

Name: _____ Date: _____

Clear Your Cognitive Path: Advanced Optics for University Physicists

Quantify phase shifts and analyze wavefront aberrations as you tackle complex non-paraxial ray tracing and dielectric boundary conditions.

1. A monochromatic beam transitions from a vacuum into a non-magnetic dissipative medium with a complex refractive index $\tilde{n} = n + ik$. Which physical phenomenon is fundamentally described by the imaginary component κ ?

- A. The spatial frequency of the electric field oscillations
- B. The attenuation of the wave amplitude as it propagates through the medium
- C. The phase velocity of the wave relative to the speed of light
- D. The Brewster angle at which p-polarized light is perfectly transmitted

2. When considering the Abbe Sine Condition for an optical system to be free of coma, the magnification must be constant for all rays, satisfying the relation: _____. (Assume n and n' are refractive indices of object and image space).

- A. $n \sin(\theta) / n' \sin(\theta') = \beta$
- B. $n \tan(\theta) = n' \tan(\theta')$
- C. $n y \sin(\theta) = n' y' \sin(\theta')$
- D. $\sin(\theta) + \sin(\theta') = \text{constant}$

3. True or False: In a birefringent uniaxial crystal, the 'extraordinary' ray behaves according to Snell's Law at all angles of incidence relative to the optic axis.

- A. True
- B. False

4. Evaluate the transverse Goos-Hänchen shift. This phenomenon occurs during total internal reflection because:

- A. The incident wave is longitudinal rather than transverse
- B. Reflection occurs instantaneously at a zero-depth interface
- C. An evanescent wave penetrates the lower-index medium before re-emerging
- D. The angle of reflection exceeds the angle of incidence in dense media

5. In Fourier Optics, a thin lens of focal length ' f ' placed a distance ' f ' from an object acts as a natural processor that performs a _____ of the input field distribution.

- A. Laplace Transform
- B. Gaussian Convolution
- C. 2D Fourier Transform
- D. Hilbert Transform

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6. True or False: According to the Fermat Principle of Least Time, light traveling through a medium with a non-uniform refractive index will always take the path of shortest geometrical distance.

- A. True
- B. False

7. Consider a Fabry-Pérot interferometer with a high finesse. What happens to the transmission peaks as the reflectivity of the mirrors approaches unity?

- A. The peaks broaden, increasing the Full-Width at Half-Maximum (FWHM)
- B. The peaks undergo a blue-shift toward higher frequencies
- C. The Free Spectral Range (FSR) doubles in size
- D. The peaks become significantly narrower, increasing spectral resolution

8. The Malus Law describes the intensity of light passing through a polarizer. For a beam with initial intensity I_0 passing through two polarizers with an angle ' α ' between their transmission axes, the output intensity is _____.

- A. $I = I_0 \sin^2(\alpha)$
- B. $I = I_0 \cos^2(\alpha)$
- C. $I = I_0 \exp(-\alpha)$
- D. $I = I_0 \tan(\alpha)$

9. An achromatic doublet is designed primarily to correct which of the following third-order aberrations by using two different glass types (e.g., crown and flint)?

- A. Spherical Aberration
- B. Astigmatism
- C. Chromatic Aberration
- D. Petzval Field Curvature

10. True or False: In a step-index optical fiber, the V-number (normalized frequency) must be less than 2.405 to ensure strictly single-mode propagation.

- A. True
- B. False