

**Acoustics Exercise 6.** To be returned on Friday 8.5.2009

- (1) A plane wave is reflected from a rigid wall at angle  $\theta$ . Calculate what really happens, i.e derive the equation for viscous and thermal boundary impedances for rigid walls that apply for the Helmholtz equation. (6 points)

$$\frac{1}{Z_{rigid}} = \left\{ \frac{1-i}{\rho c} \left[ (\gamma-1) \sqrt{\frac{\omega d_\kappa}{2c}} + \left(\frac{k_t c}{\omega}\right)^2 \sqrt{\frac{\omega d_\nu}{2c}} \right] \right\}$$

The proper boundary condition at the wall is temperature fluctuation is  $\tau = 0$ , velocity  $\mathbf{v} = \mathbf{0}$ , (a no slip and no movement of the wall in normal direction.  $k_t$  is the tangential vector of the plane wave wave vector.

- (2) Derive the value the velocity profile for the slit of previous exercise at higher frequencies. (6 points)
- (3) Here are two measurements of the impedance magnitude of an electrodynamical speaker as a function of frequency. The measurements are done in two closed back cavities, with a closed cavity of  $V_1 = 1000000mm^3$  and of  $V_2 = 2000000mm^3$  behind the speaker. Which curve is which? Figure 2 provides a close-up near the resonance.

Use the graph to calculate as many values as possible of the coil resistance  $R_e$ , coil inductance  $L_e$ , mass  $m_c$  of the speaker cone + coil system, and the force factor  $\phi$ .

The surface area of the speaker is  $S = 6000mm^2$  (6 points)

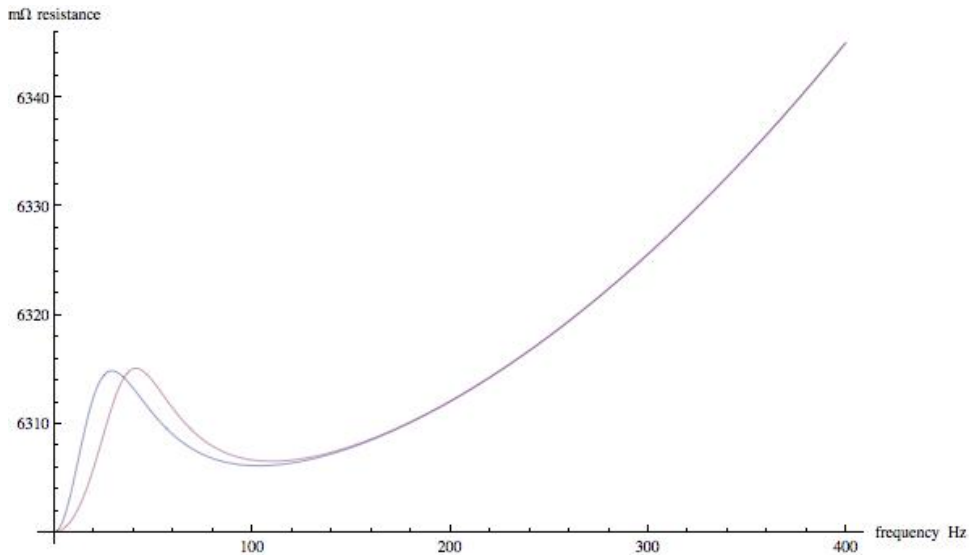


FIGURE 1. The absolute value of the electrical speaker impedance as a function of frequency

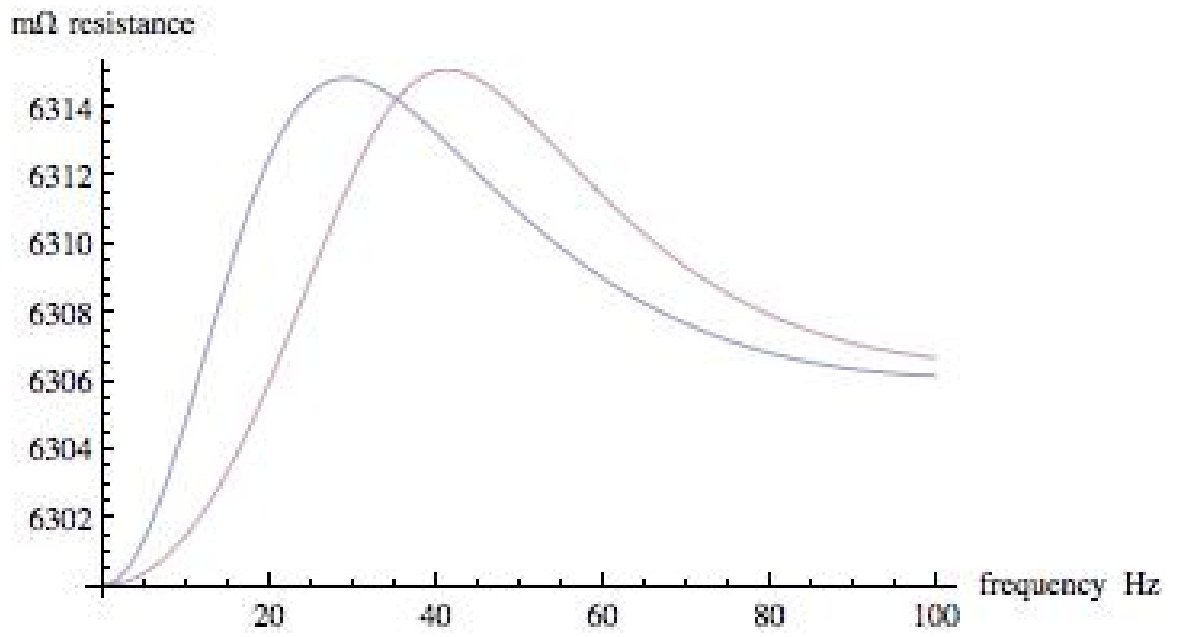


FIGURE 2. A close up

- (4) Derive the equation for the force  $F$  to a membrane at potential  $V_{pol}$  residing between two capacitor plates in potential  $V$ .