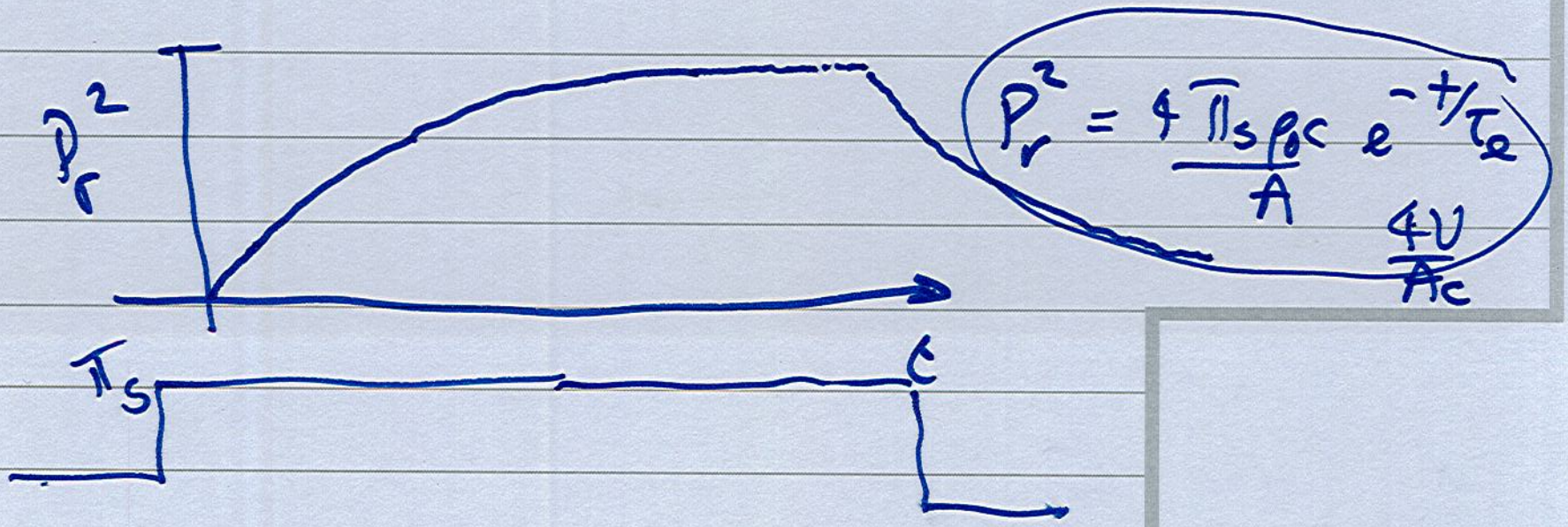
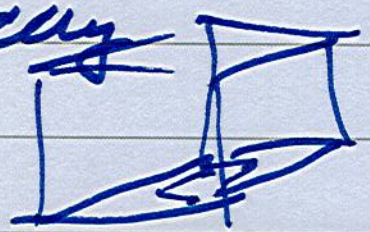
Room Acoustics

$$\Pi = V\frac{dE}{dt} + \frac{Ac}{4}E$$ ODE



$T = 0.161\frac{V}{A}$ 60 dB decay

$A = \bar{a}S$



- ignored air absorption

As a plane wave travels in a

$$P \propto P_0 e^{-\alpha x}$$

exponential decay with distance

$x = ct$ for a propagating wave

$$P_r^2(t) \simeq P_r^2(0)\, e^{-2\alpha ct}$$

exponential decay with time

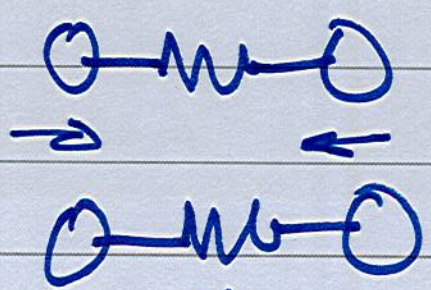
$$P_r^2(t) = P_r^2(0)\, e^{-\left[\frac{S_m A}{4V} + m\right]ct}$$

Rev Time $T = \dfrac{0.161\ V}{A + 4mV}$

m air absorption coefficient

- classical
  - viscous effects
  - Thermal effects
    - heat conductivity
- molecular abs

O_2



N_2

Air Absorption can control rev time at 4 kHz & above.

air absorption can generally be neglected at low frequencies (depending on propagation distance) - neglect in small spaces.

$$20\% \leq \text{relative humidity} \leq 70\%$$

$$1.5\ \text{kHz} \leq f \leq 10\ \text{kHz}$$

$$m \simeq 5.5 \times 10^{-4} \left(\frac{50}{h}\right)\left(\frac{f}{1000}\right)^{1.7}$$

h ← relative humidity

attenuation increases & approx as f^2

Res time formula
works in spaces with low
absorption

when absorption is high &
when spaces non-proportional

- Norris-Eyring
- Millington-Sette

6.5 Absorbing Materials

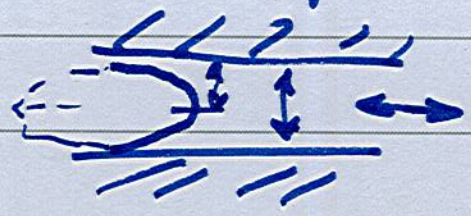
Acoustic environments can be controlled by adding or removing absorbing elements

4 major types of absorbing media

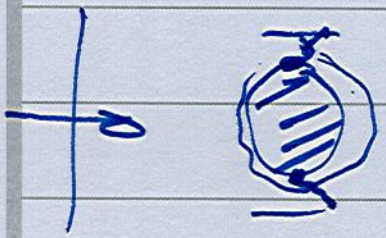
(i) Porous materials

- acoustic tiles, glass fiber, foams, curtains, carpets

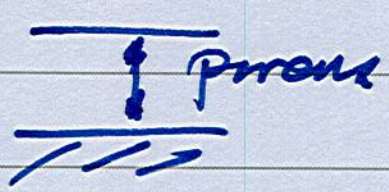
sound produces oscillatory flow in pores within the material



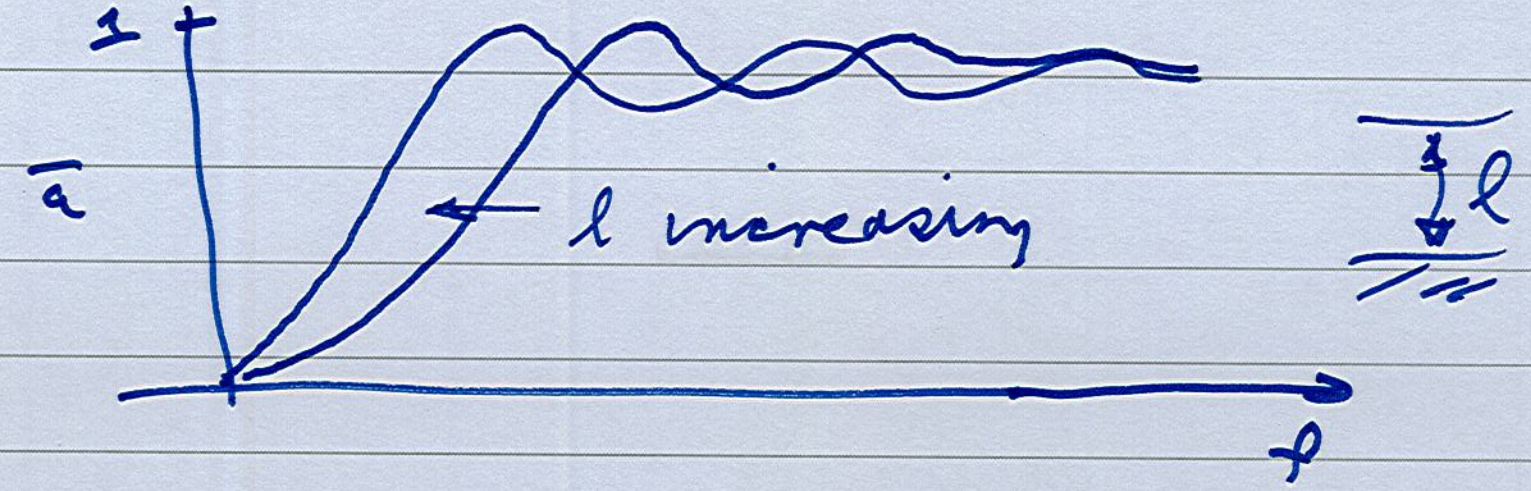
+ visco-thermal dissipation of energy



absorption - increases with depth & frequency



layer depth must be at least $\frac{1}{10}\lambda$ to be effective



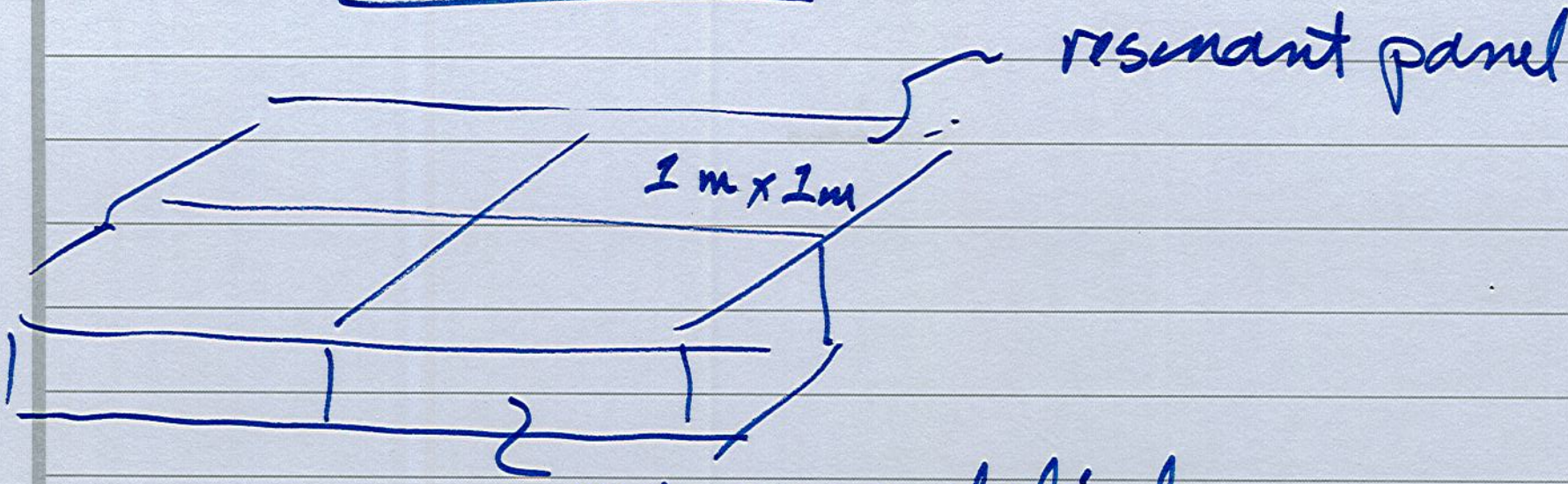
1" of glass fiber (25mm) absorbs well at 1 kHz & above

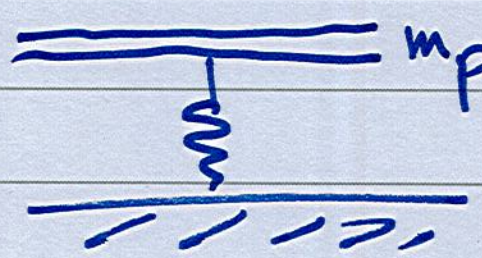
$\bar{a} \sim 0.5$ at 1kHz

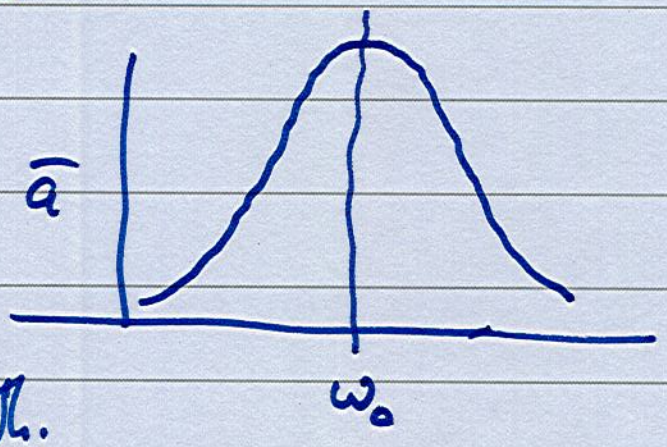
2" of glass fiber 500 Hz & above

4" " " 250 Hz and above.

(ii) Panel Absorber





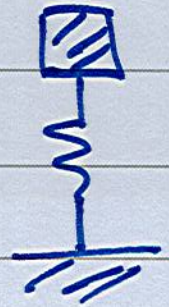


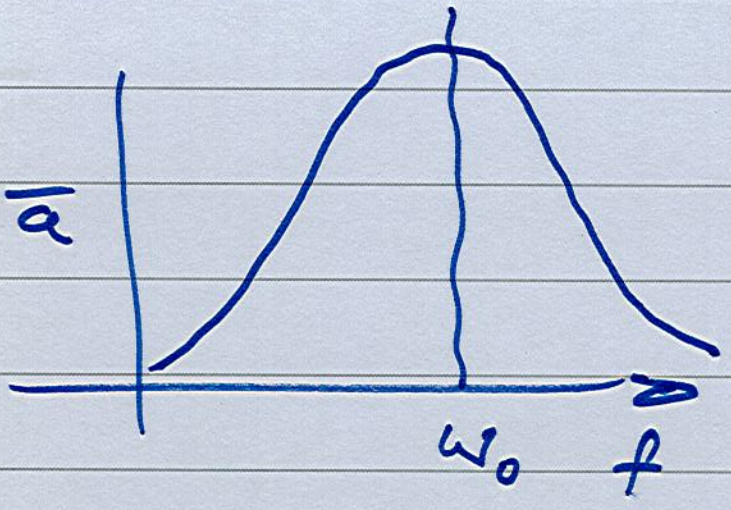
ω_0 is controlled by panel mass & air depth.

(iii) Cavity Absorbers (e.g., Helmholtz resonator)

build them into walls

tuned device





Array of differently sized resonator to cover a broad band