Read Notes §1 *Introduction*, Skim §2 *Wave Optics and Imaging*, start to read §3 *Optical Diffraction and Imaging*

Warmup Problems

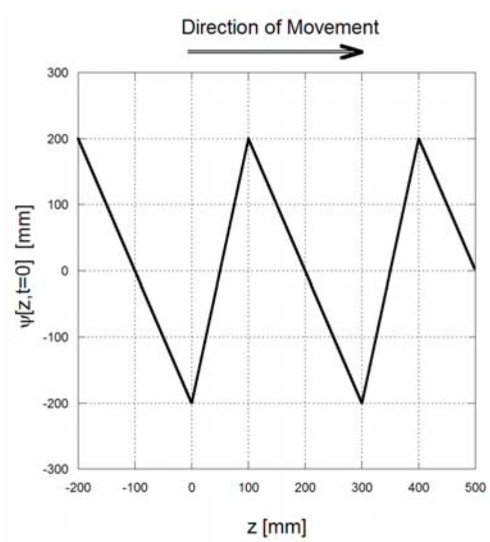
1. The speed of light in vacuum is approximately $3 \times 10^8 \frac{\text{m}}{\text{sec}}$. Find the wavelength of light having a frequency of 1 PHz. Compare this to the wavelength of a 60 Hz electromagnetic wave.

2. (HW1-20072-2) The figure shows the profile of a transverse wave on a string traveling in the positive z-direction at a speed of $1 \frac{\text{m}}{\text{s}}$.

   (a) Determine its spatial period.

   (b) Notice that as the wave passes any fixed point on the z-axis, the string at that location oscillates in time. Draw a graph of $\psi[t]$ showing how a point on the rope at $z = 0$ oscillates.

   (c) Determine the temporal frequency of the wave.



3. A harmonic traveling wave is moving in the negative z-direction with an amplitude of 2 arbitrary units, a wavelength of 5 m, and a period of 3 s. Its displacement at $z = 0$ and $t = 0$ is zero. Write a wave equation for this wave under the following conditions:

   (a) explicitly in terms of both wavelength and period

   (b) exhibits both propagation constant and velocity

   (c) in complex form

Diffraction problems

4. A hole with diameter $d_0 = 1\,\mathrm{mm}$ is illuminated by light with $\lambda_0 = 546\,\mathrm{nm}$. Determine which approximation (Fresnel or Fraunhofer) is valid for observation planes located at the distances: $z_1 = 500\,\mathrm{mm}$, $z_2 = 1\,\mathrm{m}$, and $z_3 = 5\,\mathrm{m}$.

5. For the quadratic-phase impulse response for Fresnel diffraction without the constant phase:
$$h[x, y; z_1, \lambda_0] = \frac{1}{i\lambda_0 z_1} \exp\left[+i\frac{\pi}{\lambda_0 z_1}\left(x^2 + y^2\right)\right]$$
   (a) Show that the volume is unity.
   (b) Show that the two-dimensional sinusoidal part of this function contributions ALL of the volume and that the cosine part contributes none.

6. Consider propagation over the distance z_1 and then over the distance z_2, where both distances satisfy the conditions for Fresnel diffraction. Show that a single propagation over the distance $z_1 + z_2$ gives the same result as the propagations over z_1 and then over z_2.

7. Consider a spherical wave expanding about the point $[0, 0, -z_1]$ in a Cartesian coordinate system. The wavelength of the light is λ_0 and $z_1 > 0$.
   (a) Express the phase distribution of the spherical wave across the $[x, y]$ plane located normal to the z-axis at coordinate $z = 0$.
   (b) Use the paraxial approximation to find an expression for the phase distribution of the parabolic wavefront (quadratic-phase factor) that approximates this spherical wavefront.