Name: _____ **Date:** _____

Answer Key: Blast Beyond Boundaries: 12th Grade Advanced Wave Optics Quiz

How does diffraction limit the resolution of the world's most powerful telescopes? Analyze Huygens-Fresnel principles and Malus's Law in this rigorous AP-level review.

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1. A beam of unpolarized light passes through two polarizing filters. If the second filter (the analyzer) is rotated to an angle of 60 degrees relative to the first (the polarizer), what fraction of the original unpolarized intensity (I_0) is transmitted?

Answer: A) 0.125 I_0

According to Malus's Law, the first polarizer reduces unpolarized light to 0.5 I_0. The second filter further reduces it by a factor of $\cos^2(60°)$, which is 0.25. Therefore, 0.5 * 0.25 = 0.125.

2. In a Young's Double Slit experiment, the distance between the third-order bright fringe and the central maximum can be decreased by _____ the separation between the two slits.

Answer: A) Increasing

The position of a bright fringe is given by $y = (m\lambda L)/d$. Since distance (y) and slit separation (d) are inversely proportional, increasing 'd' decreases the fringe spacing.

3. According to the Rayleigh Criterion, the angular resolution of an optical system improves (becomes smaller) as the wavelength of light being used increases.

Answer: B) False

The Rayleigh Criterion is $\theta = 1.22\lambda/D$. Therefore, a larger wavelength result in a larger (worse) angular resolution; shorter wavelengths provide better resolution.

4. When light undergoes internal reflection at the boundary of a thin film with a higher refractive index than the surrounding media, what is the phase shift of the reflected wave?

Answer: D) π radians

Light reflecting off a medium with a higher refractive index (denser) undergoes a 180-degree or π radian phase shift, similar to a wave on a string reflecting at a fixed boundary.

5. If a light ray enters a dispersive prism, the _____ light will bend the most because it travels the slowest within the glass medium.

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Answer: D) Violet

Due to chromatic dispersion, higher frequency (shorter wavelength) light like violet experiences a higher refractive index and thus bends more than lower frequency light.

6. An anti-reflective coating on a lens uses destructive interference. To eliminate reflection for a specific wavelength λ in a coating with index 'n', what is the minimum thickness required?

Answer: B) λ / 4n

For destructive interference with two π-phase shifts (or none), the path length difference (2t) must be λ/2n. Solving for thickness 't' gives λ/4n.

7. The Brewster's angle is the specific angle of incidence where light reflected from a dielectric surface is completely polarized parallel to the plane of incidence.

Answer: B) False

At Brewster's angle, the reflected light is completely polarized perpendicular (s-polarized) to the plane of incidence, not parallel.

8. A diffraction grating has 5000 lines per centimeter. What is the slit spacing 'd' used in the grating equation?

Answer: C) 2.0 x 10^-6 m

Slit spacing d = 1 / N. Converting 5000 lines/cm to lines/meter gives 500,000 lines/m. 1 / 500,000 = 2.0 x 10^-6 meters.

9. Spherical aberration in a large reflecting telescope can be corrected by replacing a spherical mirror with a _____ mirror.

Answer: D) Parabolic

Parabolic mirrors focus all parallel incoming rays to a single point, whereas spherical mirrors suffer from aberration where marginal rays focus closer to the mirror than central rays.

10. Huygens' Principle states that every point on a wavefront may be considered the source of secondary spherical wavelets.

Answer: A) True

This is the fundamental definition of Huygens' principle, which explains how wavefronts propagate and undergo diffraction and refraction.

Name: _____ Date: _____