Physics 8660, Fall 2008
Homework 5, 10/30/2008, due 11/24/2008

1 Acoustical wave guides

Density displacements $\psi(\vec{r},t)$ for a gas in a confined volume satisfy a wave equation of the form $\frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2}-\nabla^2\psi=0,\frac{\partial\psi}{\partial n}=0$, where c is the sound velocity and $\partial\psi/\partial n=\hat{n}\nabla\psi$ is the normal derivative at a boundary surface.

a) Evaluate the normal modes for a long rectangular wave guide with cross sectional dimensions a x b. Show that for most modes there is a minimum frequency for transmission. Compare the phase and group velocities.

a) Evaluate the normal modes for a long cylindrical wave guide with cross sectional radius R. Show that for most modes there is a minimum frequency for transmission. Compare the phase and group velocities.

2. Acoustic modes

Sound waves in a confined volume satisfy a wave equation of the form $\frac{1}{v^2}\frac{\partial^2\psi}{\partial t^2}-\nabla^2\psi=0,\frac{\partial\psi}{\partial n}=0$ where c is the sound velocity and $\partial\psi/\partial n=\hat{n}\nabla\psi$ is the normal derivative at a boundary surface. The normal modes take the form $\psi_i(\vec{r},t)=\psi_i(\vec{r})e^{-i\omega_i t}$, where the eigenfrequencies ωi may be degenerate, requiring additional indices to distinguish between degenerate modes.

a) Evaluate the normal modes and eigenfrequencies in a rectangular with dimensions a x b x c.

b) Evaluate the normal modes and eigenfrequencies for a sphere of radius R.

c) Evaluate the normal modes and eigenfrequencies for a cylinder of radius R and length L.