PX-1
(Practice Exercises Set 1)

1) A traveling electromagnetic wave in vacuum has an electric field magnitude given by

$$E(x,t) = E_0 \cos\left(\omega_E t - k_E x\right)$$

with t in seconds and x in meters; the constants E_0 and w_E have the values $E_0 = 5.0 \times 10^4$ N/C and $w_E = 6.0 \times 10^{10}$ rad/sec. The magnetic field has a similar form; its magnitude is given by

$$B(x,t) = B_0 \cos\left(\omega_B t - k_B x\right)$$

a) What direction is the electromagnetic wave traveling?

$+x$ $+y$ $+z$

$-x$ $-y$ $-z$

b) At a location and time for which $\vec{E}$ points along the $+y$–axis, along which axis does $\vec{B}$ point?

c) Determine B_0 (a number and a unit).

d) Calculate k_B (in radians/meter).

2) A harmonic waves propagates across the surface of a lake. The vertical displacement of the water is given by the function

$$y(x,t) = (0.12)\sin(0.8x - 1.4t),$$

where distance is in meters and time is in seconds.

a) Write down the amplitude, wavelength, and frequency of this wave.

b) Determine the propagation speed of the wave (i.e., how fast the wave is moving).

c) Write an expression for the vertical velocity of the water molecules at the surface of the lake as the wave goes by.

3) You are developing a new musical instrument called the *squawkaphone* that is designed so that you can play both the fundamental (lowest frequency) mode along with the second mode. The squawkaphone can be modeled as an organ pipe with one end open and the other closed.

a) Draw sketches of the modes with the ***two*** lowest frequencies. (Draw the appropriate mode on each of the dotted lines below.)

---------- Lowest-freq. mode

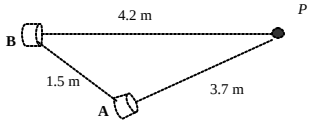
---------- 2nd lowest-freq. mode

b) If you want the lowest (fundamental) frequency to be 200 Hz, how long should the pipe be? (You can assume that the speed of sound is 340 m/s.)

c) Given your answer to (b), calculate the frequency of the second mode.

d) What is a problem with the intended use of the squawkaphone?

4) Two speakers are placed a distance of 1.5 m apart as shown at right and a sound wave of wavelength 2.5 m is produced from each speaker. You are standing at point *P* a distance of 3.7 m from speaker A and 4.2 m from speaker B.



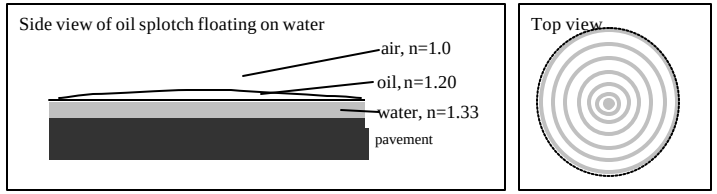
a) Compute the phase difference $\Delta\phi$ between the two waves arriving at point *P* from the speakers A and B.

b) Draw a phasor diagram for the two waves arriving at point *P*. (Assume the amplitude of each wave arriving individually at point *P* is the same.)

c) The amplitude of each of the waves arriving at *P* from the speakers is $y_m = 3\ \mu m$. Compute the amplitude of the total wave arriving at point *P*.

PX-2
(Practice Exercises Set 2)

1) It has been raining, and you notice a circular oil splotch near your car. It is dark outside, but the splotch is illuminated by the green light from an overhead street light. From the reflected light you see a pattern of 6 concentric bright rings and a bright dot in the center, as shown in the sketch. Assume that the thickness of the film is zero at the edges, and assume that the green light has a wavelength of 520 nm in air.



Determine the thickness of the oil film at the center.

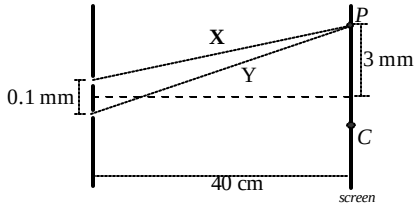
2) Let's say that a compact disk has 24,000 lines distributed evenly along a 3.0 cm radial distance. Suppose you direct a blue laser beam (λ = 470 nm) normal to the disk, in the region where the lines are. The beam's reflection on a distant screen has several bright spots to the left and right of the central maximum.

a) What would be the angle (relative to the central maximum) for the first side maximum of the interference pattern?

b) How many total bright spots would you observe? (hint: what is the maximum value for $\sin\theta$?)

3) Light of wavelength λ_o falls on a single slit of width w_o. For the third side minimum in the single slit diffraction pattern, draw the phasor diagram and write down the phase difference between beams coming from the top and bottom of the slit. What is the path length difference for beams coming from the top and bottom of the slit in terms of givens?

4) Consider light of wavelength $\lambda = 500$ nm incident on a barrier with two very narrow slits. The two slits have slightly different widths, so that the amplitude of the electric field of the light reaching the screen from **just** the top slit is 0.05 N/C, and the amplitude of the electric field of the light reaching the screen from **just** the bottom slit is 0.02 N/C.



X = 40.0010878 cm

Y = 40.0011628 cm

a) Draw a phasor diagram and determine the amplitude of the **total** electric field at the position of the central maximum at point ***C*** on the screen.

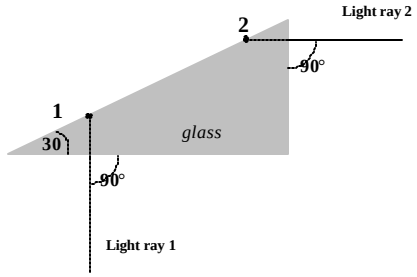
b) Draw a phasor diagram and determine the amplitude of the **total** electric field at the illustrated point ***P*** on the screen.

5) A spy satellite has a telescope with aperture diameter of 0.62 m, and is orbiting a distance of 800 km above the earth's surface. For light with a wavelength of 500 nm (in the range of visible light), determine the shortest distance between two objects on the earth that the satellite is capable of resolving.

6) You are using ultrasound to image a developing fetus. You find that you can't resolve the spinal cord of the fetus due to diffraction limitations. Should you increase or decrease the frequency of the ultrasonic wave, or will changing the frequency not make any difference? Briefly explain your answer.

PX-3
(Practice Exercises Set 3)

1) Consider the glass prism shown in the diagram as viewed from above as it sits on a laboratory table. The refractive index of glass is 1.50 and the refractive index of the surrounding air is 1.00.



a) Using Snell's Law and your other knowledge of the propagation of light through different materials, sketch all **reflected** and/or **transmitted (refracted)** rays occurring at points 1 and 2. Calculate and label all ray angles with numerical values.

b) Suppose the electric field vector associated with light ray 1 is polarized in a direction perpendicular to the page (i.e., the electric field vector oscillates in and out of the page) and the electric field vector associated with light ray 2 is polarized in a direction parallel to the page and perpendicular to the direction of light ray 2. Viewing the prism as shown in the figure, which light ray will appear brighter due to the scattering of light from the molecules in the glass? Explain your answer.

2) You are out sailing on an extremely foggy evening. Looking straight ahead, you see the fog scattering light towards you. You know the source of light is a nearby lighthouse, but you can't see the lighthouse itself. You use your polaroid sunglasses to figure out that the light scattered from the fog straight ahead is **unpolarized** What can you say about the location of the lighthouse (from the choices below)? Explain your choice

a) From your perspective, the lighthouse is on a cliff, and its light is shining down into the fog from above.

b) From your perspective, the lighthouse is either to the left or to the right of the glowing foggy region.

c) From your perspective, the lighthouse is behind the glowing foggy region.

d) This is not possible - the light must somehow be polarized.

e) There isn't enough information here to make any statement about where the lighthouse is located.

3) A particular infrared laser emits electromagnetic waves with a wavelength of 30.2 μm and a total power of 2.0 mW.

a) Calculate the rate at which photons are emitted by this laser (that is, how many photons/sec?).

b) The beam falls on a piece of photographic film. The binding energy for the AgBr molecules on the film is 0.6 eV. What is the largest number of AgBr molecules that could be chemically altered each second by this beam of infrared radiation?

4) You are building a residential development (i.e., a group of houses) but there are some high voltage power lines in the vicinity and you want to be careful about potential cancer hazards. The electromagnetic radiation emitted from these power lines has a frequency of 60 Hz. Assume that the intensity of the radiation from the wires is $I = 2/d2$ where I is in $W/m2$ and d is the distance (in m) from the wires.

a) What is the energy of each photon that emanates from the high-voltage power lines?

b) A typical molecular binding energy of a person's DNA is 0.1 eV. Using the assumptions of the photoelectric effect, how far away from the wires should you build the houses to be confident that the radiation from the wires won't break the molecular bonds of the residents' DNA (and possibly cause cancerous mutations)?

5) Let's say that you are developing a neutron microscope to investigate a recently-discovered virus. You need to be able to resolve structures as small as 0.02 nm.

a) Estimate the maximum wavelength for the neutron beam that you should use in this microscope. Explain your choice.

b) What is the minimum kinetic energy for the neutrons that you should use?