

## ME413/MW513/ME504ST/ME523/EE579 HW#3

### Acoustic Absorption

1. Acoustic absorption relaxation data for air is given in the following table

Temperature (°F)	Relative Humidity (%)	Relaxation Frequency Oxygen $f_{rO}$ (Hz)	$(\alpha\lambda)_{max}$ Oxygen Relaxation	Relaxation Frequency Nitrogen $f_{rN}$ (Hz)	$(\alpha\lambda)_{max}$ Nitrogen Relaxation
30	0	24	$6.76 \times 10^{-4}$	9.34	$1.49 \times 10^{-5}$
60	0	24	$9.72 \times 10^{-4}$	9.06	$2.72 \times 10^{-5}$
90	0	24	$1.33 \times 10^{-3}$	8.81	$4.63 \times 10^{-3}$
30	10	402	$6.76 \times 10^{-4}$	28.8	$1.49 \times 10^{-5}$
60	10	2518	$9.72 \times 10^{-4}$	58.2	$2.72 \times 10^{-5}$
90	10	11560	$1.33 \times 10^{-3}$	151.9	$4.63 \times 10^{-3}$
30	50	5003	$6.76 \times 10^{-4}$	81.8	$1.49 \times 10^{-5}$
60	50	25490	$9.72 \times 10^{-4}$	254	$2.72 \times 10^{-5}$
90	50	86510	$1.33 \times 10^{-3}$	724.4	$4.63 \times 10^{-3}$

The data were calculated from formulae contained in D.T. Blackstock, “*Fundamentals of Physical Acoustics*”, Wiley Interscience, 2000.

- a. Comment on the dependence of the relaxation frequencies and  $(\alpha\lambda)_{max}$  for the two relaxations.
  - b. Generate a plot of absorption in dB/m versus  $\log_{10}$  frequency for a temperature of 60 °F and three relative humidities  $h_r=0\%$ , 10% and 50%.
2. An acoustic plane wave propagates in air at a frequency of 100 Hz. How far will the wave propagate before the SPL has dropped 6dB? Repeat the calculations at 1000 Hz, 10 kHz, and 1000 kHz. You may assume that the temperature is 60 °F, and the relative humidity is  $h_r=50\%$ .
3. An acoustic spherical wave propagates in air at a frequency of 20 kHz. It is caused by a pulsating spherical source with radius 1 cm, and displacement amplitude 3  $\mu\text{m}$ .
- a. Compute the sound pressure amplitude at a distance of 20 m.
  - b. Relative to the SPL at a distance of 1m, what how many dB are lost through geometric spreading, and how many dB are lost to absorption at a distance of 20m?
4. In “*Fundamentals of Physical Acoustics*”, Wiley Interscience, 2000, it is claimed that the classical absorption coefficient for air can be computed with

$$\alpha = 1.84 \times 10^{-11} \sqrt{\frac{T_K}{299.15}} f^2,$$

where  $T_K$  is the temperature in Kelvin, and  $f$  is the frequency in Hz.

- a. Check the frequency coefficient of this expression at 20°C.
- b. What is the percent change in the frequency coefficient as the temperature changes from 5°C to 30°C?