Wave Optics

Class 12 Physics · 24 NEET MCQs with answers & explanations

Wave Optics covers Huygens' principle, Young's double-slit experiment (YDSE), diffraction, polarisation and interference. NEET tests YDSE fringe width and position, single-slit diffraction, Brewster's angle and conditions for constructive/destructive interference.

Key Wave Optics Concepts

Concept	Key Formula
YDSE fringe width	$\beta = \lambda D/d$; D = screen distance, d = slit separation
Bright fringe	Path diff = $n\lambda$ (n = 0, 1, 2...); central maximum at n = 0
Dark fringe	Path diff = $(2n-1)\lambda/2$; first dark fringe closest to centre
Single slit diffraction	First minimum at $a\sin\theta = \lambda$; central maximum width = $2\lambda D/a$
Brewster's angle	$\tan \theta_B = n_2/n_1$; reflected light completely polarised
Malus's law	$I = I_0 \cos^2\theta$; intensity after analyser at angle θ to polariser

Questions

Q1. An unpolarised light beam travelling in air is incident on a medium of refractive index 1.73 at Brewster's angle. Which statement is correct?

(A) Reflected light is completely polarised and the reflection angle is about 60°
(B) Transmitted light is completely polarised at a refraction angle of about 30°
(C) Both reflected and transmitted light are completely polarised
(D) Reflected light is partially polarised and the reflection angle is about 30°

Q2. In the phenomenon of interference, light energy at destructive interference points is:

(A) Permanently destroyed in those regions
(B) Redistributed to regions of constructive interference, conserving total energy
(C) Converted to heat at the dark fringes
(D) Partially absorbed by the medium between sources

Q3. Which of the following correctly defines a wavefront?

(A) A surface joining all points of a wave that are in the same phase
(B) A surface joining points of maximum amplitude only
(C) A path followed by individual photons
(D) A surface perpendicular to the direction of propagation in all media

Q4. A plane wavefront enters a denser medium where the speed of light decreases. Which of the following correctly describes the change?

(A) Wavelength increases; frequency decreases
(B) Both wavelength and frequency decrease
(C) Wavelength decreases; frequency remains unchanged
(D) Both wavelength and frequency remain unchanged

Q5. Which of the following is the correct decreasing order of wavelength?

(A) Radio waves > Microwaves > Infrared > Visible > UV > X-rays > Gamma rays
(B) Gamma rays > X-rays > UV > Visible > Infrared > Microwaves > Radio waves
(C) Radio waves > Microwaves > Visible > Infrared > UV > X-rays > Gamma rays
(D) Microwaves > Radio waves > Infrared > Visible > UV > X-rays > Gamma rays

Q6. Unpolarised light of intensity I_0 passes through a polariser P_1, then through a polariser P_2 whose axis is at 30° to P_1. The final transmitted intensity is:

(A) $I_0/2$
(B) $3I_0/8$
(C) $I_0/4$
(D) $I_0/8$

Q7. A plane wavefront is incident obliquely on a plane mirror. Which statement about the reflected wavefront obtained by Huygens' construction is correct?

(A) The angle of reflection equals the angle of incidence
(B) The reflected angle is always twice the incident angle
(C) The reflected wavefront becomes spherical
(D) The frequency of reflected light differs from that of incident light

Q8. A plane wavefront passes normally from air into glass of refractive index 1.5. Which pair correctly describes the changes in the wave?

(A) Speed unchanged and wavelength unchanged
(B) Speed decreases to 2×10^8 m/s and wavelength becomes $2\lambda_0/3$
(C) Speed increases to 4.5×10^8 m/s and wavelength becomes $1.5\lambda_0$
(D) Frequency decreases by a factor of 1.5

Q9. For two coherent waves to produce a sustained interference pattern, which condition is essential?

(A) They must have different frequencies
(B) They must have a randomly varying phase difference
(C) They must have the same frequency and a constant phase difference
(D) They must have equal amplitudes

Q10. Two waves are represented by $y_1 = a\sin(\omega t)$ and $y_2 = a\sin(\omega t - \varphi)$, where φ is a constant. Which statement correctly describes these waves?

(A) They cannot interfere because their equations look different
(B) They can produce a sustained interference pattern because they have the same frequency and a constant phase difference
(C) They produce diffraction rather than interference
(D) They must have different frequencies because their phase constants differ

Q11. An unpolarised light beam strikes a glass surface at Brewster's angle. Which statement is correct?

(A) The reflected light is completely polarised; the refracted light is partially polarised
(B) The reflected light is partially polarised
(C) The refracted light is completely polarised
(D) Both reflected and refracted light are completely polarised

Q12. The Brewster angle for an interface between air and a transparent medium must lie in which range for refractive index of the medium greater than 1?

(A) $\theta_B = 45°$
(B) $45° < \theta_B < 90°$
(C) $0° < \theta_B < 45°$
(D) $\theta_B = 90°$

Q13. Two slits in Young's double slit experiment are 1.5 mm apart and the screen is placed at a distance of 1 m from the slits. If the wavelength of light used is 600×10^{-9} m, the fringe separation is:

(A) 4×10^{-5} m
(B) 4×10^{-7} m
(C) 9×10^{-8} m
(D) 4×10^{-4} m

Q14. In a Young's double slit experiment, a student observes 8 fringes in a certain region of the screen using monochromatic light of wavelength 600 nm. If the wavelength is changed to 400 nm, the number of fringes observed in the same region will be:

(A) 6
(B) 8
(C) 12
(D) 16

Q15. In single-slit diffraction, the first minimum occurs when the path difference between waves from the extreme ends of the slit is:

(A) λ
(B) $\lambda/2$
(C) 2λ
(D) $3\lambda/2$

Q16. In a single-slit diffraction experiment, the angular width of the central maximum is θ_0 for wavelength 6000 Å. The angular width decreases by 30% when wavelength is changed. The new wavelength is:

(A) 1800 Å
(B) 3600 Å
(C) 4200 Å
(D) 5400 Å

Q17. Consider the following statements about Huygens' principle: I. It can determine the new position of a wavefront. II. It can derive Snell's law of refraction. III. It explains the particle nature of light. IV. It can determine the absolute speed of light in vacuum from first principles. How many of the above statements are correct?

(A) Only I
(B) Only I and II
(C) Only I, II and IV
(D) All four

Q18. A wavefront is best defined as:

(A) A surface on which all points are at the same phase
(B) A surface on which wave amplitude is maximum
(C) A surface on which all points have the same intensity
(D) A surface parallel to the direction of propagation

Q19. A plane wavefront propagates in a homogeneous isotropic medium. Which of the following correctly describes the relationship between rays and the wavefront?

(A) Rays are perpendicular to the wavefront and represent the direction of energy propagation
(B) Rays are tangential to the wavefront and represent the direction of energy propagation
(C) Rays are parallel to the wavefront
(D) Rays and wavefronts are always inclined at 45° to each other

Q20. A plane wavefront is incident normally on a perfectly homogeneous isotropic medium. As it propagates, the wavefront will:

(A) Become spherical immediately
(B) Remain plane and advance parallel to itself
(C) Become cylindrical
(D) Gradually curve due to diffraction at the beam boundary

Q21. Huygens' construction predicts that when light travels from a rarer medium (refractive index n_1) into a denser medium (refractive index $n_2 > n_1$), the speed of light in the denser medium is:

(A) Greater than in the rarer medium
(B) Equal in both media
(C) Less than in the rarer medium
(D) Dependent only on the wavelength, not the medium

Q22. Which instrument is correctly associated with Huygens in the context of wave optics?

(A) Telescope used to discover Neptune
(B) Pendulum clock used to measure g
(C) Telescope used to observe Saturn's rings and derive the wave theory of light
(D) Diffraction grating used to measure wavelength of light

Q23. A monochromatic source produces a spherical wavefront in an isotropic medium. The wavefront radius increases from 3.0 m to 3.6 m. If the wave speed is 3.0×10^8 m/s, the time interval required is:

(A) 1.0×10^{-10} s
(B) 2.0×10^{-10} s
(C) 1.0×10^{-9} s
(D) 2.0×10^{-9} s

Q24. In a homogeneous isotropic medium, a point source emits monochromatic light. Which correctly explains why the spherical wavefront remains spherical as it propagates?

(A) All secondary wavelets have equal radius vΔt; their forward envelope centred on a sphere is again a sphere
(B) Light travels in straight lines, so the sphere cannot deform
(C) Amplitude decreases as 1/r, which preserves the spherical shape
(D) Wavelength changes with radius, compensating for asymmetry

Answer key

1-A	2-B	3-A	4-C	5-A	6-B	7-A	8-B
9-C	10-B	11-A	12-B	13-D	14-C	15-A	16-C
17-B	18-A	19-A	20-B	21-C	22-B	23-D	24-A

Answers with explanations

Q1 — Answer: (A) Reflected light is completely polarised and the reflection angle is about 60°
$\tan\theta_B = \mu = \sqrt{3}$ gives $\theta_B = 60°$. Reflected beam is completely plane polarised; transmitted beam is only partially polarised. Angle of reflection equals angle of incidence = 60°. Trap: option B incorrectly claims transmitted light is completely polarised.

Q2 — Answer: (B) Redistributed to regions of constructive interference, conserving total energy
Energy is never destroyed in interference. Dark regions have zero or near-zero intensity because energy is redistributed to bright regions where intensity exceeds the average. Total energy over the entire pattern is conserved. Trap: confusing redistribution with absorption or permanent loss.

Q3 — Answer: (A) A surface joining all points of a wave that are in the same phase
A wavefront is the locus of all points in a wave oscillating in the same phase at a given instant. Option D describes a consequence in isotropic homogeneous media only — perpendicularity is derived from the equal-phase property, not the definition. Option C describes a ray.

Q4 — Answer: (C) Wavelength decreases; frequency remains unchanged
Frequency is fixed by the source and never changes at an interface. From $v = f\lambda$, since f is constant and v decreases, λ decreases in the same ratio. Speed and wavelength change together; frequency never does. Trap: option A reverses the wavelength change — wavelength decreases, not increases, in a denser medium.

Q5 — Answer: (A) Radio waves > Microwaves > Infrared > Visible > UV > X-rays > Gamma rays
The electromagnetic spectrum in decreasing wavelength order is: Radio > Microwave > IR > Visible > UV > X-ray > Gamma. Option C is the trap: it places Visible before IR, reversing their correct order (IR has longer wavelength than visible).

Q6 — Answer: (B) $3I_0/8$
After P_1: $I_1 = I_0/2$. After P_2 at 30°: $I_2 = I_1\cos^2 30° = (I_0/2)(3/4) = 3I_0/8$. Option C ($I_0/4$) is the trap: students use $\cos^2 45° = 1/2$ by reflex rather than $\cos^2 30° = 3/4$ — a direct substitution error with the wrong standard angle.

Q7 — Answer: (A) The angle of reflection equals the angle of incidence
Huygens' equal-time construction gives secondary wavelets of equal radius on the reflecting surface; their envelope geometry directly yields i = r. Reflection from a plane surface preserves the plane shape of the wavefront and does not alter frequency.

Q8 — Answer: (B) Speed decreases to 2×10^8 m/s and wavelength becomes $2\lambda_0/3$
Speed: $v = c/n = 3\times10^8/1.5 = 2\times10^8$ m/s. Frequency is unchanged (set by source). Wavelength: $\lambda = v/f = \lambda_0/n = 2\lambda_0/3$. Option C multiplies c by n — the classic corpuscular-theory error. Option D is wrong because frequency never changes at an interface.

Q9 — Answer: (C) They must have the same frequency and a constant phase difference
Sustained interference requires coherence: same frequency and constant phase difference. Equal amplitudes are not mandatory — unequal amplitudes still give a stable pattern with reduced visibility. A randomly varying phase difference shifts maxima and minima continuously, destroying the pattern.

Q10 — Answer: (B) They can produce a sustained interference pattern because they have the same frequency and a constant phase difference
Both waves share the same angular frequency ω and have a fixed phase difference φ — satisfying both coherence conditions. Option D is the trap: the phase constant φ does not imply different frequencies; ω is identical in both expressions.

Q11 — Answer: (A) The reflected light is completely polarised; the refracted light is partially polarised
At Brewster's angle, reflected light is completely plane-polarised perpendicular to the plane of incidence. Refracted light is only partially polarised; both planes of vibration are present but the in-plane component dominates. Option C is wrong because the refracted beam retains both components.

Q12 — Answer: (B) $45° < \theta B < 90°$
Brewster's law gives $\tan\theta B = \mu$. For $\mu > 1$, $\tan\theta B > 1$, so $\theta B > 45°$. Since μ is always finite, θB never reaches 90°. Therefore Brewster angle lies strictly between 45° and 90°.

Q13 — Answer: (D) 4×10^{-4} m
Fringe width $\beta = \lambda D/d = (600\times10^{-9}\times1)/(1.5\times10^{-3}) = 4\times10^{-4}$ m. Common trap: forgetting to convert 1.5 mm to 1.5×10^{-3} m, giving a power-of-ten error.

Q14 — Answer: (C) 12
Since $\beta \propto \lambda$, fringe width decreases with shorter wavelength, so more fringes fit. $N_2 = N_1 \times (\lambda_1/\lambda_2) = 8 \times (600/400) = 12$. Option A (6) is the trap for students who apply the ratio inverted.

Q15 — Answer: (A) λ
For the first minimum, the total path difference across the full slit width is λ, giving condition $a\sin\theta = \lambda$. Option B (λ/2) is the most common trap — it is the path difference used in pairing wavelets for the cancellation argument, not the total across the full slit.

Q16 — Answer: (C) 4200 Å
Angular width $2\theta = 2\lambda/a \propto \lambda$ for fixed a. A 30% decrease means new width is 70% of original, so $\lambda_2 = 0.70 \times 6000 = 4200$ Å. Option D (5400 Å) results from applying a 10% decrease instead of 30%.

Q17 — Answer: (B) Only I and II
Huygens' principle locates new wavefronts via secondary wavelets (I: true) and geometrically derives Snell's law (II: true). It is a wave construction and cannot explain the particle nature of light (III: false) nor independently yield the absolute speed of light (IV: false). Only I and II are correct.

Q18 — Answer: (A) A surface on which all points are at the same phase
A wavefront is the locus of all points at the same phase at a given instant. Amplitude and intensity can vary across a wavefront. Wavefronts are perpendicular, not parallel, to the direction of propagation — option D is a common directional trap.

Q19 — Answer: (A) Rays are perpendicular to the wavefront and represent the direction of energy propagation
In a homogeneous isotropic medium, energy flows along rays, which are always normal (perpendicular) to the wavefront. Option B is a common confusion between tangent and normal. Options C and D have no physical basis.

Q20 — Answer: (B) Remain plane and advance parallel to itself
In a homogeneous isotropic medium, every point of a plane wavefront has the same speed. Secondary wavelets after time Δt all have radius vΔt; their forward envelope is a plane parallel to the original. The wavefront does not curve or change shape.

Q21 — Answer: (C) Less than in the rarer medium
Snell's law derived via Huygens gives $v_2 = v_1(n_1/n_2)$. Since $n_2 > n_1$, $v_2 < v_1$: light slows down in the denser medium. This directly contradicted Newton's corpuscular prediction that light speeds up in a denser medium, making it a critical result of the wave theory.

Q22 — Answer: (B) Pendulum clock used to measure g
Huygens used telescopic observations of Saturn's rings and developed the wave theory of light to explain his observations, including the nature of wavefronts. The diffraction grating was developed much later (Fraunhofer). Newton used a telescope for optics but proposed the corpuscular theory, not the wave theory.

Q23 — Answer: (D) 2.0×10^{-9} s
$\Delta r = 3.6 - 3.0 = 0.6$ m; $\Delta t = \Delta r/v = 0.6/(3.0 \times 10^8) = 2.0 \times 10^{-9}$ s. Option C results from the common error of dividing 0.3 m (half of Δr) by v; option B from misplacing the power of ten by one.

Q24 — Answer: (A) All secondary wavelets have equal radius vΔt; their forward envelope centred on a sphere is again a sphere
In an isotropic medium, wave speed v is the same in all directions. Every surface point generates a wavelet of equal radius vΔt. The forward envelope of equal-radius wavelets from a spherical surface is a larger concentric sphere. Options C and D introduce amplitude and wavelength incorrectly — neither determines wavefront shape.

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