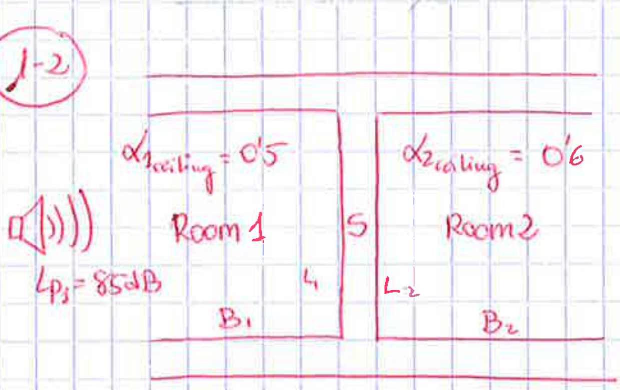
1-2



$S = 4 \times 2'5 \ m^2$

Room 1: $L_1 \times B_1 \times H_1 = 4 \times 5 \times 2'5 \ m^3$

Room 2: $L_2 \times B_2 \times H_2 = 4 \times 6 \times 2'5 \ m^3$

Walls made of dense concrete $\rightarrow R_w = 45$ dB

Flanking transmission neglected

All surfaces totally reflectant except ceilings

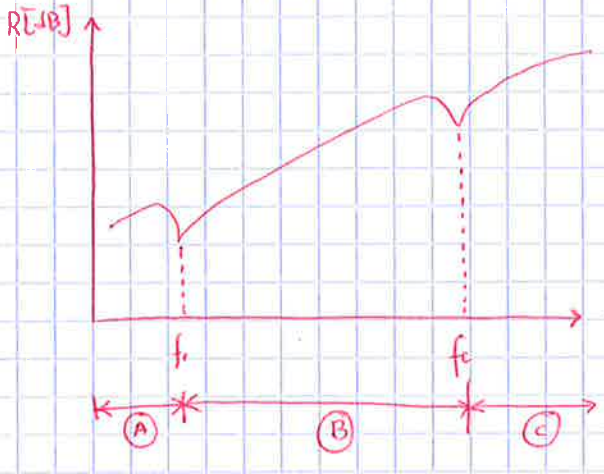
α, R_w = cte. (not totally realistic)

(a) $R = L_{sending} - L_{receiving} + 10\log\left(\frac{S}{A}\right) \Rightarrow$

$L_{receiving} = L_{sending} - R + 10\log\left(\frac{S}{A}\right) \Rightarrow$

$L_{receiving} = 85 - 45 + 10\log\left(\frac{(4\cdot 2'5)}{(4\cdot 6\cdot 0'6)}\right) \Rightarrow \boxed{L_{receiving} = 38'41 \text{ dB}}$

(b)



f_1 = frequency of resonance

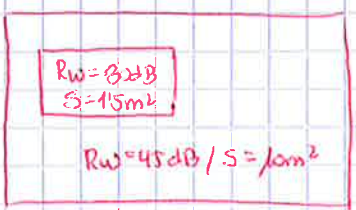
f_c = coincident frequency $\rightarrow$ very bad insulation

(A) Stiffness-controlled region

(B) Mass-controlled region

(C) Damping-controlled region

(c)



$R_{combined} = 10\log\left[\frac{1}{S_{tot}}\left(\sum_{i=1}^{n} S_i \cdot 10^{\frac{-R_i}{10}}\right)\right]$

Therefore, in our case we have

Solution: sealing, elastomer

$R_{combined} = -10\log\left[\frac{1}{10}\left(1'5\cdot 10^{\frac{-32}{10}} + 8'5\cdot 10^{\frac{-45}{10}}\right)\right] \Rightarrow \boxed{R_{combined} = 37'52 \text{ dB}}$

(d) $R_{leackages} = -10\log\left(10^{\frac{-R}{10}} + \frac{S_\ell}{S}\right) \Rightarrow (37'52 - 3) = -10\log\left(10^{\frac{-37'52}{10}} + \frac{S_\ell}{10}\right) \Rightarrow$

$\Rightarrow \frac{34'52}{-10} = \log\left(10^{-3'752} + \frac{S_\ell}{10}\right) \Rightarrow \left(10^{-3'452} - 10^{-3'752}\right)\cdot 10 = S_\ell \Rightarrow \boxed{S_\ell = 1'76\cdot 10^{-3} \ m^2}$

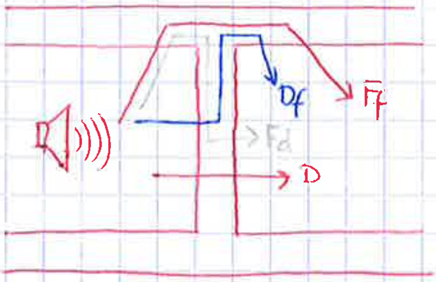
(e) $T_{60} = 0'16\cdot\frac{V}{A} = 0'16\cdot\frac{(4\cdot 6\cdot 2'5)}{(4\cdot 6\cdot 0'6)} \Rightarrow \boxed{T_{60} = 0'667 \text{ sec}}$

T_{60} is the time for the sound to decrease 60 dB from its initial value.

(f) $0'4 = 0'16\cdot\frac{(4\cdot 6\cdot 2'5)}{(4\cdot 6\cdot\alpha') + (2'5\cdot 6\cdot\alpha')} \Rightarrow (24\alpha' + 15\alpha') = \frac{(4\cdot 6\cdot 2'5)\ 0'16}{0'4} \Rightarrow$

$\Rightarrow 39\alpha' = 24 \Rightarrow \boxed{\alpha' = 0'615}$

③



$$R'_w = -10\log\left[10^{-\frac{R_{Dd,w}}{10}} + \sum_{F=f=1}^{n} 10^{-\frac{R_{Ff,w}}{10}} + \sum_{f=1}^{n} 10^{-\frac{R_{Df,w}}{10}} + \sum_{F=1}^{n} 10^{-\frac{R_{Fd,w}}{10}}\right]$$

with the approximation

$$(R_f)_{ij,w} = R_{ij,w} = \frac{R_{i,w} + R_{j,w}}{2} + K_{ij} + 10\log\left(\frac{S_s}{l_0 \cdot l_{ij}}\right)$$

In our case (neglecting ceiling and floor flanking transmission), we have

2 Df paths
2 Fd paths
2 Ff paths
1 D path

$\Rightarrow$ In total, we have 7 reduction indexes to take into account

⊛ We first calculate Df (blue in the figure)

$$R_{Df,w} = \frac{45+45}{2} + \underset{\text{table}}{6} + 10\log\left(\frac{10}{1 \cdot 2'5}\right) = 57'02 \text{ dB}$$

⊛ We now calculate the Ff path

$$R_{Ff,w} = \frac{45+45}{2} + 6 + 10\log\left(\frac{10}{1 \cdot 2'5}\right) = 57'02 \text{ dB}$$

Therefore, the total sound reduction index becomes:

$$R'_w = -10\log\left[10^{-\frac{45}{10}} + 6 \cdot 10^{-\frac{57'02}{10}}\right] = 43'61 \text{ dB}$$

Thus, we conclude that

$$R_w = L_{sending} - L_{receiving} + 10\log\left(\frac{S}{A}\right) \Rightarrow L_{receiving} = L_{sending} - R_w + 10\log\left(\frac{S}{A}\right) \Rightarrow$$

$$\Rightarrow L_{receiving} = 85 - 43'61 + 10\log\left(\frac{(4 \cdot 2'5)}{(4 \cdot 6 \cdot 0'6)}\right) \approx 40 \text{ dB}$$
$(39'80$ dB$)$

$$\boxed{L_{receiving} = 40 \text{dB}}$$

(4) (a) for two uncorrelated sources: $\tilde{p}_{tot}^2 = \tilde{p}_1^2 + \tilde{p}_2^2$

$$L_{p_{TOT}} = 10\log\left(\frac{\tilde{p}_{TOT}^2}{\tilde{p}_{ref}^2}\right) = 10\log\left(\left(\frac{\tilde{p}_1^2}{\tilde{p}_{ref}^2} + \frac{\tilde{p}_2^2}{\tilde{p}_{ref}^2}\right)\right) = 10\log\left(\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}}\right)\right) = 10\log\left(\sum_{i=1}^{2} 10^{\frac{L_{pi}}{10}}\right)$$

OK!

$$L_p = 10\log\left(\frac{\tilde{p}_i^2}{\tilde{p}_{ref}^2}\right) \Rightarrow \frac{L_{pi}}{10} = \log\left(\frac{\tilde{p}_i^2}{\tilde{p}_{ref}^2}\right) \Rightarrow \frac{\tilde{p}_i^2}{\tilde{p}_{ref}^2} = 10^{\frac{L_{pi}}{10}}$$

(b) $L_{eq,24h} = 10\log\left(\frac{1}{T}\int_0^T 10^{\frac{L_p}{10}} dt\right) = 10\log\left(\frac{1}{24}\left(10^6 \cdot 6 + 10^{6'5} \cdot 5 + 10^{5'8} \cdot 10 + 0\right)\right) = 60'17 \text{ dBA}$

Express also in dB and explain why A-weighting is used.

(c) $L_p = 20\log\left(\frac{\tilde{p}}{\tilde{p}_{ref}}\right) \Rightarrow L_p = 20\log\left(\frac{0}{\tilde{p}_{ref}}\right) = -\infty \longrightarrow$ impossible to achieve $L_p = -\infty$ $(p=0)$

(d) $L_p = 10\log\left(\frac{\left(\frac{55}{\sqrt{2}}\right)^2}{(2\cdot 10^{-5})^2}\right) = 125 \text{ dB}$

(5) (a) Insert $p(x,t)$ in $\frac{d^2p}{dx^2} - \frac{1}{c}\frac{d^2p}{dt^2} = 0$ and use $w = k/c$

(b) p-t plot of a cosine with amplitude 0'1 Pa and period $T = 1$ms

The sound pressure as a function of time measured by a microphone at $x=0$

(c) p-x plot of a cosine curve with amplitude 0'1 Pa and period $\lambda = c/f = cT = 0'34$m

The sound pressure as a function of location, that can be captured by a snapshot.

(d) $p_{eff} = \frac{0'1}{\sqrt{2}} = 0'0707$ Pa

(e) $L_p = 20\log\left(p_{eff}/p_{ref}\right) = 71$ dB

(6) $f = 340$ Hz $\longrightarrow \lambda = 1$m (the room length is an even number of λ in both directions)

The pressure is maximum at $n\cdot\frac{\lambda}{2}$ from the wall, i.e. 0, 0'5, 1, 1'5 and 2m. from the wall. The maximum sound reduction is where the particle velocity is maximal, i.e. at $\frac{\lambda}{4} + n\frac{\lambda}{2}$ from the wall; i.e. 0'25, 0'75, 1'25 and 1'75 from wall