1. A certain tuning fork vibrates at frequency 256 Hz. Use the speed of sound 343 m/s (at 20 °C) to find: (a) the wavelength of the sound made by the tuning fork, (b) the range of wavelengths audible to humans – frequencies from 20 Hz to 20 kHz.

2. A certain laser has wavelength 650 nm. Use the speed of light 3.00×10^8 m/s (in air or vacuum) to find: (a) the frequency of the laser light, (b) the range of frequencies visible to humans – wavelengths from 400 nm to 750 nm.

3. Transverse waves in a certain "string" have troughs that are separated by 4.5 cm and which occur with frequency 1.4 Hz. (a) Determine the speed of the wave. (b) If frequency increases to 2.1 Hz how far apart are the crests of the wave?

4. Use a microphone to measure the sound of a tuning fork and produce a graph of voltage vs. time. (a) Find the frequency using curve fit coefficient(s). (b) Determine the speed and wavelength. (c) The microphone output is generated by a coil of wire that vibrates back and forth in a magnetic field. How does this relate to the compressions and rarefactions of the wave and the voltages measured?

5. The radio signal from FM station 107.7 MHz is broadcast with power 91 kW and travels 30 miles before reaching the antenna of a car. (a) Use the formulas $I = P/A$ and $I = EB/2\mu_0$ to determine the strength of the fields in the signal. (b) Determine the wavelength. (c) Write equations for E and B as functions of time at the location of the car.

6. A certain laser pointer creates light with wavelength 532 nm in the form of a plane wave with power 5.0 mW and beam of diameter 1.0 mm. Use the equations from above to determine an equation for the magnetic field in the wave as a function of position and time.

7. A certain microwave generator has a frequency 10.525 GHz. A diode of length 5.0 mm placed in the beam has a voltage output of 0.075 mV. (a) Find the average electric field strength at the diode. (b) Determine the average magnetic field strength. (c) Determine the wavelength. (d) Graph electric field vs. position on your calculator and adjust the window range to show two cycles.

8. Show that the microwaves generated above have wave properties by demonstrating a standing wave and illustrating polarization. (a) What should be the spacing from one node to the next in a standing wave pattern? What interference occurs at a node? (b) How does the metallic grate stop the microwave? Which field is aligned with the metal bars in order to stop the wave?

9. Light of wavelength 650 nm falls upon two slits separated by 0.11 mm. The resulting bright fringes are viewed on a screen that is 2.0 m away from the slits. (a) Determine the angle between the central bright line and the 1^{st} order bright line. (b) Find the width of the central bright line on the screen.

10. A laser shines through two slits separated by 66 μm producing bright dots separated by 1.2 cm appearing on a wall 1.5 m from the slits. (a) Find the frequency of the laser. (b) What different values of frequency, separation, or distance from the wall would double the spacing of the dots?

11. A metal plate with slots that are separated by 5.7 cm is placed over the emitter of a microwave generator with wavelength 2.85 cm. (a) What is the angle between the central "bright" line and an adjacent "bright" line of microwave? (b) How many lines are there?

12. In a spectrometer it is desired to separate white light into its component wavelengths. A grating with how many lines per cm would create a spectrum of width 10.0°?

13. One type of retroreflector consists of mirror surfaces forming right angles. Show that a ray that is incident on such a reflector will emerge traveling in the opposite direction.

14. The angle of incidence is 30.0° for a ray of light moving parallel to a diameter of a concave spherical mirror with radius 20.0 cm. (a) Determine where the reflected ray crosses the diameter. (b) Show that as the angle of incidence decreases this location is at half the radius.

15. A laser is shone at an angle of incidence equal to 40.0° into a block of clear plastic that has index of refraction 1.45. (a) Determine the angle of refraction. (b) Find the angle between the transmitted beam and the reflected beam. (c) By how many degrees is the beam "bent" (change in direction)?

16. A person sees a coin on the bottom of a 4.0 foot deep pool (n = 1.33). The light entering the person's eye leaves the coin initially at an angle 20.0° from vertical. (a) Find the angle with the vertical as the light enters the eye. (b) Assuming the image of the coin is directly above it, how deep does the water appear? (c) At what minimum distance from the coin could a person stand and see it with their eye just *above* the surface?

17. Looking straight down at an object at depth d_o below the surface of a pool it can be shown that the image of the object appears at depth d_i closely approximated by $d_i = d_o/n$ – derive this. (Given the index of refraction for water this means that the depth of a pool appears about ¾ its actual – why?)

18. A ray of light from a fish in an aquarium enters the glass wall of the tank at incidence 30.0°. (a) Find the angle relative to the normal that it exits the tank given $n = 1.34$ for the water and $n = 1.52$ for the glass. (b) Light at what angle(s) incident to the wall would fail to exit the tank?

19. Light passes through a transparent rectangular solid of thickness x and refractive index n. (a) Show that light emerging from the other side of the solid is traveling parallel to that entering, no matter the angle. (b) Given n, measure x and the angle of incidence, and calculate the "offset" distance d of the beam of light on the other side of the solid.

20. A certain spherical mirror with radius 20.0 cm is made of a thin material and reflective on both sides. Using both sides, a student looks at herself in the mirror, with her face 60.0 cm away from the surface. (a) Find the image type and distance for each side. (b) How much bigger does her face appear in the concave side than in the convex side? (c) How close to her face and which side would allow her to see an upright image with magnification 2.00?

21. A telescope with a focal length 70$\underline{0}$ mm is used in a demonstration. A light bulb is placed 1.5 m away from the mirror. (a) If the mirror is spherical what is its radius? (b) At what distance does the image form and what is the magnification? (c) When viewing Jupiter with this telescope what is the size of the real image created by the mirror?

22. A certain cell phone camera lens has a focal length of 4.25 mm and a 12 MP chip of dimensions 5.6 by 4.2 mm. A student takes a picture of a friend's face from a distance of 20.0 cm. (a) Determine the distance from the lens to the chip for the best focus. (b) The friend's brown eyes have irises of diameter 11 mm – how many pixels wide is each iris in the picture?