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Class 12
Physics

Chapter 18

Printed Notes

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By Fairy (misbah)

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Class 12 — Physics

Chapter: Wave Optics | Topic: Diffraction & Interference

SLOs: P-12-D-20 to P-12-D-25 | With Complete Answer Key

SECTION A — MULTIPLE CHOICE QUESTIONS (40 Questions × 1 Mark = 40 Marks)

Q1. Two-source interference occurs when two waves are:

A. Incoherent and same frequency
B. Coherent and have constant phase difference
C. Moving in opposite directions
D. Of different amplitudes
Answer: B

Q2. In Young's double slit experiment, if the distance between slits is halved, the fringe width:

A. Halves
B. Doubles
C. Remains same
D. Becomes four times
Answer: B

Q3. The formula for fringe width in double-slit interference is:

A. $\beta = \lambda d/L$
B. $\beta = \lambda L/d$
C. $\beta = dL/\lambda$
D. $\beta = d/\lambda L$
Answer: B

Q4. Constructive interference occurs when path difference is:

A. $(2n+1)\lambda/2$
B. $n\lambda$ where $n = 0,1,2...$
C. $\lambda/4$
D. $3\lambda/4$
Answer: B

Q5. Destructive interference occurs when path difference is:

A. $n\lambda$
B. $(2n+1)\lambda/2$
C. $2n\lambda$
D. $n\lambda/4$
Answer: B

Q6. In a ripple tank, two-source interference is demonstrated using:

A. Two coherent vibrators
B. A single vibrator and mirror
C. White light
D. Polarized waves
Answer: A

Q7. The condition for a bright fringe in double-slit experiment is:

A. $d \sin\theta = (2n+1)\lambda/2$
B. $d \sin\theta = n\lambda$
C. $d \sin\theta = n\lambda/2$
D. $d \sin\theta = 2n\lambda$
Answer: B

Q8. Diffraction is the phenomenon of:

A. Reflection of light
B. Bending of waves around obstacles or edges
C. Refraction of light at surfaces
D. Polarization of waves
Answer: B

Q9. A diffraction grating has 500 lines/mm. Its grating element d is:

A. 500 mm
B. 0.002 mm
C. 2000 mm
D. 0.5 mm
Answer: B

Q10. The equation for a diffraction grating is:

A. $d \cos\theta = n\lambda$
B. $d \sin\theta = n\lambda$
C. $d \tan\theta = n\lambda$
D. $n\lambda \sin\theta = d$
Answer: B

Q11. Which of the following is NOT required for observable interference?

A. Coherent sources
B. Same frequency
C. Large path difference
D. Constant phase difference
Answer: C

Q12. In $\Delta y = \lambda L/d$, 'L' represents:

A. Wavelength of light
B. Distance from slits to screen
C. Slit width
D. Fringe number
Answer: B

Q13. Microwaves can demonstrate two-source interference because:

A. They are transverse waves
B. They have long wavelengths making effects observable
C. They travel faster than light
D. They cannot be diffracted
Answer: B

Q14. The central maximum in a single-slit diffraction pattern is:

A. Half the width of other maxima
B. Same width as other maxima
C. Twice the width of other maxima
D. Narrower than other maxima
Answer: C

Q15. If wavelength increases, the fringe spacing in YDSE:

A. Decreases
B. Increases
C. Remains unchanged
D. Becomes zero
Answer: B

Q16. A spectrometer combined with a diffraction grating is used to:

A. Measure refractive index
B. Determine the wavelength of light
C. Measure the speed of light
D. Observe reflection
Answer: B

Q17. The order of maximum 'n' in a diffraction grating equation can be:

A. Only positive integers
B. Only 0 and 1
C. Any integer including 0, ±1, ±2...
D. Only odd integers
Answer: C

Q18. Sound waves from two speakers can demonstrate interference. This is because sound waves are:

A. Transverse waves
B. Can be polarized
C. Longitudinal waves with coherent sources possible
D. Electromagnetic in nature
Answer: C

Q19. In two-source interference, dark fringes correspond to:

A. Maximum intensity
B. Minimum intensity (destructive interference)
C. Average intensity
D. No change in intensity
Answer: B

Q20. Diffraction effects are most noticeable when the obstacle size is:

A. Much larger than the wavelength
B. Comparable to or smaller than the wavelength
C. Much smaller than the wavelength
D. Exactly ten times the wavelength
Answer: B

Q21. Which color of light produces the widest fringes in YDSE?

A. Violet
B. Green
C. Blue
D. Red
Answer: D

Q22. If d sin(θ) = nλ and n=2, λ=600 nm, sinθ=0.6, then d =

A. 1000 nm
B. 2000 nm
C. 500 nm
D. 3000 nm
Answer: B

Q23. The path difference for the 3rd bright fringe from center in YDSE is:

A. λ
B. 2λ
C. 3λ
D. 3λ/2
Answer: C

Q24. Two-source interference using light requires the sources to be:

A. Far apart
B. Coherent (from same source or laser)
C. Of different intensities
D. Moving
Answer: B

Q25. In a diffraction grating, increasing the number of lines per mm:

A. Decreases the angle of diffraction
B. Increases the angle of diffraction for same order
C. Has no effect on diffraction
D. Reduces intensity only
Answer: B

Q26. The unit of grating element 'd' is:

A. Lines per mm
B. Metres or mm
C. Degrees
D. Hz
Answer: B

Q27. At the central maximum (n=0) in diffraction grating, the path difference is:

A. λ
B. λ/2
C. Zero
D. 2λ
Answer: C

Q28. Coherent sources must have:

A. Equal amplitudes only
B. Constant phase difference and same frequency
C. Random phases
D. Different frequencies
Answer: B

Q29. Which phenomenon explains the colors seen in thin soap films?

A. Diffraction
B. Polarization
C. Interference
D. Dispersion
Answer: C

Q30. The formula $\Delta y = \lambda L/d$ applies when:

A. $L << d$
B. $L >> d$ (far field)
C. $\lambda >> d$
D. $d >> \lambda$
Answer: B

Q31. In a ripple tank, the nodal lines represent:

A. Constructive interference
B. Destructive interference
C. Reflection points
D. Single-source waves
Answer: B

Q32. For a diffraction grating, $n_{max} \approx d/\lambda$. If $d=3000$ nm, $\lambda=600$ nm, n_{max} =

A. 2
B. 3
C. 5
D. 10
Answer: C

Q33. When two identical waves are exactly out of phase (180°), the result is:

A. Double amplitude
B. Zero amplitude (cancellation)
C. Same amplitude
D. Half amplitude
Answer: B

Q34. The spectrometer uses a diffraction grating instead of a prism because:

A. Prisms are expensive
B. Grating gives more precise and linear dispersion
C. Grating works only for UV
D. Prisms cannot refract light
Answer: B

Q35. Fringe width β in YDSE is independent of:

A. Wavelength λ
B. Distance L
C. Slit separation d
D. Order number n
Answer: D

Q36. Light from two independent bulbs cannot produce interference because:

A. They emit different colors
B. They are not coherent (random phase relationship)
C. Bulbs are too bright
D. Light speed differs
Answer: B

Q37. In YDSE, the path difference for m-th dark fringe is:

A. mλ
B. (2m-1)λ/2
C. mλ/2
D. 2mλ
Answer: B

Q38. A diffraction grating can resolve two closely spaced spectral lines better when it has:

A. Fewer lines
B. More lines (higher resolving power)
C. Wider slits
D. Shorter grating length
Answer: B

Q39. When light passes through a single narrow slit, the pattern on screen shows:

A. No pattern
B. Uniform illumination
C. A single-slit diffraction pattern with central bright maximum
D. Only two bright lines
Answer: C

Q40. The phenomenon used by a CD to produce rainbow colors is:

A. Reflection only
B. Diffraction and interference
C. Refraction
D. Polarization
Answer: B

MCQ ANSWER KEY SUMMARY

Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans
1	B	9	B	17	C	25	B	33	B
2	B	10	B	18	C	26	B	34	B
3	B	11	C	19	B	27	C	35	D
4	B	12	B	20	B	28	B	36	B
5	B	13	B	21	D	29	C	37	B
6	A	14	C	22	B	30	B	38	B
7	B	15	B	23	C	31	B	39	C
8	B	16	B	24	B	32	C	40	B

SECTION B — SHORT ANSWER QUESTIONS (15 Questions × 3 Marks = 45 Marks)

Q1. State the conditions necessary for two-source interference fringes to be observed. [SLO P-12-D-21]

Answer:

The conditions are: (1) The two sources must be coherent — same frequency and constant phase difference. (2) Both sources must emit waves of the same type. (3) Amplitudes should be equal or nearly equal for maximum contrast. (4) The path difference at any point must be small. In practice, both sources are derived from a single source (e.g., two slits lit by one source) to ensure coherence.

Q2. Define constructive and destructive interference with path difference conditions. [SLO P-12-D-21]

Answer:

Constructive interference: crest meets crest (in phase). Condition: path difference = nλ (n = 0,1,2,...). Resultant amplitude is maximum — bright fringe. Destructive interference: crest meets trough (phase difference = 180°). Condition: path difference = (2n-1)λ/2. Resultant amplitude is minimum — dark fringe.

Q3. Derive the formula Δy = λL/d for fringe width in Young's double slit experiment. [SLO P-12-D-22]

Answer:

In YDSE, slits S1 and S2 are separated by distance d; screen is at distance L. For nth bright fringe: path difference = d·yn/L = nλ, so yn = nλL/d. Fringe width: Δy = y(n+1) - yn = (n+1)λL/d - nλL/d = λL/d. Therefore Δy = λL/d. Fringe width is directly proportional to λ and L, inversely proportional to d.

Q4. In YDSE, d = 0.5 mm, L = 1.2 m, fringe width = 1.44 mm. Calculate wavelength used. [SLO P-12-D-22]

Answer:

Using Δy = λL/d: λ = Δy × d / L = (1.44 × 10^-3 × 0.5 × 10^-3) / 1.2 = 0.72 × 10^-6 / 1.2 = 6.0 × 10^-7 m = 600 nm. The wavelength is 600 nm (orange-red).

Q5. Write the grating equation and explain each term. [SLO P-12-D-23]

Answer:

Grating equation: d sin(θ) = nλ. d = grating element (distance between consecutive slits = 1/N where N = lines per metre). θ = angle of diffraction for nth order maximum. n = order of diffraction (n = 0, ±1, ±2,...). λ = wavelength of incident light. Different wavelengths diffract at different angles, separating colors.

Q6. A diffraction grating has 400 lines/mm. Find the angle of 2nd order maximum for λ = 550 nm. [SLO P-12-D-23]

Answer:

Grating element: d = 1/400 mm = 2.5 × 10^-3 mm = 2.5 × 10^-6 m. Using d sinθ = nλ: sinθ = nλ/d = (2 × 550 × 10^-9) / (2.5 × 10^-6) = 0.44. θ = sin^-1(0.44) ≈ 26.1°

Q7. Describe how a diffraction grating is used to determine the wavelength of light (spectrometer method). [SLO P-12-D-24]

Answer:

Setup: Mount the diffraction grating on the spectrometer turntable. Procedure: (1) Align the collimator for a parallel beam from the source. (2) View the central (zero-order) maximum through the telescope at 0°. (3) Rotate the telescope to find the 1st order maximum and record angle θ. Calculation: Using d sinθ = nλ with n=1: λ = d sinθ, where d = 1/N (N = lines/metre).

Q8. How is two-source interference demonstrated using water waves in a ripple tank? [SLO P-12-D-20]

Answer:

Two small dippers (vibrators) are attached to the same motorized arm so they vibrate in phase (coherent) with the same frequency. Both touch the water surface and generate circular ripples. Where crests of both waves meet — constructive interference — large ripples (antinodal lines). Where a crest meets a trough — destructive interference — calm water (nodal lines). The alternating nodal/antinodal pattern demonstrates two-source interference.

Q9. Explain how sound waves demonstrate two-source interference. [SLO P-12-D-20]

Answer:

Two loudspeakers connected to the same signal generator produce coherent sound waves of the same frequency. As an observer walks in front of the speakers, they pass through: LOUD regions (constructive — path difference = nλ) and QUIET regions (destructive — path difference = (2n-1)λ/2). The periodic rise and fall in sound intensity demonstrates interference.

Q10. What is a diffraction grating? How does it differ from a double slit? [SLO P-12-D-24]

Answer:

A diffraction grating is an optical device with a large number of equally spaced parallel slits (100-1000 lines/mm). Differences from double slit: (1) Number of slits: grating — thousands; double slit — two. (2) Sharpness: grating gives very sharp bright maxima; double slit gives broader fringes. (3) Resolving power: grating can resolve closely spaced spectral lines; double slit cannot.

Q11. What is coherence? Why must sources be coherent for interference? [SLO P-12-D-21]

Answer:

Coherence means two waves maintain a constant phase difference and have the same frequency over time. Sources must be coherent because if the phase difference changes randomly, fringe positions shift so rapidly that no stable pattern is observed — only uniform illumination results. Coherent sources maintain fixed phase relationships, giving a stable, observable interference pattern.

Q12. Calculate fringe width if λ = 680 nm, d = 0.4 mm, L = 0.8 m. [SLO P-12-D-22]

Answer:

Using Δy = λL/d: Δy = (680 × 10^-9 × 0.8) / (0.4 × 10^-3) = (544 × 10^-9) / (4 × 10^-4) = 1.36 × 10^-3 m = 1.36 mm.

Q13. Why does white light produce colored fringes while monochromatic light gives black-and-white fringes in YDSE? [SLO P-12-D-22]

Answer:

Monochromatic light: all bright fringes occur at positions for one wavelength — uniform bright and dark bands. White light: each wavelength has a different fringe width (Δy = λL/d). Central fringe is white (all colors overlap at n=0). On either side, colors spread: violet closest to center (short λ, small Δy), red farthest (long λ, large Δy) — forming a spectrum.

Q14. State two uses of a diffraction grating spectrometer. [SLO P-12-D-24]

Answer:

(1) Wavelength determination: Precisely measures wavelengths of spectral lines emitted by excited gases, helping identify elements through spectral analysis. (2) Studying atomic spectra: Used to study emission and absorption spectra to verify atomic energy level models. (3) Astronomy: Analyzes composition of stars and galaxies by studying their light spectra.

Q15. A grating with 600 lines/mm is used with λ = 500 nm. Find the maximum order of diffraction. [SLO P-12-D-23]

Answer:

Grating element: d = 1/600 mm = 1.667 × 10^-6 m. Maximum order: n_max = d/λ = (1.667 × 10^-6) / (500 × 10^-9) = 3.33. Since n must be a whole number and sinθ cannot exceed 1, n_max = 3 (3rd order).

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