer coupling is used in amplifier:

(a) Power
(b) Voltage
(c) Current
(d) None

Answer: (a) Power

Explanation: Transformer coupling is used in power amplifiers for impedance matching and efficient power transfer.

3. RC coupling is used for amplification:

(a) Power

(b) Voltage

(c) Current

(d) None

Answer: (b) Voltage

Explanation: RC coupling is commonly used in voltage amplifiers (e.g., audio) due to its simplicity and wide frequency response.

4. The final stage of a multistage amplifier normally uses .... coupling:

(a) RC

(b) Transformer

(c) Direct

(d) None

Answer: (b) Transformer

Explanation: The final stage of a multistage amplifier often uses transformer coupling for power amplification and load matching.

5. The process of converting a weak signal, without changing its shape, into strong one, is known as:

(a) Modulation

(b) Rectification

(c) Amplification

(d) Biasing

Answer: (c) Amplification

Explanation: Amplification increases signal strength while preserving its shape, distinguishing it from modulation or rectification.

6. In an RC coupled amplifier:

(a) resistance is used as load and capacitance as the coupling element

(b) capacitance is used as load and resistance as coupling element

(c) inductor is used as load and capacitance as coupling element

(d) capacitance is used as load and the inductor as the coupling element

Answer: (a) resistance is used as load and capacitance as the coupling element

Explanation: In RC coupling, a resistor serves as the load, and a capacitor couples the signal between stages.

7. The current flows through the active device for half of the output cycle. Which operation of the amplifier is:

(a) Class A

(b) Class B

(c) Class C

(d) None of these

Answer: (b) Class B

Explanation: Class B amplifiers conduct for half the cycle, typically used in push-pull configurations.

8. The gain of RC coupled amplifier:

(a) Falls at high frequency only

(b) Falls at low frequency only

(c) Falls at high as well as low frequencies

(d) Remains constant at all frequencies

Answer: (c) Falls at high as well as low frequencies

Explanation: RC-coupled amplifier gain drops at low frequencies (capacitor blocking) and high frequencies (parasitic capacitance).

9. Coupling capacitors mainly affect:

(a) Upper cut off frequency

(b) Lower cut off frequency

(c) both upper and lower cut off frequency

(d) gain in high frequency range

Answer: (b) Lower cut off frequency

Explanation: Coupling capacitors primarily affect the lower cutoff frequency by blocking low-frequency signals.

10. Three amplifier stages each with a gain of 10 are cascaded. The net gain will be:

(a) 30

(b) 1000

(c) 10

(d) 1/3

Answer: (b) 1000

Explanation: Cascaded gain is the product of individual gains: $10 \times 10 \times 10 = 1000$.

11. The voltage gain in an amplifier is 200. If the output voltage is 21, the input voltage must be:

(a) 1 mv

(b) 10 mv

(c) 100 mv

(d) 200 mv

Answer: (c) 100 mv

12. A voltage gain of 1000 can be expressed as:

(a) 20 dB

(b) 30 dB

(c) 60 dB

(d) 80 dB

Answer: (c) 60 dB

13. The power gain in an amplifier is P and current gain is C, then the voltage gain is:

(a) C/P

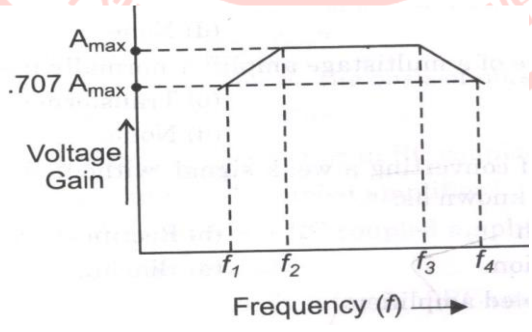
(b) PC

(c) P/C

(d) P+C

Answer: (c) P/C

14. The frequency response curve of a RC coupled amplifier is shown in the given diagram:



The bandwidth of this amplifier would be:

(a) $f_3 - f_2$

(b) $f_4 - f_1$

(c) $\frac{f_4 - f_2}{2}$

(d) f_3 - f_1

Answer: (b) f4 - f1

Explanation: Bandwidth is the difference between upper (f_4) and lower (f_1) cutoff frequencies.

15. The overall gain of a two-stage amplifier is 10,000. If the voltage gain of the first stage is 100, then the voltage gain of the second stage is:

(a) 20

(b) 100

(c) 180

(d) 8000

Answer: (b) 100

16. The best amplifier to match a high impedance source and a low impedance load is the:

(a) RC coupled amplifier

(b) transformer coupled amplifier

(c) common-emitter amplifier

(d) direct coupled

Answer: (b) transformer coupled amplifier

Explanation: Transformer coupling matches high source impedance to low load impedance efficiently.

17. If we increase the load resistance in a common-emitter amplifier, true out of the following statement is:

(a) The gain and bandwidth will decrease

(b) The gain and bandwidth will both increase

(c) The gain will increase and the bandwidth will decrease

(d) The gain will decrease and the bandwidth will increase

Answer: (c) The gain will increase and the bandwidth will decrease

18. The point of intersection of d.c. and a.c. load line represents:

(a) Operating point

(b) Current gain

(c) Voltage gain

(d) None of the above

Answer: (a) Operating point

Explanation: The intersection of DC and AC load lines defines the Q-point.

19. Which of the following amplifier has maximum collector efficiency?

(a) class A

(b) class B

(c) class C

(d) class AB

Answer: (c) class C

Explanation: Class C amplifiers have the highest collector efficiency (up to 90%) due to conduction for less than half the cycle.

20. The RC coupling is normally used in audio frequency amplifier because:

(a) it requires low voltage d.c. supply

(b) it has almost constant gain in audio frequency range

(c) it gives an output signal in phase with input signal

(d) none of the above

Answer: (b) it has almost constant gain in audio frequency range

Explanation: RC coupling is used in audio amplifiers for its flat gain response in the audio range (20 Hz–20 kHz).

21. A power amplifier is a:

(a) frequency converter

(b) voltage to current converter

(c) frequency mixer

(d) none of these

Answer: (d) none of these

Explanation: A power amplifier increases power, not converting voltage to current or mixing frequencies.

22. Which is incorrect?

(a) RC coupled amplifier is an audio amplifier

(b) TC coupled amplifier is used for impedance matching

(c) LC coupling is also called impedance coupling

(d) None of these

Answer: (c) LC coupling is also called impedance coupling

Explanation: LC coupling is not typically called impedance coupling; transformer coupling is used for impedance matching.

23. Maximum efficiency of Class-B, TC coupled amplifier is:

(a) 50%

(b) 25%

(c) 78.5%

(d) 58.5%

Answer: (c) 78.5%

Explanation: Class B transformer-coupled amplifiers achieve a maximum theoretical efficiency of 78.5%.

24. Maximum Collector efficiency for direct coupled Class A amplifier is:

(a) 25%

(b) 50%

(c) 78.5%

(d) 100%

Answer: (b) 50%

Explanation: Direct-coupled Class A amplifiers have a maximum efficiency of 50%, limited by constant conduction.

25. Class-B push-pull amplifier uses coupling:

(a) RC coupling

(b) LC coupling

(c) Transformer coupling

(d) Direct coupling

Answer: (c) Transformer coupling

Explanation: Class B push-pull amplifiers use transformer coupling for impedance matching and efficient power transfer.

26. In the Class B push-pull amplifier, the Q-point lies on the load line at:

(a) the centre

(b) cut-off

(c) saturation

(d) can lie anywhere on the load line

Answer: (b) cut-off

Explanation: In Class B push-pull, the Q-point is at cutoff, with each transistor conducting for half the cycle.

27. Distortion is:

(a) more in small signal amplifiers

(b) more in large signal (power) amplifiers

(c) equal in both small signal and large signal amplifiers

(d) zero in both small signal and large signal amplifiers

Answer: (b) more in large signal (power) amplifiers

Explanation: Power amplifiers handle larger signals, increasing the likelihood of distortion due to non-linearity.

28. The primary purpose of coupling in an amplifier is to:

(a) Prevent signal loss

(b) Transfer the input signal to the next stage

(c) Minimize distortion

(d) Maximize bandwidth

Answer: (b) Transfer the input signal to the next stage

Explanation: Coupling transfers the signal between stages while blocking DC.

29. The efficiency of a class A amplifier is typically:

(a) 100%

(b) 50%

(c) 25%

(d) 78.5%

Answer: (c) 25%

Explanation: Class A efficiency is typically 25% for resistive loads, up to 50% with ideal conditions.

30. In a transformer-coupled amplifier, the impedance matching is important for:

(a) Minimizing distortion

(b) Maximizing signal gain

(c) Maximizing power transfer

(d) Minimizing biasing

Answer: (c) Maximizing power transfer

Explanation: Transformer coupling matches impedances to maximize power transfer to the load.

31. The frequency response of an amplifier is determined by:

(a) The type of coupling used

(b) The quality of the active device

(c) The bandwidth of the load

(d) Both **(a)** and **(b)**

Answer: (d) Both **(a)** and **(b)**

Explanation: Frequency response depends on coupling type and the active device's characteristics.

32. The gain of an amplifier is directly affected by:

(a) The type of coupling

(b) The load resistance

(c) The input signal frequency

(d) All of the above

Answer: (d) All of the above

Explanation: Gain is affected by coupling, load resistance, and signal frequency.

33. In a common-emitter amplifier, increasing the emitter resistor will:

(a) Increase the voltage gain

(b) Decrease the voltage gain

(c) Increase the current gain

(d) Have no effect on the voltage gain

Answer: (b) Decrease the voltage gain

Explanation: Increasing the emitter resistor adds negative feedback, reducing voltage gain.

34. In a Class C amplifier, the current flows for:

(a) Half of the input cycle

(b) Less than half of the input cycle

(c) More than half of the input cycle

(d) The entire input cycle

Answer: (b) Less than half of the input cycle

Explanation: Class C amplifiers conduct for less than half the cycle, optimizing efficiency for RF applications.

35. Which of the following coupling methods is used to connect stages in high-power amplifier systems?

(a) RC coupling

(b) Direct coupling

(c) Transformer coupling

(d) LC coupling

Answer: (c) Transformer coupling

Explanation: Transformer coupling is used in high-power amplifiers for efficient power transfer.

36. A high current gain is a characteristic of:

(a) Power amplifiers

(b) Voltage amplifiers

(c) Class A amplifiers

(d) Transistor amplifiers

Answer: (d) Transistor amplifiers

Explanation: High-op-amp High current gain is a general feature of transistor amplifiers, not specific to power or Class A.

37. The efficiency of a Class A amplifier depends on:

(a) The load resistance

(b) The Q-point

(c) The biasing circuit

(d) The coupling type

Answer: (b) The Q-point

Explanation: Class A efficiency depends on the Q-point's position on the load line.

38. A Class A amplifier is generally used for:

(a) Power amplification

(b) High-fidelity audio systems

(c) RF circuits

(d) Low noise amplification

Answer: (b) High-fidelity audio systems

Explanation: Class A amplifiers are used for high-fidelity audio due to low distortion.

39. Which of the following factors can cause distortion in an amplifier?

(a) Incorrect biasing

(b) Overdriving the input signal

(c) Using improper coupling methods

(d) All of the above

Answer: (d) All of the above

Explanation: Distortion can result from improper biasing, overdriving, or coupling issues.

40. In a transformer-coupled amplifier, what is the primary function of the transformer?

(a) Provide impedance matching

(b) Amplify the input signal

(c) Filter the signal

(d) Provide DC isolation

Answer: (a) Provide impedance matching

Explanation: The transformer matches source and load impedances for maximum power transfer.

41. In the frequency response of an RC-coupled amplifier, the lower cutoff frequency is determined by:

(a) The value of the coupling capacitor

(b) The collector resistor

(c) The emitter resistor

(d) The input resistance of the amplifier

Answer: (a) The value of the coupling capacitor

Explanation: The lower cutoff frequency is set by the coupling capacitor's reactance.

42. Which class of amplifier has the highest efficiency?

(a) Class A

(b) Class B

(c) Class C

(d) Class AB

Answer: (c) Class C

Explanation: Class C has the highest efficiency (up to 90%) due to minimal conduction time.

43. The typical collector efficiency for a Class B amplifier is:

(a) 100%

(b) 50%

(c) 78.5%

(d) 25%

Answer: (c) 78.5%

Explanation: Class B amplifiers achieve a maximum efficiency of 78.5% in push-pull configurations.

44. The distortion in an amplifier is caused primarily by:

(a) Power supply fluctuations

(b) Non-linear behavior of the active device

(c) Improper biasing

(d) All of the above

Answer: (d) All of the above

Explanation: Distortion arises from power supply issues, non-linear devices, and biasing errors.

45. A Class B amplifier operates efficiently in:

(a) Low-power applications

(b) High-power audio applications

(c) Both low and high-power applications

(d) None of the above

Answer: (b) High-power audio applications

Explanation: Class B is efficient for high-power audio, especially in push-pull designs.

46. The maximum efficiency of a Class A amplifier is:

(a) 25%

(b) 50%

(c) 78.5%

(d) 100%

Answer: (b) 50%

Explanation: The maximum theoretical efficiency of a Class A amplifier is 50%.

47. In a push-pull amplifier, the Q-point is ideally placed at:

(a) Cut-off

(b) The center of the load line

(c) Saturation

(d) Any point along the load line

Answer: (a) Cut-off

Explanation: In a push-pull Class B amplifier, the Q-point is at cutoff for each transistor.

48. In a multistage amplifier, each stage typically has:

(a) A higher voltage gain than the previous stage

(b) A lower voltage gain than the previous stage

(c) The same voltage gain

(d) No voltage gain

Answer: (c) The same voltage gain

Explanation: Multistage amplifiers often have stages with similar gains, though this varies by design.

49. The bandwidth of an amplifier can be increased by:

(a) Decreasing the load resistance

(b) Increasing the emitter resistor

(c) Reducing the value of the coupling capacitor

(d) Using negative feedback

Answer: (d) Using negative feedback

Explanation: Negative feedback increases bandwidth by flattening the frequency response.

50. In a Class C amplifier, the efficiency is generally:

(a) Very low

(b) Moderate

(c) High

(d) 100%

Answer: (c) High

Explanation: Class C amplifiers achieve high efficiency (up to 90%) for RF applications.

51. An amplifier operating in the saturation region typically has:

(a) High distortion

(b) Low distortion

(c) No output signal

(d) Zero efficiency

Answer: (a) High distortion

Explanation: Operation in saturation causes clipping and high distortion.

52. The key benefit of using a direct-coupled amplifier is:

(a) High power gain

(b) Low frequency response

(c) High bandwidth

(d) Simple design

Answer: (c) High bandwidth

Explanation: Direct coupling offers a wide bandwidth, including DC response.

Unit VII

Unit 7: Feedback and Oscillator Circuits

Negative Feedback in Amplifiers

- **Effects of Negative Feedback:**
  - **Decreases Gain:** Negative feedback reduces the overall gain of an amplifier. This might seem counterintuitive, but it's crucial for stability.
  - **Stabilizes Gain Against Variations:** By feeding back a portion of the output, the amplifier becomes less sensitive to changes in component values, temperature, or power supply fluctuations. This results in a more consistent and reliable gain.
  - **Increases Input Impedance:** Negative feedback can increase the input impedance of an amplifier, meaning it draws less current from the signal source. This is beneficial for minimizing loading effects.
  - **Increases Bandwidth:** Negative feedback extends the frequency range over which the amplifier provides a relatively flat gain response. It effectively "flattens" the gain curve.
- **Feedback Network:** Typically uses resistive networks because resistors are stable and provide predictable feedback ratios across a wide range of frequencies.
- **Feedback Voltage:**
  - In **voltage feedback**, the feedback signal is proportional to the output voltage.
  - In **current feedback**, the feedback signal is proportional to the output current.
- **Purpose:** The overarching purpose of negative feedback is to improve the overall performance and stability of an amplifier. It reduces distortion, stabilizes gain, and enhances bandwidth.

Positive Feedback and Oscillators

- **Effects of Positive Feedback:**
  - **Increases Gain:** Positive feedback reinforces the input signal, leading to a significant increase in gain.
  - **Leads to Instability or Oscillation:** If the positive feedback is not carefully controlled, it can cause the amplifier to become unstable and oscillate, generating its own output signal.

- **Opposite Effects Compared to Negative Feedback:** Positive feedback's effects are the direct opposite of negative feedback's, with increased gain and the risk of instability.

- **Applications:** Positive feedback is essential for oscillators, which are circuits that generate periodic signals without an external input.
- **Barkhausen Criterion:**
    - **Loop Gain (Aβ) Must Equal 1:** This condition ensures that the feedback signal is sufficient to sustain oscillations.
    - **Phase Shift Between Input and Output Must Be 0° or 360°:** This condition ensures that the feedback signal reinforces the input signal, leading to sustained oscillations.
- **Oscillator Function:** Oscillators convert DC power into AC signals. This is achieved by using positive feedback to create an unstable condition that results in a periodic output.
- **Essential Oscillator Components:**
    - **Tank Circuit (LC):** This circuit, consisting of an inductor (L) and a capacitor (C), determines the frequency of oscillation.
    - **Transistor Amplifier:** This provides the necessary gain to sustain oscillations.
    - **Feedback Circuit:** This provides the positive feedback required for oscillation.
- **Oscillator Gain:** In an ideal oscillator, the closed-loop voltage gain tends toward infinity, as the circuit generates its own output without an external input.
- **Starting Oscillations:** The loop gain (βA) must be greater than or equal to 1 to initiate oscillations.

Oscillator Types and Characteristics

- **Hartley Oscillator:**
    - Uses a tapped inductor in the tank circuit to provide feedback.
    - The frequency of oscillation is determined by the values of the inductors and the capacitor in the tank circuit.
- **Colpitts Oscillator:**
    - Uses a tapped capacitor in the tank circuit to provide feedback.
    - The frequency of oscillation is determined by the values of the capacitors and the inductor in the tank circuit.

  - uses capacitive voltage divison for feedback.
  - commonly used in RF applications, due to good high frequency stability.
- **Wein Bridge Oscillator:**
  - Uses an RC network for feedback, providing a sinusoidal output.
  - Provides excellent frequency stability and low distortion, making it suitable for audio applications.
  - uses positive feedback to create oscillations.
- **RC Phase Shift Oscillator:**
  - Uses a network of resistors and capacitors to provide the necessary phase shift for oscillation.
  - The frequency of oscillation is determined by the values of the resistors and capacitors in the network.
- **Frequency of Oscillation:** The frequency of oscillation in an LC oscillator is determined by the values of the inductor and capacitor in the tank circuit. In an RC oscillator, it's determined by the values of the resistors and capacitors in the feedback network.
- **Phase Shift:** Oscillators require a total phase shift of 0° or 360° around the feedback loop to ensure that the feedback signal reinforces the input signal.
- **Frequency Stabilization:** Tank circuits (LC) are commonly used to stabilize the frequency of oscillation in oscillators. Phase locked loops can also be used for better frequency stability.

Feedback Conditions and Calculations

- **Feedback Factor (β):** The feedback factor is the fraction of the output signal that is fed back to the input. In oscillators, it is typically less than 1.
- **Loop Gain (Aβ):** The loop gain is the product of the amplifier gain (A) and the feedback factor (β). It must be equal to or greater than 1 for oscillations to start.
- **Calculating Feedback Factor:** The feedback factor needed to create oscillations can be calculated using the Barkhausen criterion.
- **Phase Shift in RC Phase Shift Oscillator:** The phase shift provided by the RC network in an RC phase shift oscillator can be calculated using trigonometric functions.

Applications and Components

- **Signal Generation:** Oscillators are used in a wide range of applications, including signal generators, frequency synthesizers, and clock circuits.
- **Operational Amplifiers (Op-amps):** Op-amps are often used in oscillator circuits, especially Wein bridge oscillators, due to their high gain and stability.
- **Frequency Tuning Range:** The frequency tuning range of an RC oscillator is determined by the range of values that can be achieved by the variable resistors or capacitors in the network.
- **Frequency Stability:** Tank circuits or phase locked loops are used to improve the frequency stability of oscillators.

OBJECTIVE TYPE QUESTIONS

1. Negative feedback in an amplifier:

(a) decreases the gain

(b) stabilizes the gain

(c) increases the input impedance

(d) all of these

Answer: (d) all of these

Explanation: Negative feedback decreases gain, stabilizes it against variations, and increases input impedance.

2. A feedback circuit usually employs a network:

(a) capacitive

(b) resistive

(c) inductive

(d) none of the above

Answer: (b) resistive

Explanation: Feedback circuits typically use resistive networks for simplicity and stability in amplifiers.

3. Negative feedback:

(a) Increases bandwidth

(b) decreases input impedance

(c) increases output impedance

(d) increases non-linear distortion

Answer: (a) Increases bandwidth

Explanation: Negative feedback flattens the gain curve, increasing bandwidth while reducing gain.

4. Positive feedback:

(a) stabilizes the gain

(b) decreases the gain

(c) increases the gain

(d) has no effect on gain

Answer: (c) increases the gain

Explanation: Positive feedback amplifies the gain, potentially leading to instability or oscillation.

5. In negative voltage feedback, the feedback voltage is proportional to the:

(a) output current

(b) output voltage

(c) input voltage

(d) none of the above

Answer: (b) output voltage

Explanation: In negative voltage feedback, the feedback signal is proportional to the output voltage.

6. In negative current feedback, the feedback voltage is proportional to:

(a) input current

(b) output current

(c) output voltage

(d) input voltage

Answer: (b) output current

Explanation: In negative current feedback, the feedback voltage is proportional to the output current.

7. Positive feedback is used in:

(a) amplifier

(b) rectifier

(c) oscillator

(d) detector

Answer: (c) oscillator

Explanation: Positive feedback is used in oscillators to sustain oscillations.

8. Effects of positive feedback:

(a) are opposite to those of negative feedback

(b) better than those of negative feedback

(c) result in the stability of gain

(d) decrease the gain of amplifier

Answer: (a) are opposite to those of negative feedback

Explanation: Positive feedback increases gain and instability, opposite to negative feedback's effects.

9. The voltage gain without feedback is 100 and feedback fraction is 0.39 with negative feedback. That will be the gain with feedback?

(a) 1.5

(b) 39

(c) 2.5

(d) 1

Answer: (c) 2.5

10. The Barkhausen criterion for oscillator stability is:

(a) $\beta A = 0$

(b) $\beta A = 1$

(c) $-\beta A = 1$

(d) $A = \frac{1}{\sqrt{\beta}}$

Answer: (b) $\beta A = 1$

11. For sustained oscillations in an oscillator:

(a) feedback should be positive

(b) feedback factor should be unity

(c) phase shift between i/p and o/p should be 0° or 360°

(d) all of the above

Answer: (d) all of the above

Explanation: Sustained oscillations require positive feedback and a phase shift of 0° or 360°.

12. The condition of sustained oscillations in Hartley oscillator is:

(a) $h_{fe} = \frac{L_2}{L_1}$

(b) $h_{fe} = \frac{L_1}{L_2}$

(c) $h_{fe} = \frac{1}{L_1 L_2}$

(d) $h_{fe} = \frac{L_1+M}{L_2+M}$

Answer: (d) $h_{fe} = \frac{L_1+M}{L_2+M}$

13. Which of these is an essential part of transistor oscillator:

(a) tank circuit

(b) transistor amplifier

(c) feedback circuit

(d) all of the above

Answer: (d) all of the above

Explanation: A transistor oscillator needs a tank circuit (frequency), amplifier (gain), and feedback circuit.

14. An oscillator converts:

(a) ac into dc

(b) dc into ac

(c) both **(a)** & **(b)**

(d) neither **(a)** nor **(b)**

Answer: (b) dc into ac

Explanation: Oscillators convert DC power into AC signals via feedback.

15. Which of these does not require an external input signal?

(a) rectifier

(b) amplifier

(c) oscillator

(d) detector

Answer: (c) oscillator

Explanation: Oscillators generate signals without an external input, unlike amplifiers or rectifiers.

16. The closed-loop voltage gain in an oscillator would be:

(a) zero

(b) infinity

(c) $\frac{1}{A}$

(d) βA

Answer: (b) infinity

17. The voltage amplification factor of a device is 50. The feedback factor needed to turn it into an oscillator will be:

(a) 0.02

(b) 0.04

(c) 0.1

(d) 1

Answer: (a) 0.02

18. An LC oscillator that uses a tapped inductor in its tank circuit is:

(a) Hartley oscillator

(b) Phase shift oscillator

(c) Colpitts

(d) Wein bridge oscillator

Answer: (a) Hartley oscillator

Explanation: A Hartley oscillator uses a tapped inductor in its tank circuit.

19. The frequency of oscillations in Hartley oscillator is:

(a) $f = \frac{1}{2\pi}\sqrt{\{\frac{1}{L}(\frac{1}{C_1}+\frac{1}{C_2})\}}$

(b) $f = \frac{1}{2\pi\sqrt{C_1 C_2 R_1 R_2}}$

(c) $f = \frac{1}{2\pi\sqrt{(L_1+L_2)\,C}}$

(d) $f = \frac{1}{2\pi\sqrt{LC}}$

Answer: (c) $f = \frac{1}{2\pi\sqrt{(L_1+L_2)\,C}}$

20. The condition of sustained oscillations in Colpitts oscillator is:

(a) $h_{fe} = \frac{C_1}{C_2}$

(b) $h_{fe} = \frac{C_2}{C_1}$

(c) $h_{fe} = \frac{1}{C_1 C_2}$

(d) $h_{fe} = \frac{C_1+M}{C_2+M}$

Answer: (a) $h_{fe} = \frac{C_1}{C_2}$

21. The frequency of oscillations in a Colpitts oscillator is:

(a) $f = \frac{1}{2\pi\sqrt{LC_T}}$

(b) $f = \frac{1}{2\pi\sqrt{C_T R}}$

(c) $\frac{1}{2\pi}\sqrt{LC_T}$

(d) $f = 2\pi\sqrt{LC_T}$

Where $C_T = \frac{C_1 C_2}{C_1+C_2}$

Answer: (a) $f = \frac{1}{2\pi\sqrt{LC_T}}$

22. The resonant frequency in Wein bridge oscillator is:

(a) $f = 2\pi C_1 C_2 R_1 R_2$

(b) $f = \frac{1}{2\pi X_1 C_2 R_1 R_2}$

(c) $f = 2\pi\sqrt{C_1 C_2 R_1 R_2}$

(d) $f = \frac{1}{2\pi\sqrt{C_1 C_2 R_1 R_2}}$

Answer: (d) $f = \frac{1}{2\pi\sqrt{C_1 C_2 R_1 R_2}}$

23. The frequency of RC phase shift oscillator is:

(a) $f = 2\pi RC\sqrt{6}$

(b) $f = \frac{\sqrt{6}}{2\pi RC}$

(c) $f = 2\pi RC$

(d) none of the above.

Answer: (b) $f = \frac{\sqrt{6}}{2\pi RC}$

24. The phase shift produced in a RC phase shift oscillator is given by:

(a) $\phi = \tan^{-1} 2\pi RC\sqrt{6}$

(b) $\phi - \tan^{-t} 2\pi RC$

(c) $\phi = \tan^{-1}\frac{1}{2\pi fRC}$

(d) $\phi = \tan^{-1}\frac{1}{2\pi RC}$

Answer: (d) $\phi = \tan^{-1}\frac{1}{2\pi RC}$

25. The tuning range in an RC oscillator is proportional to:

(a) $\frac{1}{R}$

(b) $\frac{1}{C}$

(c) $\frac{1}{L}$

(d) $\frac{1}{LC}$

Answer: (b) $\frac{1}{C}$

26. The purpose of negative feedback in an amplifier is to:

(a) Increase the gain

(b) Stabilize the gain

(c) Decrease input impedance

(d) Decrease bandwidth

Answer: (b) Stabilize the gain

Explanation: Negative feedback stabilizes gain against component variations.

27. Which type of feedback leads to instability in an amplifier circuit?

(a) Negative feedback

(b) Positive feedback

(c) Both **(a)** and **(b)**

(d) None of the above

Answer: (b) Positive feedback

Explanation: Positive feedback can cause instability or oscillation in amplifiers.

28. Which of the following is true about positive feedback?

(a) It decreases bandwidth

(b) It increases stability

(c) It decreases the gain

(d) It increases the gain

Answer: (d) It increases the gain

Explanation: Positive feedback boosts gain, unlike negative feedback.

29. What effect does negative feedback have on the input impedance of an amplifier?

(a) It decreases input impedance

(b) It increases input impedance

(c) It has no effect

(d) It makes it infinite

Answer: (b) It increases input impedance

Explanation: Negative feedback increases input impedance by reducing input current demand.

30. The condition for sustained oscillations in a transistor oscillator is:

(a) Positive feedback with phase shift of 90°

(b) Positive feedback with phase shift of 180°

(c) Feedback factor must be 1

(d) Phase shift must be 0° or 360°

Answer: (d) Phase shift must be 0° or 360°

Explanation: Sustained oscillations require positive feedback with a total phase shift of 0° or 360°.

31. Which of the following types of oscillators uses a tank circuit?

(a) Hartley oscillator

(b) Colpitts oscillator

(c) Wein bridge oscillator

(d) All of the above

Answer: (a) Hartley oscillator

Explanation: Hartley and Colpitts use tank circuits; Wein bridge uses RC networks.

32. In a feedback circuit, the feedback voltage is:

(a) Always in phase with the input voltage

(b) Always in phase with the output voltage

(c) Proportional to the input voltage in negative feedback

(d) Proportional to the output current in positive feedback

Answer: (Not clear; likely **(b)**)

Explanation: Feedback voltage depends on feedback type (e.g., output voltage for voltage feedback).

33. Which type of oscillator is commonly used in RF (Radio Frequency) applications?

(a) Colpitts oscillator

(b) RC phase shift oscillator

(c) Hartley oscillator

(d) Wein bridge oscillator

Answer: (a) Colpitts oscillator

Explanation: Hartley and Colpitts are common in RF due to their LC tank circuits.

34. In an oscillator, the feedback factor (β) is typically:

(a) Less than 1

(b) Equal to 1

(c) Greater than 1

(d) Zero

Answer: **(a)** Less than 1

35. For an oscillator to function correctly, the phase shift between input and output must be:

(a) 90°

(b) 180°

(c) 0° or 360°

(d) 270°

Answer: (c) 0° or 360°

Explanation: Oscillators require in-phase feedback (0° or 360°) for sustained oscillations.

36. Which of the following oscillators is designed to provide both frequency stability and low distortion?

(a) Hartley oscillator

(b) Colpitts oscillator

(c) Wein bridge oscillator

(d) Phase shift oscillator

Answer: (c) Wein bridge oscillator

Explanation: Wein bridge oscillators provide frequency stability and low distortion for audio.

37. The frequency of oscillation in a Colpitts oscillator depends on:

(a) The value of the inductor and capacitors

(b) The transistor's current gain

(c) The feedback loop gain

(d) The supply voltage

Answer: (a) The value of the inductor and capacitors

Explanation: Colpitts frequency depends on the LC tank circuit values.

38. In a Wein bridge oscillator, the feedback network consists of:

(a) Two inductors and two capacitors

(b) Two resistors and two capacitors

(c) Two resistors and two inductors

(d) One resistor and one capacitor

Answer: (b) Two resistors and two capacitors

Explanation: Wein bridge uses an RC network with two resistors and two capacitors.

39. In a Hartley oscillator, the frequency of oscillation is determined by:

(a) Two capacitors and a resistor

(b) The ratio of inductances in the tank circuit

(c) The total impedance of the circuit

(d) The supply voltage

Answer: (b) The ratio of inductances in the tank circuit

Explanation: Hartley frequency depends on the tapped inductor ratio and capacitance.

40. Which of the following oscillators uses a phase shift network for feedback?

(a) Hartley oscillator

(b) RC phase shift oscillator

(c) Wein bridge oscillator

(d) Colpitts oscillator

Answer: (b) RC phase shift oscillator

Explanation: RC phase shift oscillators use a network of resistors and capacitors for feedback.

41. Which of the following is the feedback condition for sustained oscillations in an oscillator?

(a) The loop gain is greater than or equal to 1

(b) The loop gain is equal to 1 and the phase shift is 180°

(c) The loop gain is less than 1

(d) The phase shift is 90°

Answer: (a) The loop gain is greater than or equal to 1

Explanation: Barkhausen criterion requires $A\beta \geq 1$ for oscillation onset.

42. Which of the following feedback methods is used in the Colpitts oscillator?

(a) Voltage feedback

(b) Current feedback

(c) Series feedback

(d) Capacitive feedback

Answer: (d) Capacitive feedback

Explanation: Colpitts uses capacitive voltage division for feedback.

43. The frequency of oscillation in a Colpitts oscillator is inversely proportional to:

(a) The inductance in the tank circuit

(b) The resistance in the tank circuit

(c) The capacitance in the tank circuit

(d) The feedback factor

Answer: (c) The capacitance in the tank circuit

44. What type of feedback is used in a Wein bridge oscillator?

(a) Voltage feedback

(b) Current feedback

(c) Series feedback

(d) Positive feedback

Answer: (d) Positive feedback

Explanation: Wein bridge uses positive feedback via an RC network for oscillation.

45. In the Barkhausen criterion for sustained oscillations, the phase shift between the input and the feedback signal should be:

(a) 90°

(b) 180°

(c) 0° or 360°

(d) 270°

Answer: (c) 0° or 360°

Explanation: Barkhausen criterion specifies a total phase shift of 0° or 360°.

46. Which of the following is the main application of an oscillator?

(a) Frequency conversion

(b) Amplification

(c) Signal generation

(d) Impedance matching

Answer: (c) Signal generation

Explanation: Oscillators generate periodic signals for various applications.

47. Which of the following amplifiers uses negative feedback to improve its stability?

(a) Class A amplifier

(b) Class B amplifier

(c) Operational amplifier

(d) Class C amplifier

Answer: (c) Operational amplifier

Explanation: Op-amps often use negative feedback for stability in amplifiers.

48. In an oscillator, the loop gain is the product of:

(a) Amplifier gain and feedback factor

(b) Signal frequency and amplifier gain

(c) Feedback factor and oscillator power

(d) None of the above

Answer: (a) Amplifier gain and feedback factor

Explanation: Loop gain is \(A\beta \), the product of amplifier gain and feedback factor.

49. The feedback network in a phase shift oscillator typically includes:

(a) Inductors

(b) Resistors and capacitors

(c) Only resistors

(d) Only capacitors

Answer: (b) Resistors and capacitors

Explanation: RC phase shift oscillators use RC networks for phase shift.

50. Which of the following is NOT a condition for oscillation in a Colpitts oscillator?

(a) Phase shift of 180°

(b) Feedback factor equal to 1

(c) Proper tuning of the tank circuit

(d) Feedback should be positive

Answer: (a) Phase shift of 180°

Explanation: Colpitts uses positive feedback with a 180° phase shift from the tank circuit, corrected to 0° overall.

51. The gain required in an oscillator to start oscillations can be calculated using:

(a) βA=1

(b) βA=0

(c) βA>1

(d) βA=0.5

Answer: (a) βA=1

Explanation: Oscillations start when \(A\beta = 1 \), per Barkhausen criterion.

52. What type of circuit is used for frequency stabilization in an oscillator?

(a) Phase-locked loop

(b) Tank circuit

(c) Feedback loop

(d) Rectifier circuit

Answer: (b) Tank circuit

Explanation: Tank circuits (LC) stabilize frequency in oscillators like Hartley and Colpitts.

Unit VIII

Unit 8: Introduction to Fibre Optics

Optical Fiber Fundamentals

- **Total Internal Reflection (TIR):**
  - TIR is the cornerstone of optical fiber technology. It occurs when light traveling in a denser medium (the core) strikes the boundary with a less dense medium (the cladding) at an angle greater than the critical angle.
  - This causes the light to be completely reflected back into the core, preventing it from escaping.
  - The core-cladding interface acts like a perfect mirror, guiding the light along the fiber's length.
  - This process is essential for minimizing signal loss and enabling long-distance transmission.
- **Core and Cladding:**
  - **Core:**
    - The core is the central part of the fiber, where light propagates.
    - It's made of a material with a higher refractive index to ensure TIR.
    - Common materials include glass (silica) and plastic.
  - **Cladding:**
    - The cladding surrounds the core and has a lower refractive index.
    - Its primary function is to create the refractive index difference necessary for TIR.
    - It also provides a protective layer for the core.
  - **Step-Index Fibers:**
    - These fibers have a sharp, step-like change in refractive index at the core-cladding boundary.
    - Light travels in a zigzag path within the core.
    - They are susceptible to modal dispersion, especially multimode step index fibers.
  - **Graded-Index Fibers:**
    - These fibers have a refractive index that gradually decreases from the center of the core to the cladding.
    - This gradient causes light rays to bend, reducing modal dispersion.

        - They are often used for medium distance applications.

- **Numerical Aperture (NA):**
    - NA quantifies the light-gathering ability of an optical fiber.
    - It is defined as the sine of the maximum acceptance angle, which is the angle at which light can enter the fiber and still undergo TIR.
    - A higher NA means the fiber can collect more light, making it easier to couple light into the fiber.
    - NA is a dimensionless value.
- **Attenuation:**
    - Attenuation refers to the loss of signal strength as light travels through the fiber.
    - It is typically measured in decibels per kilometer (dB/km).
    - **Causes of Attenuation:**
        - **Absorption:** Impurities in the fiber material absorb light.
        - **Rayleigh Scattering:** Light is scattered by microscopic variations in the fiber's density. This scattering is higher at shorter wavelengths.
        - **Bending Loss:** Sharp bends in the fiber can cause light to escape.
    - Fiber diameter does not directly affect attenuation, but fiber materials and manufacturing processes do.
- **Applications:**
    - **Endoscopy:** Optical fibers transmit light and images inside the body for medical diagnosis and treatment.
    - **Long-Distance Communication:** Single-mode fibers are essential for transmitting high-bandwidth data over long distances, forming the backbone of modern telecommunications networks.

Fiber Types and Characteristics

- **Single-Mode Fiber (SMF):**
    - SMF has a small core diameter, allowing only one mode of light to propagate.
    - This eliminates modal dispersion, enabling high-bandwidth transmission over long distances.
    - It is used in long-haul telecommunications, submarine cables, and other high-capacity applications.
- **Multimode Fiber (MMF):**

  - MMF has a larger core diameter, allowing multiple modes of light to propagate.
  - This leads to modal dispersion, which limits the bandwidth and distance capabilities.
  - It is used in short-distance applications, such as local area networks (LANs) and data centers.
- **Step-Index Fiber:**
  - As mentioned earlier, it has an abrupt change in refractive index.
  - This causes light to follow a zigzag path, increasing modal dispersion.
- **Graded-Index Fiber:**
  - The graded refractive index profile minimizes modal dispersion by causing light rays to follow curved paths.
  - This reduces the difference in travel times between different modes.

Fiber Components and Functions

- **Jacket (Buffer):**
  - The outermost layer of the fiber, providing mechanical protection.
  - It shields the fiber from abrasion, moisture, and other environmental factors.
  - It adds strength to the fiber.
- **Cladding:**
  - Surrounds the core and provides the lower refractive index for TIR.
  - It also helps to protect the core from surface contamination, which can cause signal loss.
- **Core:**
  - The light-carrying portion of the fiber.
  - Its material and diameter determine the fiber's transmission characteristics.
- **Buffer layer:**
  - This is a coating directly on the cladding. It provides physical protection from moisture, and other environmental hazards.

Optical Fiber Calculations and Concepts

- **Critical Angle:**
  - The critical angle is the minimum angle of incidence at which TIR occurs.

  - It is calculated using Snell's law and the refractive indices of the core and cladding.
- **Decibel (dB):**
  - Decibels are used to express the ratio of two power levels, such as the input and output power of an optical fiber.
  - It provides a logarithmic scale, making it convenient to represent large power ratios.
- **Maximum Angle of Incidence:**
  - The maximum angle of incidence is the largest angle at which light can enter the fiber and still be guided by TIR.
  - This angle is related to the numerical aperture (NA) of the fiber.
- **Normalized Refractive Index Difference:**
  - This value is used to describe the difference between the refractive index of the core and the cladding.
  - It influences the numerical aperture and the acceptance angle of the fiber.

Optical Fiber Advantages

- **Compared to Copper Wire:**
  - **Higher Bandwidth:** Optical fibers can carry much more data than copper wires.
  - **Lower Attenuation:** Optical signals can travel much farther without significant loss.
  - **Immunity to Electromagnetic Interference (EMI):** Optical fibers are not affected by EMI, making them ideal for noisy environments.
  - **Lighter and Smaller:** Optical fibers are much lighter and smaller than copper wires, making them easier to install and manage.
- **Single-Mode vs. Multimode:**
  - Single-mode fibers offer significantly lower modal dispersion, enabling higher bandwidth and longer transmission distances.
  - Multimode fibers are cheaper, and easier to work with, but are limited in distance and bandwidth

OBJECTIVE TYPE QUESTIONS

1. An optical fiber has a core with refractive index 1.52 and cladding with a refractive index of 1.45. Its numerical aperture is:

(a) 0.15

(b) 0.20

(c) 0.46

(d) 0.70

Answer: (c) 0.46

2. Light is confined within the core of a simple fiber by:

(a) refraction

(b) total internal reflection at outer edge of cladding

(c) total internal reflection at core-cladding boundary

(d) reflection from fibers plastic coating

Answer: (c) total internal reflection at core-cladding boundary

Explanation: Light is confined in the core by total internal reflection at the core-cladding interface

3. The input power to an optical power cable is 1 mW. The cable loss is 20 dB. Assuming there are no other losses, the output power is:

(a) 0.1 mW

(b) 0.05 mW

(c) 0.01 mW

(d) 0.001 mW

Answer: (c) 0.01 mW

4. The output of a 20 Km optical fiber cable is 0.005 mW. The fiber loss is 0.5 dB/km. The input power to the fibers is:

(a) 1 mW

(b) 0.5 mW

(c) 0.05 mW

(d) 0.01 mW

Answer: (c) 0.05 mW

5. The optical fiber attenuation is lowest at:

(a) 800 nm

(b) 1300 nm

(c) 1600 nm

(d) 2000 nm

Answer: (b) 1300 nm

Explanation: Fiber attenuation is lowest at 1300 nm and 1550 nm, with 1300 nm being a common standard.

6. Optical fiber works on the phenomenon of:

(a) refraction

(b) diffraction

(c) polarization

(d) total internal reflection

Answer: (d) total internal reflection

Explanation: Optical fibers operate based on total internal reflection at the core-cladding boundary.

7. The refractive index of core material of an optical fiber is:

(a) same as that of cladding

(b) higher than that of cladding

(c) lower than that of cladding

(d) sometimes lower and sometimes higher than that of cladding

Answer: (b) higher than that of cladding

Explanation: The core's refractive index must be higher than the cladding's for total internal reflection.

8. Optical fibers are used in:

(a) x-ray photographs

(b) ultrasound scans

(c) Endoscopy

(d) CT scans

Answer: (c) Endoscopy

Explanation: Optical fibers are used in endoscopy to transmit light and images inside the body.

9. Which of the following is incorrect for optical fiber cables as compared to traditional copper wire cable?

(a) They are lighter

(b) They carry more data

(c) They are more flexible

(d) They are bulky

Answer: (d) They are bulky

Explanation: Optical fibers are lighter, carry more data, and are more flexible than copper; they are not bulky.

10. Which fiber is preferred for long distance communication?

(a) Step index single mode fiber

(b) Graded index multimode fiber

(c) Step index multimode fiber

(d) Graded index fiber

Answer: (a) Step index single mode fiber

Explanation: Single-mode fibers minimize dispersion, making them ideal for long-distance communication.

11. In an optical fiber, the refractive index of cladding material should be:

(a) nearly unity

(b) very low

(c) less than that of core

(d) more than that of core

Answer: (c) less than that of core

Explanation: Cladding's refractive index must be lower than the core's for total internal reflection.

12. The fiber in which refractive index of core is uniform and then undergoes an abrupt change at the cladding boundary, is known as:

(a) graded index fiber

(b) step index fiber

(c) uniform index fiber

(d) Non uniform index fiber

Answer: (b) step index fiber

Explanation: Step-index fibers have a uniform core refractive index with an abrupt change at the cladding.

13. The numerical aperture (NA) in optical fiber communication is used to describe:

(a) Light spreading ability

(b) Light gathering or Light collecting ability

(c) Light output from an external field

(d) Light leakage ability

Answer: (b) Light gathering or Light collecting ability

Explanation: Numerical aperture (NA) measures the fiber's ability to collect light from a source.

14. The critical angle θ_c in an optical fiber at core-cladding interface with refractive indices of core and cladding μ_1 and μ_2 respectively is :

(a) $\sin^{-1}\left(\frac{\mu_2}{\mu_1}\right)$

(b) $\sin^{-1}\left(\frac{\mu_1}{\mu_2}\right)$

(c) $\sin^{-1}(\mu_1\mu_2)$

(d) $\sin^{-1}(\mu_2)$

Answer: (a) $\sin^{-1}\left(\frac{\mu_2}{\mu_1}\right)$

15. The cladding which surrounds the optical fiber:

(a) is used to protect the fiber

(b) is used to reduce optical interference

(c) is used to guide light in core

(d) is used to ensure that the refractive index remains constant

Answer: (a) is used to protect the fiber

Explanation: Cladding protects the core and enables total internal reflection.

16. Which material is used for fabricating optical fiber?

(a) Glass and plastic

(b) Copper

(c) Silver

(d) Aluminum

Answer: (a) Glass and plastic

Explanation: Optical fibers are typically made of glass (silica) or plastic for flexibility and cost.

17. Which among the following is described by the concept of NA in an optical fiber?

(a) Light collection

(b) Light scattering

(c) Light dispersion

(d) Light polarisation

Answer: (a) Light collection

Explanation: NA describes the fiber's light-collecting capability.

18. The overall thickness of an optical fiber is:

(a) 50 μm

(b) 100 μm

(c) 125 μm

(d) 200 μm

Answer: (c) 125 μm

Explanation: Standard optical fiber diameter (including cladding) is 125 μm

19. The attenuation formula in optical fiber is :

(a) $\alpha\ (dB) = 10 \log\left(\frac{P_{in}}{P_{out}}\right)$

(b) $\alpha\ (dB) = 10 \log\left(\frac{P_{out}}{P_{in}}\right)$

(c) $\alpha\ (dB) = 10 \ln\left(\frac{P_{in}}{P_{out}}\right)$

(d) $\alpha\ (dB) = 10 \ln\left(\frac{P_{out}}{P_{in}}\right)$

Answer: (b) $\alpha\ (dB) = 10 \log\left(\frac{P_{out}}{P_{in}}\right)$

20. dB in optical fiber stands for:

(a) deci-bel

(b) data-base

(c) discussion-Board

(d) Douche-Bag

Answer: (a) deci-bel

21. A measurement of the ability of an optical fiber to capture light is called:

(a) acceptance angle

(b) cladding

(c) Numerical Aperture

(d) Critical angle

Answer: (c) Numerical Aperture

Explanation: NA measures the fiber's ability to capture light.

22. The unit of numerical aperture is:

(a) meter

(b) degree

(c) dB

(d) No unit

Answer: (d) No unit

Explanation: NA is dimensionless, derived from refractive indices.

23. If the numerical aperture of an optical fiber is 0.52, the maximum angle of incidence is:

(a) 54.7°

(b) 1.0°

(c) 48°

(d) 90°

Answer: (a) 54.7°

24. Intermodal dispersion is avoided in:

(a) SMF

(b) MMF

(c) Both SMF & MMF

(d) Neither in SMF nor in MMF

Answer: (a) SMF

Explanation: Single-mode fibers (SMF) avoid intermodal dispersion by supporting one mode.

25. Normalized refractive index difference between core and cladding is :

(a) $\frac{\mu_1-\mu_2}{\mu_2}$

(b) $\frac{\mu_1-\mu_2}{\mu_1}$

(c) $\frac{\mu_2-\mu_1}{\mu_1}$

(d) $\frac{\mu_2}{\mu_1}$

Answer: (b) $\frac{\mu_1-\mu_2}{\mu_1}$

26. The buffer layer that provides insulation and protection in an optical fiber, is:

(a) core

(b) cladding

(c) jacket

(d) interface

Answer: (c) jacket

Explanation: The jacket (or buffer) provides insulation and physical protection.

27. The refractive index of the core of an optical fiber is typically:

(a) Higher than that of the cladding

(b) Equal to that of the cladding

(c) Lower than that of the cladding

(d) Sometimes higher and sometimes lower than the cladding

Answer: (a) Higher than that of the cladding

Explanation: Core refractive index exceeds cladding's for total internal reflection.

28. The primary function of the cladding in an optical fiber is to:

(a) Protect the fiber from damage

(b) Reflect light back into the core

(c) Guide light through the fiber

(d) Prevent the fiber from breaking

Answer: (b) Reflect light back into the core

Explanation: Cladding reflects light via total internal reflection to confine it in the core.

29. The principle that allows light to be confined to the core of an optical fiber is:

(a) Reflection

(b) Diffraction

(c) Total internal reflection

(d) Refraction

Answer: (c) Total internal reflection

Explanation: Total internal reflection keeps light within the core.

30. The loss in optical fiber communication is typically expressed in:

(a) Meters

(b) Decibels per kilometer (dB/km)

(c) Watt per kilometer (W/km)

(d) Joules per meter (J/m)

Answer: (b) Decibels per kilometer (dB/km)

Explanation: Fiber loss is measured in dB/km, a standard unit.

31. The refractive index of cladding in an optical fiber should be:

(a) Higher than that of the core

(b) Lower than that of the core

(c) Equal to that of the core

(d) Independent of the core material

Answer: (b) Lower than that of the core

Explanation: Cladding's lower refractive index enables total internal reflection.

32. Which of the following optical fibers is most suitable for high bandwidth applications?

(a) Step-index multimode fiber

(b) Graded-index multimode fiber

(c) Step-index single-mode fiber

(d) Graded-index single-mode fiber

Answer: (c) Step-index single-mode fiber

Explanation: Single-mode fibers offer high bandwidth due to low dispersion.

33. For a step-index optical fiber, the refractive index of the core:

(a) Increases as you move towards the cladding

(b) Decreases as you move towards the cladding

(c) Remains constant across the fiber

(d) Is zero at the center of the fiber

Answer: (c) Remains constant across the fiber

Explanation: Step-index fibers have a uniform core refractive index.

34. The term "numerical aperture" (NA) in optical fibers refers to:

(a) The light propagation speed in the core

(b) The ability of the fiber to gather light

(c) The angle of incidence

(d) The refractive index of the core

Answer: (b) The ability of the fiber to gather light

Explanation: NA quantifies light-gathering capability.

35. Which of the following fibers would be ideal for reducing modal dispersion over long distances?

(a) Step-index multimode fiber

(b) Graded-index multimode fiber

(c) Single-mode fiber

(d) Both **(a)** and **(b)**

Answer: (c) Single-mode fiber

Explanation: Single-mode fibers eliminate modal dispersion for long distances.

36. In which type of fiber does light travel along the core and refract through the cladding?

(a) Step-index multimode fiber

(b) Graded-index multimode fiber

(c) Single-mode fiber

(d) None of the above

Answer: (d) None of the above

Explanation: Light does not refract through cladding; it reflects at the boundary.

37. Which part of an optical fiber directly contacts the external environment?

(a) Core

(b) Cladding

(c) Jacket

(d) Buffer layer

Answer: (c) Jacket

Explanation: The jacket contacts the external environment, protecting the fiber.

38. The term "intermodal dispersion" in multimode fiber refers to:

(a) Dispersion caused by different refractive indices of the core and cladding

(b) The spreading of light pulses due to different path lengths taken by different modes

(c) Dispersion caused by the external environment

(d) Dispersion that occurs in single-mode fibers only

Answer: (b) The spreading of light pulses due to different path lengths taken by different modes

Explanation: Intermodal dispersion arises in multimode fibers from multiple light paths.

39. Which of the following materials is commonly used for the core of optical flowers?

(a) Aluminum

(b) Glass or silica

(c) Copper

(d) Lead

Answer: (b) Glass or silica

Explanation: Glass (silica) is the primary material for optical fiber cores.

40. The attenuation in optical fibers generally increases with:

(a) Shorter wavelengths

(b) Longer wavelengths

(c) Constant wavelength

(d) The fiber diameter

Answer: (a) Shorter wavelengths

Explanation: Attenuation increases at shorter wavelengths due to Rayleigh scattering.

41. The jacket around an optical fiber serves to:

(a) Protect the fiber from external damage

(b) Guide light into the core

(c) Focus light into the cladding

(d) Provide an insulating material for the core

Answer: (a) Protect the fiber from external damage

Explanation: The jacket shields the fiber from physical and environmental harm.

42. Which of the following is true about single-mode optical fibers?

(a) They can carry multiple modes of light

(b) They are used for long-distance communication

(c) They have a large core diameter

(d) They suffer from high intermodal dispersion

Answer: (b) They are used for long-distance communication

Explanation: Single-mode fibers are designed for long-distance, low-dispersion transmission.

43. Which type of optical fiber has a core with a gradual change in refractive index?

(a) Step-index fiber

(b) Graded-index fiber

(c) Single-mode fiber

(d) None of the above

Answer: (b) Graded-index fiber

Explanation: Graded-index fibers have a gradually varying refractive index in the core.

44. Which of the following is true about the core and cladding of an optical fiber?

(a) The refractive index of the core is always lower than that of the cladding

(b) The refractive index of the core is always higher than that of the cladding

(c) The refractive index of the core and cladding are identical

(d) The cladding has no role in light transmission

Answer: (b) The refractive index of the core is always higher than that of the cladding

Explanation: This ensures total internal reflection.

45. The loss in optical fibers due to scattering is known as:

(a) Absorption loss

(b) Rayleigh scattering

(c) Bending loss

(d) Mode dispersion

Answer: (b) Rayleigh scattering

Explanation: Scattering loss in fibers is primarily due to Rayleigh scattering.

46. Which of the following does NOT affect the attenuation in optical fibers?

(a) Fiber material

(b) Fiber diameter

(c) Temperature

(d) Fiber length

Answer: (b) Fiber diameter

Explanation: Diameter does not directly affect attenuation; material, length, and temperature do.

47. The primary function of the buffer layer in an optical fiber is to:

(a) Focus light into the core

(b) Provide insulation and protect the fiber from physical damage

(c) Guide the light through the fiber

(d) Maintain the refractive index difference

Answer: (b) Provide insulation and protect the fiber from physical damage

Explanation: The buffer layer insulates and protects the fiber.

48. Which of the following statements is true about graded-index fibers?

(a) They provide the highest bandwidth

(b) They suffer from high modal dispersion

(c) They are used for short-distance communication

(d) They have a constant refractive index

Answer: (c) They are used for short-distance communication

Explanation: Graded-index fibers reduce dispersion but are typically for shorter distances than single-mode.

49. What is the primary advantage of single-mode fibers over multimode fibers?

(a) They are cheaper

(b) They carry less data

(c) They have lower modal dispersion

(d) They are easier to manufacture

Answer: (c) They have lower modal dispersion

Explanation: Single-mode fibers eliminate modal dispersion, a key advantage.

50. The refractive index of a cladding is typically:

(a) The same as the core

(b) Higher than the core

(c) Lower than the core

(d) Always close to 1.0

Answer: (c) Lower than the core