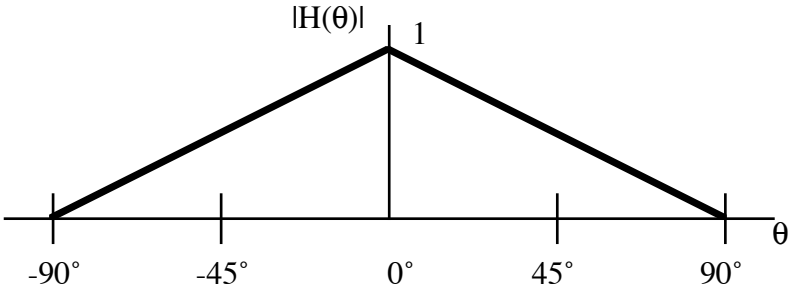
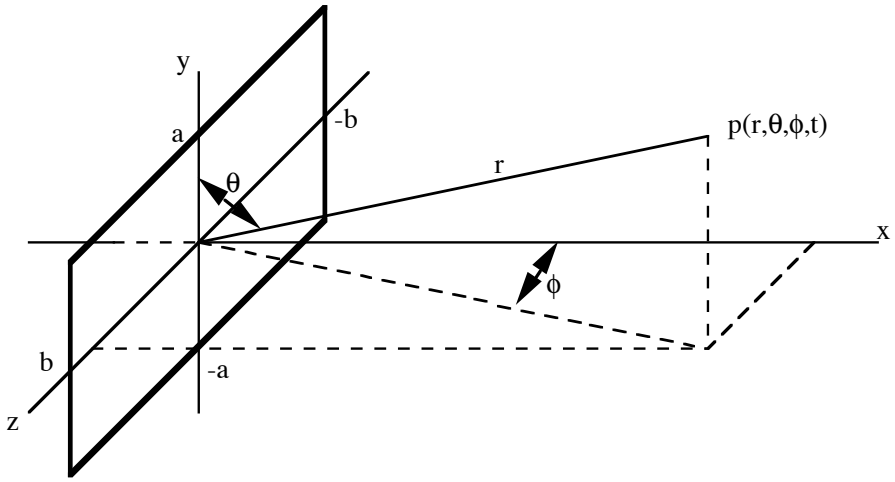
ECE 473/TAM 413
Homework Assignment #8
Due: Friday, October 30, 2009

1. Given the Cartesian representation of $|H(\theta)|$ in the figure, determine the -3-dB, the -10-dB and the -20-dB beam widths.




2. A rectangular flat piston vibrator with sides at y = ±a and z = ±b vibrates at a radian frequency of ω. Obtain a far-field expression for the acoustic pressure distribution.




3. For the plane piston, circular source of radius a, we derived the pressure for both the Fresnel Zone (on-axis only) and the Fraunhofer Zone, that is,

$$p(r,t) = 2j\rho_o c U_o e^{j\omega t} e^{-j\frac{k}{2}(R_1+r)} \mathrm{Sin}\left(\frac{k}{2}(R_1 - r)\right)$$

$$p(r,\theta,t) = \frac{j\omega\rho_o a^2 U_o}{2r} e^{j(\omega t - kr)}\left[\frac{2J_1(ka\mathrm{Sin}\theta)}{ka\mathrm{Sin}\theta}\right].$$

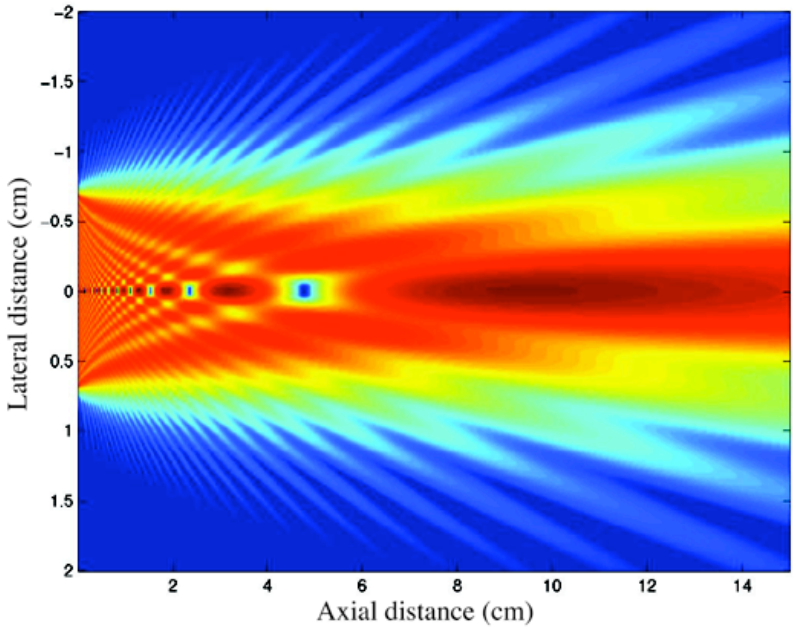
Show that in the far field, both of these expressions reduce to the same on-axis expression.

4. Two different acoustic sources (a continuous-line source and a plane piston source) operate in air (c = 340 m/s; $\rho = 1\,\mathrm{kg/m^3}$) at 1 kHz, each transmitting a temporal-average power of 500

mW. Both sources have the same zero-to-zero beamwidth of 30°. (a) For the continuous-line source, determine its length. (b) For the plane piston source, determine its radius

5. A hemisphere of radius "a" and a circular piston of radius "a" are each mounted so that they radiate on one side of an infinite baffle. They are both vibrating with the same maximum speed amplitude $U_o$ and at the same frequency so that ka << 1. (a) For a distance such that r >> a, determine the ratio of the axial intensity of the piston to that of the hemisphere. (b) Determine the ratio of the total power radiated by the piston to that radiated by the hemisphere.

6. An image of a simulated field from a baffled circular piston source is shown. The medium properties are c = 1540 m/s; $\rho = 1026\ \mathrm{kg/m^3}$; 22°C, and the source's radiated power is 5 W. The source is located along the left-hand side of the image and the field propagates to the right. All dimensions of the image are in centimeters. Estimate the source frequency.




**EXTRA: Try these problems. They will not be graded but the answers will be provided.**

E1. Problem 7.4.4 in Kinsler et al. Hint: the approximation assumes that ka is large.

E2. Determine the farfield beam pattern for an annular ring of outer radius "a" and inner radius "a/2". Compare on-axis amplitude of the annular ring and a piston of radius "a". Plot $H(\theta)$ of the annular ring and a piston of radius "a" such that ka = 25.