Building Physics

LEVEL: **1 YEAR BACHELOR**

SPECIALTY: **COP**

COURS 05

ACOUSTICS (REVERBERATION)

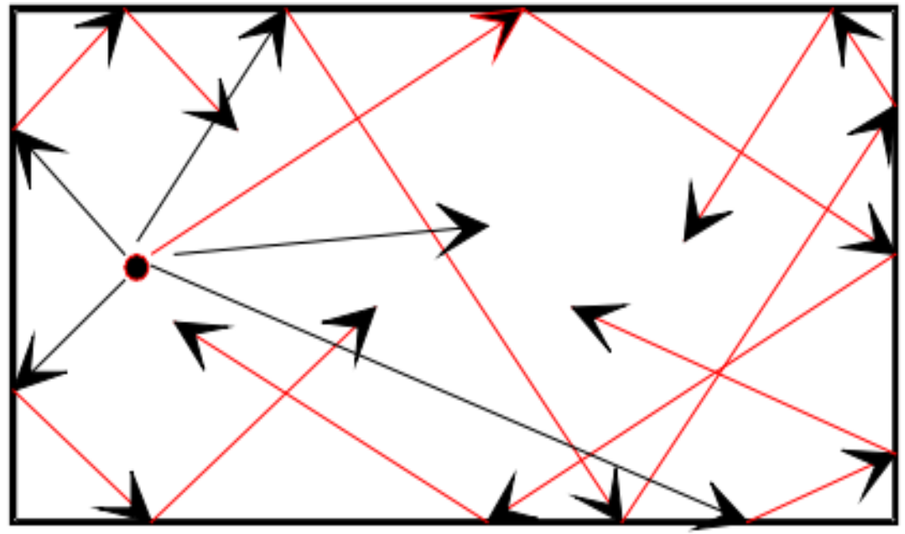
University of Biskra

2024-2025

Understanding Reverberation

Reverberation Time Tr or **T60** is **a key parameter** in **assessing a room's acoustic quality**, measured in seconds. **It can be likened to echo and resonance**, representing the lingering sound persistence in an **enclosed space**.

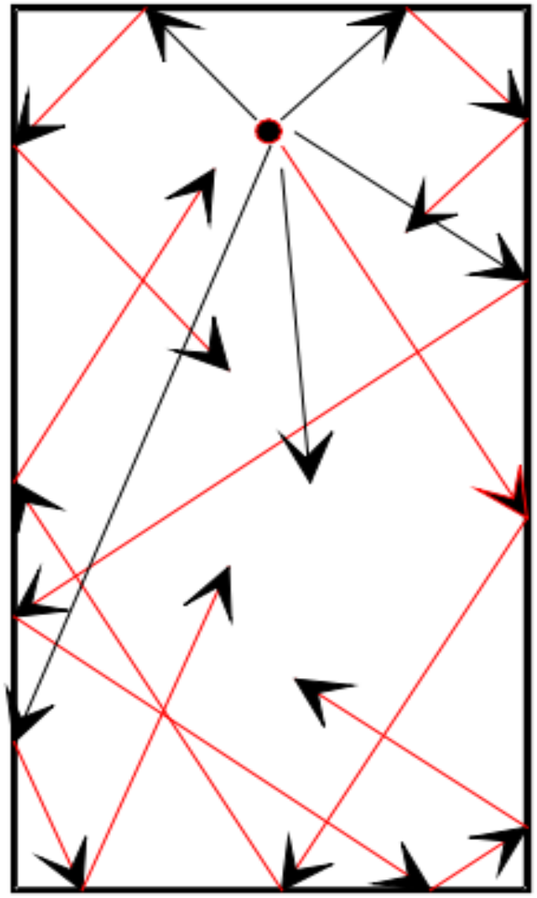
Excessive **Tr** leads to sound confusion as sounds overlap, while a very short Tr results in dry, muffled sounds. Each space requires an optimal **Tr**, depending on its intended use.



Note: there is a difference between echo and Reverberation

an **echo** is a distinct repetition of sound caused by a **single reflection off a surface** with a noticeable delay. **Reverberation**, on the other hand, is the persistence of sound in a space due to **multiple reflections off various surfaces**, creating a continuous decay of sound that contributes to **the overall ambiance of the room**.

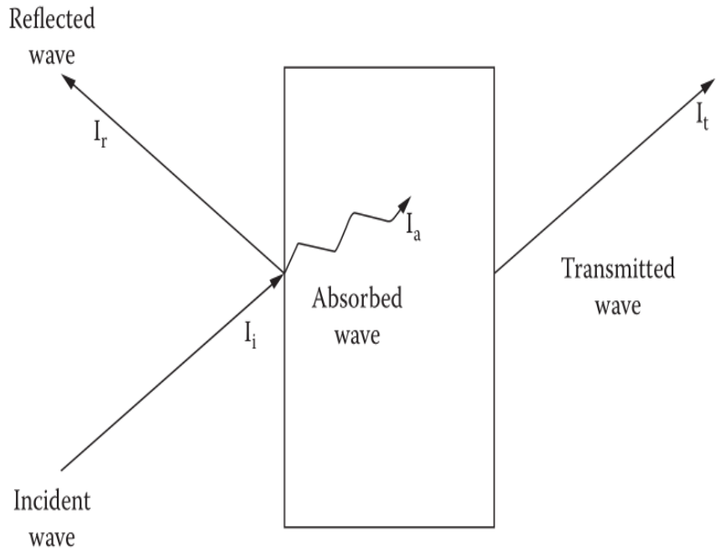
Reverberation

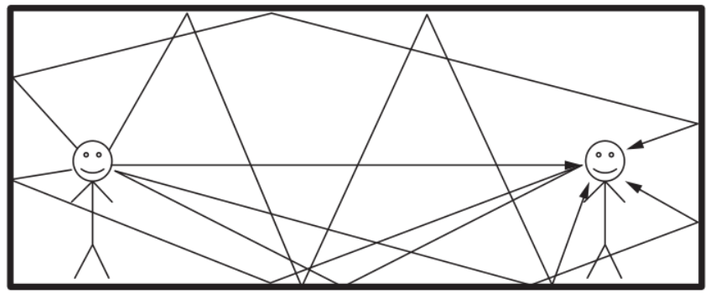


Éducation	Temps de réverbération Tr
Salle de classe	0,4 < Tr < 0,8 s.
Salle de restauration V > 250 m³	Tr <1,2 s.
Santé	
Salle de restauration V < 250 m³	Tr < 0,8 s.
Local d'hébergement et de soins	Tr < 0,8 s.
Salle de repos	Tr < 0,5 s.
Bureau	Tr < 0,8 s.
Bureau	
Bureau individuel	Tr < 0,7 s.
Bureau collectif	Tr < 0,6 s.
Espace ouvert V > 250 m³	0,6 < Tr < 0,8 s.
Restaurant V > 250 m³	Tr < 1 s.

Tableau 3-2 : Temps de réverbération selon la norme NF-S 31-080 (Bureaux).

The absorption coefficient α



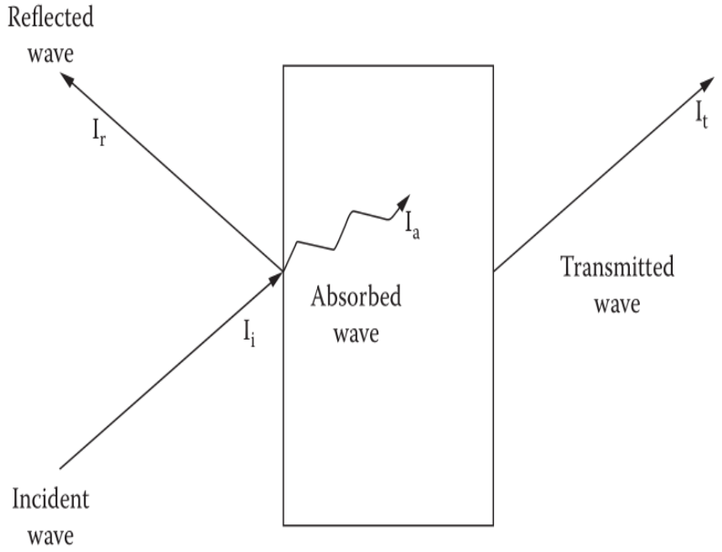


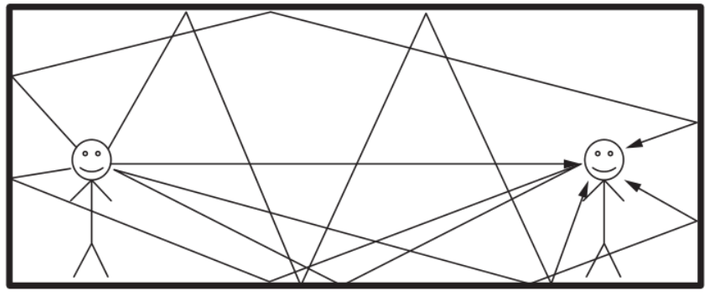
The absorption coefficient alpha is a **measure of the sound absorption capacity of a material**. It is defined as **the ratio of the absorbed sound power** to the incident sound power. **Materials with <u>high</u> alpha values <u>absorb more sound</u>** and reduce the level of noise

*Tableau 3- 1 : Exemple de valeurs **α** des matériaux pour une fréquence 1 000 Hz (Rapin, 2017).*

Matériau	α à l'octave 1 000 Hz
Béton peint	0,02
Plâtre	0,04
Rideau de coton	0,20
Tapis épais	0,40
5 cm de laine minérale dense	0,80

The Sabine formula:





The Sabine formula is a widely-used equation in acoustics to **calculate the reverberation time of a room**.

Reverberation time (Tr) refers to **the time it takes for sound** to decay by 60 decibels after the source of the **sound has stopped**.

The formula is expressed as:

$$\mathbf{Tr = 0.161 * (V/A)}$$

Where:
Tr is **the reverberation time in seconds** (s).
V is **the volume of the room** in cubic meters (m^3).
A is the **total equivalent absorption** area of the surfaces in the room in square meters

$$\mathbf{A = \alpha_1.S_1 + \alpha_2.S_2 + \cdots\cdots \alpha_n.S_n = \sum_{i=1}^{n} \alpha_i.S_i}$$

Exercice n°1:

For each room, calculate the reverberation time Tr using the Sabine formula:

Room	Dimensions (m)	Average Absorption Coefficient (α)
Room 1	8m x 8m x 2.7m	α1 = 0.04
Room 2	5m x 5m x 2.7m	α2 = 0.04
Room 3	15m x 12m x 3m	α3 = 0.06

Tr= 0.161 * (V/A)

Solution :

Metric	Room 1	Room 2	Room 3
Dimensions (m)	8 x 8 x 2.7	5 x 5 x 2.7	15 x 12 x 3
Volume (m^3)	172.8	67.5	540.0
Surface Area (m^2)	214.4	104.0	522.0
Coefficient of Absorption	0.04	0.04	0.06

$$A = \alpha_1.S_1 + \alpha_2.S_2 + \cdots\cdots\cdots \alpha_n.S_n = \sum_{i=1}^{n} \alpha_i.S_i$$

Exercice n°2:

The school cafeteria suffers from excessive noise due to **poor acoustic comfort**.

the details of the space:

- Dimensions: 20 m, 8 m, and 4 meters high.
- Surfaces: The floor area is 160 m², the ceiling area is 160 m², and the wall area is 224 m²
- Material properties: The floor is made of porcelain tile with **a phono-absorption coefficient (α) of 0.02.**
- The walls and ceiling are coated with plaster and paint, with **a coefficient (α) of 0.05.**

No consideration of windows or other highly reflective surfaces.

1. **Calculate the Time of Reverberation (Tr) using the Sabine formula**
2. **How would installing 90 m2 of sound-absorbing materials with an absorption coefficient of α = 0.8 on the ceiling and walls affect the reverberation time?**

Solution :

1.

A = (sol: 160 m2 * 0,02) + (plafond: 160 m2 * 0,05) + (murs: 224 m2 x 0,05) =22,4

V = 640 m3

Tr = 0,161 * (V/A)

Tr = 4,6 s

2.

A = 22.4 + (90 * 0.8) = 94.4 m2

Using the Sabine Formula again with the calculated equivalent absorption area A:

Tr = 0.161 * (640/94.4) = 1.09 seconds.

by installing the specified amount of sound-absorbing materials, the reverberation time in the cafeteria is significantly reduced, improving the acoustic environment and potentially enhancing the overall comfort for occupants.

Building Physics

LEVEL: **1 YEAR BACHELOR**

SPECIALTY: **COP**

Merci pour votre Attention