Physics 380H - Wave Theory **Homework #09**

Fall 2004 Due 12:01 PM, Monday 2004/11/22

[50 points total]

"Journal" questions:
– Within the subject matter of this course, what do you think the best methods of evaluating student knowledge and/or skills would be? What single change to how we do evaluation in this course do you think would be best? What is the best feature of the evaluation method used in this course? Why?
– Any comments about this week's activities? Course content? Assignment? Lab?

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1. (From Towne P12-5, pg 290) Suppose that the edges of a laboratory slit are opened symmetrically about the centre and are driven at constant velocity. A monochromatic plane wave is incident on the slit and the intensity variations at a fixed point of observation are recorded by means of a photocell. Describe these Fraunhofer radiation intensity variations as a function of time. [10]

2. (From Towne P12-9, pg 290) Consider sound waves generated in water by means of the sinusoidal vibration of a circular piston face of diameter 2 cm. How high must the frequency be to obtain plane waves collimated to within 1°? [10]

3. (From Towne P13-2, pg 303) See Towne Fig 13-2
   (a) Estimate the values of u_{20} and u_{10} corresponding to the points $\mathbf{Z}_{20}$ and $\mathbf{Z}_{10}$. [5]
   (b) Consider a slit of fixed width $a = 2\,\text{mm}$ and a wavelength of $\lambda = 5000\,\text{Å}$. At what distance should the observing screen be placed to have the slit edges correspond to $\mathbf{Z}_{10}$ and $\mathbf{Z}_{20}$ when the point of observation is on the axis $\theta = 0$? Sketch $I(\theta)$ for this case. [5]
   (c) If the observing screen is moved closer to the slit, at approximately what position will the centre of the pattern be a strong relative maximum? Sketch $I(\theta)$ for this case. [10]

4. (From Towne P13-3, pg 304) Let a plane wave of sound be normally incident on a rectangular slit. Assume that the narrow dimension of the slit is sufficiently small so that the diffraction problem can be treated by application of the formulas for the radiation from a coherent linear source. Take the long dimension of the slit to be 10 wavelengths. Consider a microphone which can be moved to different positions along the axis $\theta = 0$ (the perpendicular to the slit at its midpoint).
   (a) According to the Cornu spiral analysis there should be relative maxima and minima as the microphone is moved along the axis. Approximately where are some of these expected to be located? [5]
   (b) In what frequency range might this be a feasible experiment? (Consider the limited ability of the microphone to resolve the maxima and minima and the requirement that the dimensions of the slit be reasonable.) [5]

Headstart for next week, Week 10, starting Monday 2004/11/22:
– Read Chapter 14 "The Double Slit; Multiple-slit Arrays; Diffraction Gratings" in Towne
– – Section 14-1 "Introduction"
– – Section 14-2 "The double slit"
– – Section 14-3 "Multiple-slit arrays"
– – Section 14-4 "The diffraction grating"
– Read Chapter 15 "Waves Confined to a Limited Region" in Towne, omit 15-14, 15-15
– – Section 15-1 "Introduction"
– – Section 15-2 "Transverse waves on a string segment with fixed ends"
– – Section 15-3 "Sinusoidal solutions"
– – Section 15-4 "Solutions of product form"