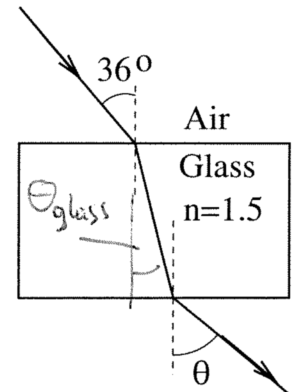
1. We can hear around corners, but we cannot see around corners. The reason is that

a) Sound waves carry more energy than do light waves
b) The frequency of sound is much greater than that of light
c) The wavelength of sound is much greater than that of light
d) Sound waves are longitudinal, while light waves are transverse
e) Sound waves are transverse, while light waves are longitudinal

The longer the wavelength, the more important diffraction effects.



2. A ray of light goes from air into a flat block of glass (index of refraction = 1.5) at an angle of 36° with the normal to the interface. After passing through the glass, at what angle to the normal will the ray emerge into air?

a) 62°
b) 23°
c) 67°
d) 36°
e) The ray won't emerge into air, because it will be totally internally reflected in the glass.

Apply Snell's law twice:

~~sin~~

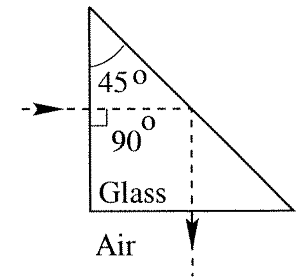
$$\sin 36^\circ = 1.5 \sin \theta_{glass} = \sin \theta \Rightarrow \theta = 36^\circ$$

3. A fish is swimming 30 cm below the water surface, and an insect is flying 12 cm above the surface. If the index of refraction of water is 4/3, how far from the water surface will the fish see the insect's image? (Assume the line of sight makes a small angle to the normal).

a) 9 cm
b) 16 cm
c) 31.5 cm
d) 56 cm
e) 12 cm

$$d_{apparent} = nd = \frac{4}{3} 12\text{ cm} = 16\text{ cm}$$

4. Total internal reflection takes place in the glass prism shown. The index of refraction of this glass is:



a) at least 1.50
b) at most 1.50
(c) at least 1.41
d) at most 1.41
e) impossible, total reflection cannot occur as shown

for TIR : $\sin\theta_{crit} = \frac{1}{n}$

in this geometry, we must have $\theta_{crit} \leq 45°$

$\Rightarrow \frac{1}{n} = \sin\theta_{crit} \leq \sin 45° = \frac{1}{\sqrt{2}}$

$\Rightarrow n \geq \sqrt{2} = 1.41$

5. An object is placed 12 cm from a lens. The image is upright and one-third as big as the object. What is the focal length of the lens?

a) +6 cm
b) +9 cm
c) +18 cm
(d) −6 cm
e) +3 cm

magnification: $m = -\frac{s'}{s} = +\frac{1}{3} \Rightarrow s' = -\frac{s}{3} = -\frac{12\,cm}{3}$
$= -4\,cm$

$f = \frac{1}{\frac{1}{s} + \frac{1}{s'}} = \frac{1}{\frac{1}{12cm} - \frac{1}{4cm}} = -6\,cm$

↑ image distance

6. Light from an incandescent bulb is passed through a filter which transmits yellow light, and then serves as the source for a Young's double slit experiment. Which of the following changes would cause the interference fringes to be more closely spaced?

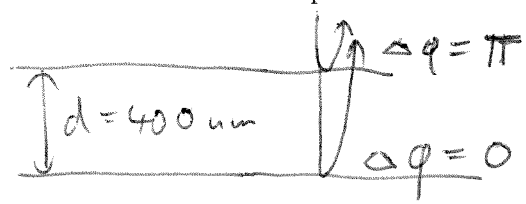
a) use slits that are closer together
b) use a light source of lower intensity
c) use a light source of higher intensity
(d) use a filter which transmits blue instead of yellow
e) move the light source farther away from the slits

$d\sin\theta = n\lambda$

fringe spacing is proportional to wavelength

7. A 4×10^{-7} m thick soap film, surrounded by air, is illuminated by white light normal to its surface. The index of refraction of the film is 1.50. At which wavelengths will the reflectance be at a peak?

a) 400 nm and 600 nm
(b)) 480 nm and 800 nm
c) 320 nm and 533 nm
d) 400 nm and 800 nm
e) 510 nm and 720 nm



Condition for maxima: $2d = \left(m + \frac{1}{2}\right)\frac{\lambda}{n}$

$\Rightarrow \lambda = \frac{2nd}{m + \frac{1}{2}} = \frac{1200\,\text{nm}}{m + \frac{1}{2}}$ for $m = 1: \lambda = 800$ nm for $m = 2: \lambda = 480$ nm

8. A real object placed closer to a converging lens than its focal length always makes an image that is

a) Virtual, upright, smaller
(b)) Virtual, upright, bigger
c) Real, inverted, smaller
d) Real, inverted, bigger
e) Real, upright, smaller

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$ if $s < f \Rightarrow \frac{1}{s} > \frac{1}{f}$

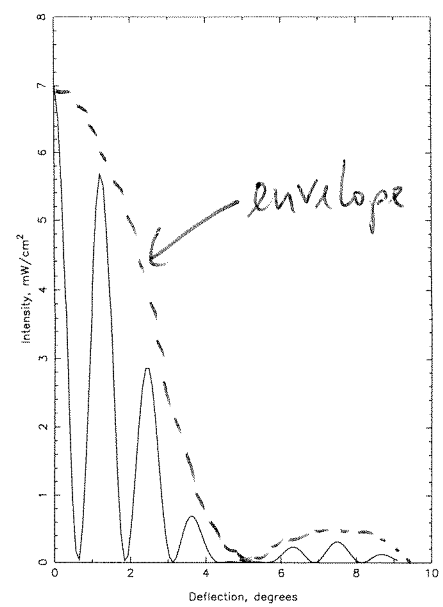
$\Rightarrow \frac{1}{s'} = \frac{1}{f} - \frac{1}{s} < 0 \Rightarrow s' < 0$

$\Rightarrow$ image is on same side as object

$\Rightarrow$ virtual, upright

magnification: $m = -\frac{s'}{s} = -\frac{\frac{1}{s}}{\frac{1}{s'}} = -\frac{\frac{1}{s}}{\frac{1}{s} - \frac{1}{f}} = \frac{f}{f - s} > 1 \Rightarrow$ bigger!

9. Light of wavelength 440 nm passes through a double slit, yielding the diffraction pattern of intensity I versus deflection angle θ shown. What is the width, a, of each slit?



a) 10 μm
b) 5.0 μm
c) 3.3 μm
d) 19 μm
e) 42 μm

The slit width gives rise to the envelope — single slit diffraction pattern

First minimum is at $a \sin\theta = \lambda$ $\quad \theta = 5^\circ$

$$\Rightarrow a = \frac{440 \text{ nm}}{\sin 5^\circ} = 5.0\ \mu\text{m}$$

10. Monochromatic light is normally incident on a grating which is 1 cm wide and has 10,000 slits. The first order maximum is deviated at a 30° angle. What is the wavelength of the incident light?

a) 300 nm
b) 400 nm
c) 500 nm
d) 600 nm
e) 1,000 nm

$$\lambda = d \sin 30^\circ = \frac{d}{2} = \frac{1}{2}\,\frac{1 \text{ cm}}{10^4} = 500 \text{ nm}$$

11. An unpolarized beam of light is incident on three parallel polarizing sheets that are lined up so that the tranmission axis of each is rotated by 30° with respect to the preceding sheet. What fraction of the incident *intensity* is transmitted?

a) 1/8
b) 1/3
c) 3/8
(d) 9/32
e) 27/64

First polarizer transmits $\frac{1}{2}$.

Second polarizer transmits $\cos^2 30° = \frac{3}{4}$

Third polarizer transmits $\cos^2 30° = \frac{3}{4}$

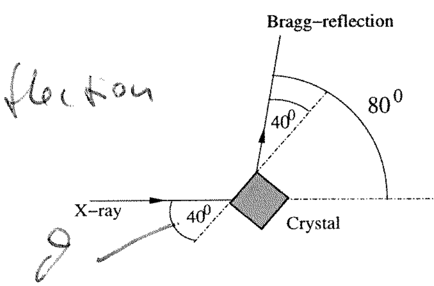
$\Rightarrow$ Total transmission $= \frac{1}{2}\cos^4 30° = \frac{9}{32}$

12. Unpolarized light is incident at the Brewster angle from a medium of refractive index n_1 onto a medium of refractive index n_2, with $n_2 < n_1$. The plane of incidence contains the normal to the interface, and the incident, transmitted, and reflected rays. Which of the following statements is true?

a) The reflected light is polarized with its E vector in the plane of incidence.
(b) The reflected light is polarized with its E vector perpendicular to the plane of incidence.
c) The transmitted light is polarized with its E vector in the plane of incidence
d) The transmitted light is polarized with its E vector perpendicular to the plane of incidence.
e) There is no transmitted light, since the Brewster angle in this case is is greater than the critical angle.

At the Brewster angle, parallel-polarized ("p-polarized") light is not reflected $\Rightarrow$ all reflected light is perpendicular polarized ("s-polarized").

13. An X-ray beam of wavelength 1.00 Å diffracts off a crystal in a first order Bragg reflection. The angle subtended between the incoming beam and the outgoing beam is 80° as shown. What is the separation of the crystal layers d that will give rise to this Bragg reflection?



a) 0.51 Å
b) 1.56 Å
c) 0.65 Å
d) 1.31 Å
(e) 0.78 Å

$2d\sin\vartheta = \lambda$ for first order Bragg reflection

$d = \frac{\lambda}{2\sin\vartheta} = \frac{1\,Å}{2\sin 40°} = 0.78\,Å$

14. A midget astronaut with blue shoes and a blue hat, 1.00 m high is observed by a telescope with an objective lens of diameter 5.00 cm. What is the greatest distance away that the astronauts shoes can be resolved from his hat? Note that wavelengths in the visible spectrum stretch from 700 nm (red light) to 400 nm (blue light).

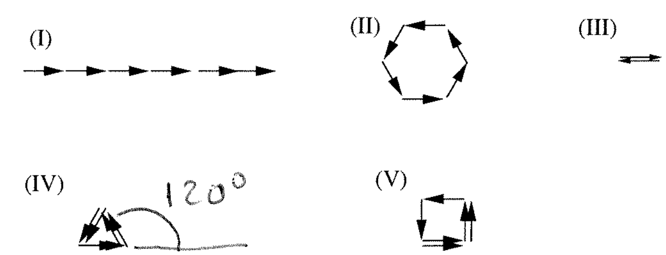
a) 10.2 km
b) 68 km
c) 125 km
(d) 102 km
e) 83.3 km

angular resolution : $d \sin\vartheta = 1.22\lambda$ $d = 5\text{cm}$

$\sin\vartheta \approx \tan\vartheta = \frac{h}{\text{distance}}$ $h = 1\text{ m}$

$\Rightarrow \text{distance} = \frac{hd}{1.22\lambda} = \frac{1\text{m} \times 0.05\text{ m}}{1.22 \times 400\text{ nm}} = 102\text{ km}$

15. In the diffraction pattern from a six slit diffraction grating, which phasor diagram represents the combination of electric fields from the six slits when the path length difference between light from neighboring slits is a third of a wavelength?



a) I
b) II
c) III
(d) IV
e) V

phase difference between amplitudes from adjacent slits $= \frac{360°}{3} = 120°$

$\Rightarrow$ IV is correct