# Optics, Spring 2011
# Test 1

D. Craig

February 18, 2011

These problems are due on Friday, Feb. 25 by 5 pm. You may use your book and notes, but I ask that you not consult each other on the problems. If you have questions, please email me at `dcraig@wtamu.edu`.

Some of these are from the text, some modified, some from elsewhere.

1. A sound wave has a frequency of 2.20 kHz and propagates with a speed of 330 m/s. Determine the wavelength of the wave and the phase difference in radians between any two points on the wave separated by 5.0 cm.
2. The presence of free ions in the ionosphere strongly influences the use of shortwave radio frequencies, making long-range communication possible as the radio waves are reflected from the ionosphere analogously to the way visible light is reflected from a metal. The F layer of the ionosphere typically has a maximum critical frequency $\nu_c$ of 1.0 MHz to 15 MHz. $\nu_c$ is known to physicists as the plasma frequency. How many electrons per cubic meter does each end of this range correspond to?
3. A small halogen bulb puts out 100 W of radiant energy, mostly in the infrared. Assume it to be a point source and calculate the irradiance 1.00 m away.
   Now figure out at what distance from your forehead to place the bulb so that it feels like bright sunlight, which is about 1000 W/m$^2$. Some physicists used a technique like this to estimate yields of nuclear weapons in the 1950s, by comparing the heat felt from an explosion at a known distance to either sunlight or a known bulb.
4. Yellow light from a sodium lamp ($\lambda_0 = 589\,\mathrm{nm}$) traverses a tank of glycerine (index 1.47) which is 20 m long, in a time $t_1$. If it takes time $t_2$ for the light to pass through the same tank when filled with carbon disulfide (index 1.63) determine the value of $t_2 - t_1$.
5. Derive the law of reflection, $\theta_i = \theta_r$, by using calculus to minimize the transit time, as required by Fermat's principle.
6. Do problem 4.34: Show that light entering a planar transparent plate emerges parallel to its initial direction. Derive an expression for the lateral displacement of the beam.
7. An exceedingly narrow beam of white light is incident at 60.0 degrees on a sheet of glass 10.0 cm thick in air. The index of refraction for red light is 1.505 and for violet light it's 1.545. Determine the approximate diameter of the emerging beam. (problem 4.20) It is pretty imperative that you draw a careful diagram to see how to find this.
8. Use the form of the Fresnel equations that takes into account Snell's law (4.42—4.45) to show that light reflected from a dielectric surface when $\theta_i + \theta_t = \pi/2$ is polarized. The particular value of $\theta_i$ for which this occurs is called $\theta_p$, the polarization angle, or Brewster's angle. Calculate Brewster's angle for a medium of refractive index 1.40 in air.