Name: _____ **Date:** _____

Answer Key: Photon Frontier: A 10th Grade Optics Odyssey

Synthesize Maxwell's predictions with geometric ray tracing to analyze how light behaves at complex material interfaces and non-spherical boundaries.

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1. A ray of light transitions from zircon (n = 1.92) into liquid carbon disulfide (n = 1.63). If the angle of incidence is increased beyond the critical angle, what phenomenon occurs, and why?

Answer: A) Total internal reflection; light cannot enter a less dense medium at high angles.

Total internal reflection occurs when light travels from a medium with a higher refractive index to one with a lower index and the angle of incidence exceeds the critical angle.

2. In a sophisticated optical system, the mathematical sign convention for a copy-machine lens dictates that a _____ image is formed on the opposite side of the lens from the object.

Answer: B) Real

In geometric optics, real images are formed by the actual convergence of light rays on the side of the lens opposite the object, satisfying the Gaussian lens equation for positive image distances.

3. An observer using a parabolic mirror will experience zero spherical aberration compared to an observer using a standard spherical mirror.

Answer: A) True

Parabolic mirrors are designed to focus all incoming parallel rays to a single point, whereas spherical mirrors suffer from aberration because rays far from the principal axis focus at different points.

4. Fermat's Principle of Least Time states that light traveling between two points takes the path that can be traversed in the least time; this explains why light _____ when entering a prism.

Answer: C) Refracts

Refraction is the physical manifestation of light following the path of stationary time (usually minimum time) across a boundary where the velocity changes.

5. Imagine a fiber optic cable with a core of silica and a cladding of a different polymer. For the cable to function via total internal reflection, which statement must be true regarding the indices of refraction?

Answer: C) n_core must be greater than n_cladding

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For TIR to occur, light must attempt to move from a higher refractive index material (core) to a lower refractive index material (cladding).

6. A virtual image produced by a convex security mirror can be projected onto a screen if the screen is placed at the focal point.

Answer: B) False

Virtual images are formed by diverging rays that only appear to intersect; because the light rays do not actually meet, the image cannot be projected onto a physical surface.

7. A student places an object 15 cm in front of a thin converging lens with a focal length of 10 cm. Based on the lens-maker formula principles, what are the characteristics of the resulting image?

Answer: B) Real, inverted, and magnified

Using 1/f = 1/do + 1/di, the image distance di is 30 cm (positive/real). Magnification M = -di/do results in -2, meaning the image is inverted and twice the size.

8. When light passes through a microscopic aperture, it deviates from a straight line and spreads out; this wave-based optical behavior is known as _____.

Answer: C) Diffraction

Diffraction is the bending of waves around obstacles or through openings, highlighting the wave nature of light rather than the ray model.

9. According to the Law of Reflection, if a surface is rough (diffuse reflection), the angle of incidence still equals the angle of reflection for every individual ray.

Answer: A) True

The Law of Reflection holds at the microscopic level for every point on a surface; diffuse reflection appears scattered only because the 'normal' vector varies across the rough surface.

10. Huygens' Principle is often used to derive the laws of optics. This principle conceptualizes every point on a wavefront as a source of:

Answer: A) Spherical secondary wavelets

Huygens' Principle states that every point on a wavefront acts as a source of tiny wavelets that spread out in the forward direction at the speed of light.