Physics 380H - Wave Theory **Homework #08**

Fall 2004 Due 12:01 PM, Monday 2004/11/15

[50 points total]

"Journal" questions:
– Of the material that has been covered in the course up to the mid term test, what has been the most difficult for you to understand? What material has been the most interesting? What material has been the most surprising? Is there any material that you thought you understood before this course that you now have a drastically different understanding of? What was is and what has changed?
– Any comments about this week's activities? Course content? Assignment? Lab?

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1. Please complete the anonymous mid-course survey online on WebCT. Early feedback will hopefully allow us to have the best possible course this semester rather than just having next year's students benefit. In addition to the bonus assignment marks, survey participation may count towards overall class participation scores. [5.01-bonus]

2. (From Towne P12-1, pg 289) Let θ be the angle in Figure 12-2 which corresponds to the *first* minimum, under the conditions of the Fraunhofer approximation, in the radiation pattern from a coherent line source.
   (a) For this case what is the phase difference at P between the contributions from O, the centre of the course, and C, the lower end? Compare the contributions from other pairs of corresponding points, i.e., other pairs in which the first point lies on the upper half of the source a certain distance above O and the second lies on the lower half the same distance above C. [5]
   (b) From this information can you predict what the resultant of all the contributions should be? [5]
   (c) Devise a similar interpretation for the *second* minimum in the Fraunhofer radiation pattern. [5]

3. (From Towne P12-4, pg 290) Sketch a polar plot of intensity vs. angular position which corresponds to the Fraunhofer diffraction of a normally indicent acoustic plane wave by an extremely narrow slit which is three wavelengths in length. [10]

4. (From Towne P12-6, pg 290) Sketch a polar plot of intensity vs. angular position which corresponds to the Fraunhofer diffraction of an acoustic plane wave by an extremely narrow slit which is three wavelengths in length where the angle of incidence of the plane wave is 45°. (Assume that the normal to the plane wave lines in a plane perpendicular to the long dimension of the slit.) [10]

5. (From Towne P12-11, pg 291) Assume that the limiting aperture of an optical system is rectangular rather than circular. For example, suppose that objects are to be viewed by an eye placed directly behind a laboratory slit. Consider two point objects which are aligned parallel to the narrow dimension a of the slit. Assume that the images of two objects are unresolved if there is any overlapping of the central lobes in their Fraunhofer patterns.
   (a) Show that the angular limit of resolution is given by $(\Delta\theta)_{\min} = 2\lambda/a\cos\theta$, where θ is the angle which the objects make with the axis normal to the slit at its centre. [10]
   (b) Consider a horizontal string of light bulbs spaced 1 m apart along the railing of a bridge. These are viewed from a distance of 1 km through a vertical slit. Apply the criterion above to find the slit width at which resolution would be lost. (Assume that $\lambda = 5500\,\text{Å}$.) [5]

Headstart for next week, Week 09, starting Monday 2004/11/15:
– Read Chapter 12 “Continuous Distribution s of Coherent Sources; the Fraunhofer Approximation” in Towne, omit 12-15
– – Section 12-10 “Oblique incidence”
– – Section 12-11 “Reflection of a plane wave from a rectangular surface”
– – Section 12-12 “Fraunhofer diffraction by a circular aperture”
– – Section 12-13 “Acoustic radiation from a circular piston”
– – Section 12-14 “Limit of resolution of image forming instruments”
– Read Chapter 13 “Fresnel Diffraction” in Towne
– – Section 13-1 “Introduction”
– – Section 13-2 “Fresnel Approximation for the radiation pattern of a linear distribution of coherent sources”
– – Section 13-3 “The Fresnel integrals and the Cornu spiral”
– – Section 13-4 “The Fresnel diffraction pattern of a single slit”
– – Section 13-5 “Fresnel diffraction by a wide slit”