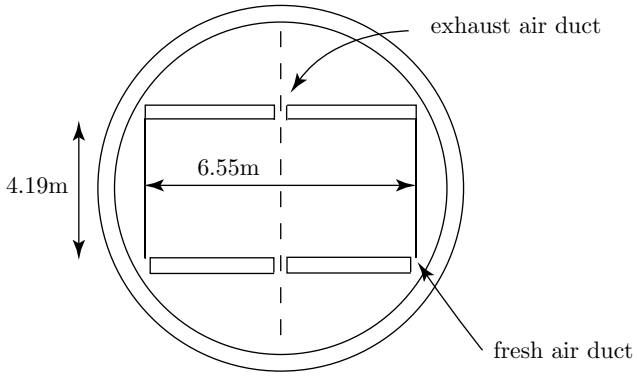
Problem Set No. 10

Note: Quiz 2 will be held on Tuesday, Dec. 9, from 2:30-4pm in Rm 32-124.
Reading assignment: Section 4.2 C, H, I ; J. A. Kong, "*Electromagnetic Wave Theory*," EMW Publishing, 2008.

Problem P10.1



Tunnel modeled as rectangular waveguide.

An AM(535-1605 kHz) radio in an automobile cannot receive any signal when the car is inside a tunnel. Consider, for example, the Lincoln Tunnel under the Hudson River, which was built in 1939. A cross-section of the tunnel as shown in the figure. Ignore the air ducts; assume they are closed. Model the tunnel as a rectangular waveguide of dimension $6.55m \times 4.19m$.

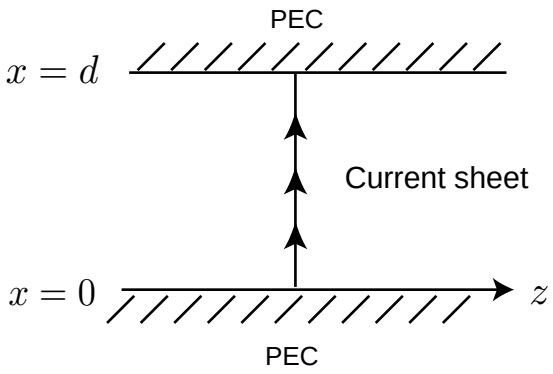
(a) Give the range of frequencies for which only the dominant mode, TE_{10} , may propagate.
(b) Explain why AM signals cannot received.
(c) Can FM(88-108 MHz) signals be received? Above what frequencies?

Problem P10.2

Consider the excitation of a parallel-plate waveguide by a current sheet with

$$\overline{J}_s = \hat{x} J_s \cos \frac{3\pi x}{d}$$

The plates are at $x = 0$ and $x = d$ and the propagation direction is $\hat{z}$. Find the amplitudes of the excited modes. (Hint: Only TM modes are excited in this case.)



Problem P10.3

A waveguide is often designed such that only the fundamental mode is able to propagate. The reason is that two different propagating modes travel with different velocities, which leads to the difficulty of receiving the clear signals at the other end of the waveguide. Consider a rectangular waveguide as shown in the figure, where $a = 2b = 3$ cm and the length $\ell = 300$ m. It is known that signals travel with their group velocity.

(a) If a signal is modulated at 6 GHz and travels from one end of this waveguide to the other end, how much time will it take?

(b) If a signal is modulated at 10.5 GHz, how many propagating modes can carry this signal? How much time will it take for each of these modes to reach the other end of the waveguide?