Physics 380H - Wave Theory
Homework #10

Fall 2004
Due 12:01 PM, Monday 2004/11/29

[45 points total]

"Journal" questions:
– How do you feel about the usefulness and/or effectiveness of these "Journal" types of activities? What do you think their best aspect has been? What change to their format or content might improve their usefulness and/or effectiveness? Why?
– Any comments about this week's activities? Course content? Assignment? Lab?

1. (From Towne P14-5, pg 319) Consider an array of N coherent point sources equally spaced along a straight line, the distance between each pair being d. Assume that the sources are of equal strength and in phase.

   (a) Use the Fraunhofer approximation and sum the contributions from each source to determine the net signal at a distant point of observation. (This method of direct summation is equivalent to that used in Towne Chapter 11 for the double source.) [10]

   (b) Show that the angular distribution of intensity is the same as that obtained from Towne Equation 14-8 by taking the limit as the length of the individual line segments tends to zero. [5]

2. (From Towne P14-9, pg 320)

   (a) What resolving power is required to resolve the sodium doublet and what information is required about the grating to predict the smallest-order spectrum in which the doublet will be resolved? [5]

   (b) Show that a knowledge of the total width of the grating is sufficient to obtain a lower bound for the *angle* at which a resolved doublet will be obtained. [5]

   (c) Calculate the order number and the angle of the first doublet resolved by a one-inch (2.54 cm) grating of 200 lines. [5]

3. (From Towne P15-1, pg 372) A string of length l is fixed at $x = 0$ but is "free" at $x = l$. (The device of a frictionless and massless slip ring would be required to maintain tension in the string and yet permit no transverse component of the force acting on the free end.)

   (a) Give arguments to show that the general motion is periodic and deduce the period. [5]

   (b) By direct substitution of a function of sinusoidal form determine the frequencies which any sinusoidal solution must have. [5]

   (c) Use the method of separation of variables to deduce the necessary form of a product-form solution satisfying the given boundary conditions. [5]

Headstart for next week, Week 11, starting Monday 2004/11/29:
– Read Chapter 15 "Waves Confined to a Limited Region" in Towne, omit 15-14, 15-15
– – Section 15-5 "Linear combination of normal-mode solutions"
– – Section 15-6 "Determination of the coefficients in a normal-modes expansion"
– – Section 15-7 "Independence of the energy contributions from different modes"
– – Section 15-8 "Normal-modes expansion of a rectangular pulse"
– – Section 15-9 "Energy spectrum of the rectangular pulse"
– – Section 15-10 "A too literal interpretation of the normal-modes expansion"
– – Section 15-11 "Normal-modes expansion of a sinusoidal wavetrain of limited extent"