Due in class Aug 10th

1. A double slit experiment uses light of wavelength 600 nm, and has a slit spacing of 0.25 mm.
   i) At what value of $\theta$ is the path difference between the light from the two slits equal to a quarter of the wavelength?
   ii) If a screen of width 1 m is located 2 m from the pair of slits, with its center on the line half-way between the slits, how many bright fringes will be seen on the screen?

   ![Diagram of a double slit experiment](image)

2. Two sources of electromagnetic waves broadcast waves of the same frequency and amplitude and with the same phase. The two sources are located on the $y$-axis, at $y = \pm 150$ m. An observer starts from $x = 1$ km, $y = 0$ where she records the zeroth maximum of intensity. She then travels in the $y$ direction, and records the second (not the first!) maximum at $x = 1$ km, $y = 0.4$ km.
   i) What is the wavelength of the signals?
   ii) How much further does she have to travel in order to be at the next intensity minimum?

   ![Diagram of two sources and observer](image)

3. Coherent light of a frequency $f$ and wavelength $\lambda$ falls normally on a screen with three slits. The slits are equally spaced, a distance $d$ apart.
   i) Find an expression for the time-averaged intensity (up to an overall proportionality constant) as a function of the angle $\theta$ at which the intensity is measured.
   ii) If you plot the intensity as a function of $\theta$, you see big peaks (primary maxima) alternating with small peaks (secondary maxima). Find the ratio of the intensity at the secondary maxima to the intensity at the primary maxima.
4. Two strings with mass per unit length $\mu_1$ and $\mu_2$ are tied together at $x = 0$ and stretched with a tension $F_T$. A wave $y = A \sin \omega (x/v_1 - t)$ propagates down the first string. When it reaches the knot at $x = 0$, it is partly reflected back into the first string, and partly transmitted into the second string. Thus

$$y(x < 0) = A \sin \omega (x/v_1 - t) + B \sin \omega (x/v_1 + t)$$

$$y(x > 0) = C \sin \omega (x/v_2 - t).$$

i) Why is $y(x)$ continuous at $x = 0$? Why is $\partial y/\partial x$ continuous at $x = 0$?

ii) Use these two conditions to obtain $B$ and $C$ in terms of $A$ and $v_2/v_1$.

iii) Obtain the limiting form for $B/A$ when $v_2/v_1 \to 0$, i.e. the second string is extremely heavy, and when $v_2/v_1 \to \infty$, i.e. the second string is extremely light.

Note: These results apply to any other transverse wave, e.g. light, when between two media whose refractive indices are very different.

5. Two flat glass plates are placed together at one end, and separated by a thin sheet of paper 0.06 mm thick at the other end. A source of 500 nm light illuminates the plates from above. Assume that the paper is sufficiently thin that the glass plates are approximately parallel (the figure is exaggerated). How many bright bands appear to an observer looking down at the plates?

6. A glass slab with refractive index 1.61 is coated with a thin layer of metal oxide with a refractive index of 2.61. Light falls from above on the slab, at normal incidence (i.e. perpendicular to the slab). If there is to be destructive interference between the light reflected from the top and the bottom of the metal oxide, what is the minimum thickness of the layer and the next possible thickness that can be used? Assume that the light is in the middle of the visible range, i.e. the wavelength in vacuum is 550 nm. (This technique is used to produce nonglare glass.)