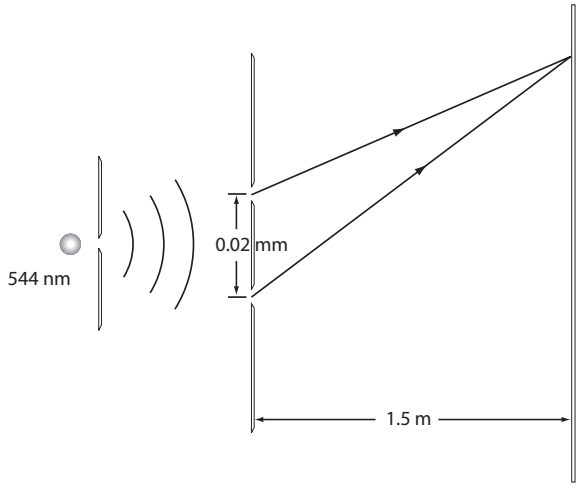
Wave Optics
Practice Items

1. Light has the property of being able to bend around corners. This phenomenon is known as

A. diffraction
B. refraction
C. dispersion
D. polarization

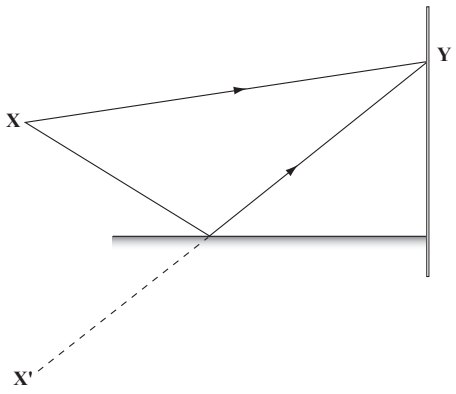
2. The figure below shows light from a helium-neon laser passing through two slits before striking a screen. Compared to the light from the upper slit, how much further does the light from the lower slit travel to reach a point on the screen at an angle 30° above the two slits?

A. 2.7×10^{-7} m
B. 1.0×10^{-5} m
C. 7.5×10^{-5} m
D. 7.5×10^{-1} m



3. A light source is placed at point **X** near a mirror as shown in the figure below. Light rays of wavelength λ can reach the screen either by a direct path or through reflection. An interference pattern is observed on the screen similar to the pattern observed in Young's interference. Which of the following descries the condition for a *dark* fringe at point **Y**?

A. $|X'Y| - |XY| = n\,\lambda \qquad (n = 1,2,3\ldots)$
B. $|X'Y| - |XY| = (n + \tfrac{1}{2})\,\lambda \qquad (n = 1,2,3\ldots)$
C. $|X'Y| - |XY| = n\,\lambda \qquad (n = 1,3,5\ldots)$
D. $|XX'|^2 + |XY|^2 = |X'Y|^2$



4. What is the minimum thickness of a soap bubble where constructive interference occurs when illuminated by a 589 nm sodium lamp?

A. 147 nm
B. 295 nm
C. 589 nm
D. 1.18 μm

5. A coin is suspended halfway between a monochromatic light source and a screen. Circular fringes are observed near the shadow's edge. What is observed in the center of the shadow?

A. an inverted image of the coin
B. an iridescent circular pattern
C. a cross-hatch pattern of bright fringes
D. a bright spot

6. What would happen if the monochromatic light source in Young's double slit experiment were replaced with white light?

A. No diffraction would occur.
B. The central fringe would be violet and the outermost fringes would be red.
C. A more widely spaced pattern of white fringes would appear.
D. The bright central fringe would be white and the other fringes would be colored.

7. Approximately 50 μm is the minimum separation between two point sources the normal human eye can distinguish at the near point. This is approximately equal to the thickness of a human hair. Why can't object points nearer than 50 μm from each other be distinguished by the human eye?

A. The inverted real image would land behind the retina.
B. Too many orders of diffracted light would be captured to separate the object points.
C. The two points could be distinguished if moved further away than the near point.
D. The central maxima of the airy disk images of the two object points would overlap.

8. The first diffraction order was observed at a 30° angle to the surface when incident X-rays having a wavelength of 2.65×10^{-10} m were reflected off of the surface of a NiS crystal. The reflected rays were visualized photographically. What is the spacing between atomic layers in this crystal?

A. 1.33 Å
B. 2.65 Å
C. 3.75 Å
D. 5.30 Å

9. If one places a block of a birefringent material such as calcite onto a sheet of paper with an image, one sees two images through the block. If the two images are then viewed through a rotating sheet of polaroid film, the two images

A. alternately appear and disappear.
B. merge into a single image.
C. will be inverted.
D. will be magnified.

10. Transmission of plane polarized light through a solution of pure optical isomer results in rotation of the optical axis of the transmitted light. The degree of observed rotation may be measured by a polarimeter. The rotation in degrees observed upon passing polarized light through a path length of 1 decimeter (dm) at a concentration of 1 g/mL is known as the

A. circular birefringence
B. dextrarotation
C. specific rotation
D. chirality

11. UV circular dichroism spectroscopy is primarily used within life sciences research to investigate

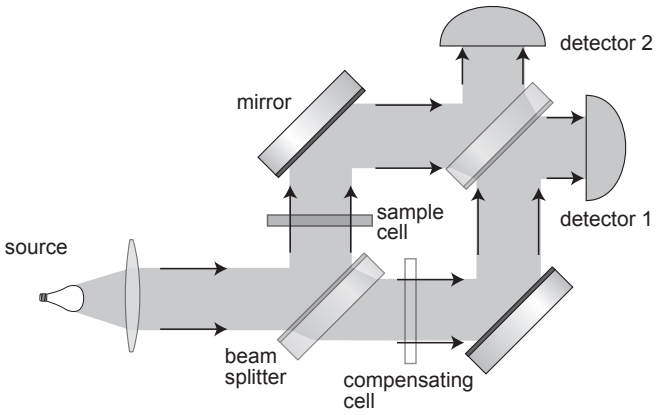
A. the secondary structure of proteins.
B. the kinetics of enzymatic reactions.
C. the crystal field splitting energy of metallic cofactors.
D. the UV absorbance of biological pigments.

The following passage pertains to questions 12 - 16.

The Mach–Zehnder interferometer is used to determine the relative phase shift variations between two collimated beams derived by splitting light from a single source. The interferometer has been used, among other things, to measure phase shifts between the two beams caused by a change in the optical path length of one of the beams by the introduction of a sample.

A collimated beam is split by a half-silvered mirror. The two resulting beams (the "sample beam" and the "reference beam") are each reflected by a mirror. The two beams then pass a second half-silvered mirror and enter two detectors. Phase change occurs for a reflection when a wave reflects off a boundary from low to high refractive index but not when it reflects off a boundary from high to low.

The fully silvered and half-silvered surfaces of all mirrors, except the last, face the inbound beam, and the half-silvered surface of the last mirror faces the outbound beam exiting in the same orientation as the collimated original beams.



The Mach–Zehnder interferometer is a more versatile instrument than the Michelson interferometer. Each of the well separated light paths is traversed only once, and the fringes can be adjusted so that they are localized in any desired plane. Typically, the fringes would be adjusted to lie in the same plane as the test object, so that fringes and test object can be photographed together.

12. The Mach–Zehnder interferometer works because when two waves originating from a single source recombine a pattern results determined by

A. the difference in frequency between the waves
B. the phase difference between the waves
C. the refractive index of the beam splitter
D. the difference in wavelength between the waves

13. Light traveling in test and reference beams of equal optical path through a Mach–Zehnder interferometer leads to which result on detector 2?

A. a bright pattern
B. no image
C. incoherence in the transversal direction
D. a horizontally inverted image

14. A sample is introduced into the sample cell in which heat transfer and convection currents produce varying indices of refraction throughout the sample.

A. A fringe pattern appears on both detectors.
B. No results may be recorded.
C. Dispersion of the monochromatic source occurs.
D. Detector 2 receives polarized light.

15. What is a likely to result with a white light source with an empty sample cell if the compensating cell is not also included?

A. fringes of varying color on detector 1
B. fringes of varying color on detector 2
C. fringes of varying color on both detectors
D. no interference patterns

16. A Mach-Zehnder interferometer is illuminated by light of λ_{vacuum} = 500 nm ($\tilde{\nu}$ = 20,000 cm^{-1}). The interferometer contains a 1 cm gas-filled sample cell. As the gas is evacuated from the cell, 8 fringes cross a point in the field of view of detector 1. The refractive index of the gas at its original concentration is closest to which of the following values?

A. 1.04
B. 1.004
C. 1.0004
D. 1.00004