Sound pressure level

The sound pressure level is represented by a logarithmic scale and is expressed in decibels by the following relationship :

$$L_P = 10 \log \left(\frac{P}{P_0}\right)^2 \ (dB)$$

Lp : The sound pressure level in dB

P : The acoustic pressure of the wave in Pa

P_0: The reference acoustic pressure equal to 2.10^{-5} Pa

log: Decimal logarithm

Remarque :

Puisque la pression acoustique pour l'oreille humaine varie de 2.10^{-5} Pa à 20Pa, on trouve :

► Le niveau de pression acoustique du seuil d'audibilité est :

$$L_P = 10 \log \left(\frac{P}{P_0}\right)^2$$

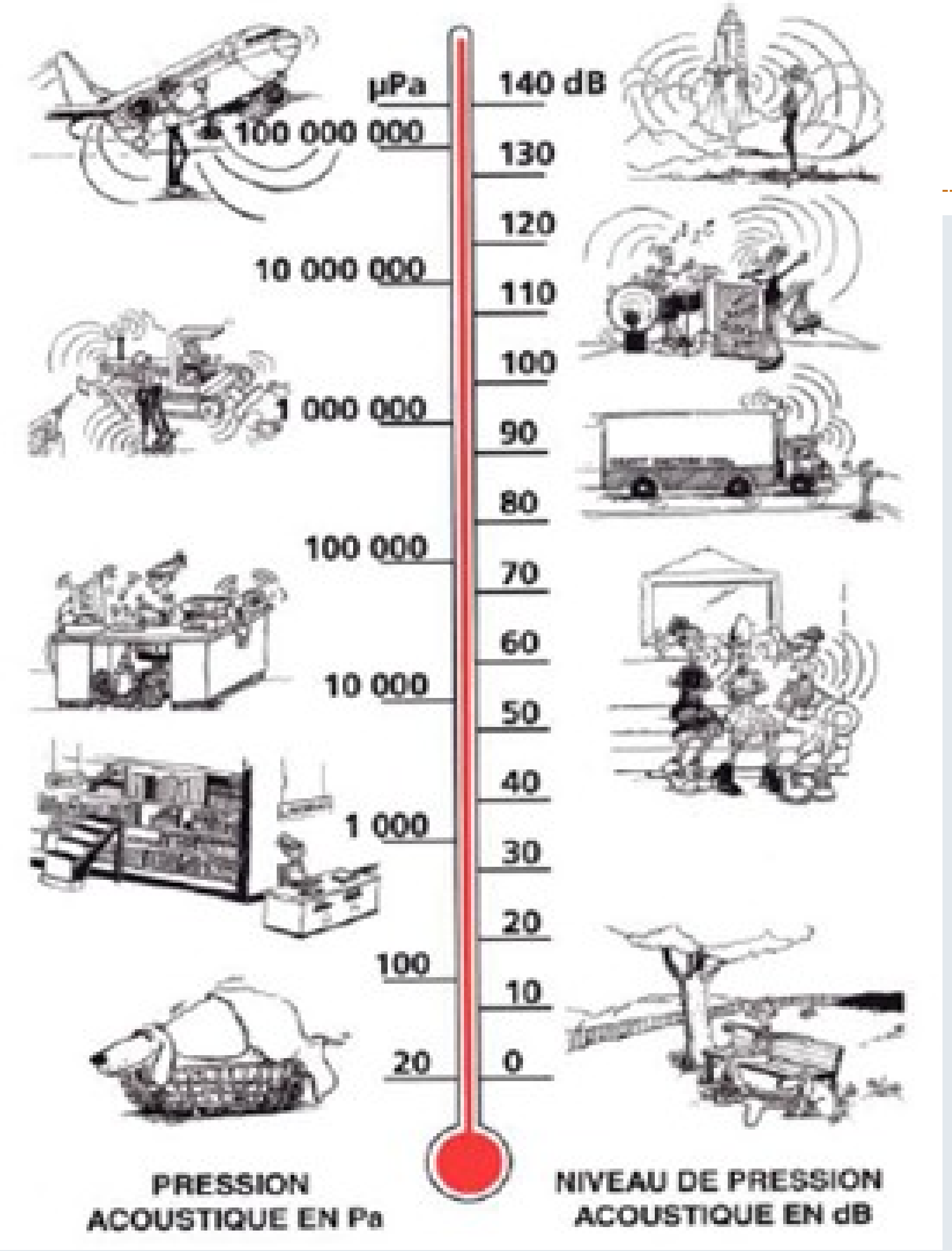
$$= 20\log\frac{2.10^{-5}}{2.10^{-5}} = 0 \text{ dB}$$

► Le niveau de pression acoustique correspond au seuil de douleur est :

$$L_P = 10 \log \left(\frac{P}{P_0}\right)^2$$

$$= 20\log\frac{20}{2.10^{-5}} = 120 \text{ dB}$$

La figure suivante donne les niveaux de pression acoustique L_P correspondant aux différentes sources :


µPa
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
20
140 dB
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PRESSION ACOUSTIQUE EN Pa
NIVEAU DE PRESSION ACOUSTIQUE EN dB

ACOUSTIC POWER LEVEL

The sound power level is represented by a logarithmic scale and is expressed in decibels by the following relationship :

$$L_w = 10 \log \left(\frac{w}{w_0}\right) \ (\text{dB})$$

Lw : The acoustic power level in dB

w : The acoustic power of the wave in w

w_0: The reference acoustic power equal to 10^{-12} w

log: Decimal logarithm

ACOUSTIC INTENSITY LEVEL

The level of acoustic intensity is represented by a logarithmic scale and is expressed in decibels by the following relationship:

$$L_I = 10 \log \left(\frac{I}{I_0}\right) \text{ (dB)}$$

LI: Sound intensity level in dB
I: Sound intensity of the sound wave in W/m^2
I_0: Reference sound intensity equal to 10^{-12} W/m^2
log: Decimal logarithm

ADDITION OF SOUND LEVELS

Two equal sound levels

Let LP1 and LP2 be the sound pressure levels of two sound sources such that LP1 = LP2. The total sound pressure level LPtotal = LP1 + LP2 is determined as follows:

$$L_{P1} = 10 \log \left(\frac{P_1}{P_0}\right)^2$$

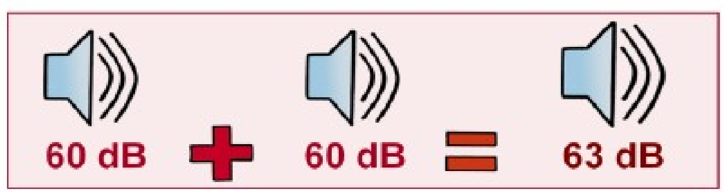
$$L_{P1} = 10 \log \left(\frac{(P_1)^2}{(P_0)^2}\right)$$

$$L_{Ptotal} = 10 \log \left(\frac{P_1{}^2 + P_1{}^2}{P_0{}^2}\right)$$

$$L_{Ptotal} = 10 \log \left(\frac{2P_1{}^2}{P_0{}^2}\right)$$

$$L_{Ptotal} = 10 \log 2 + 10 \log \left(\frac{P_1{}^2}{P_0{}^2}\right)$$

$$L_{Ptotal} = 3 + L_{P1}$$



Several sources of the same acoustic level

In the case of n sound sources with the same acoustic level, the increase in the considered level is:

$$\Delta L = 10 \log n$$

n: nombre de sources

Two different sound levels

Let LP1 and LP2 be the sound pressure levels of two sound sources such that LP1 > LP2.
The total sound pressure level LPtotal = LP1 + LP2 is determined as follows:

$$L_{Ptotal} = L_{P1} + K(dB)$$

K(dB): Determined according to the following table as a function of $\Delta L = L_{P1} - L_{P2}$

ΔL(dB)	0	0,5	1	1,5	2	3	4	5	6	7	8	9	10	12	15	20
K(dB)	3	2,8	2,5	2,3	2,1	1,8	1,5	1,2	1	0,8	0,6	0,5	0,4	0,3	0,1	0,04

Several sound sources of different acoustic levels

In the case of several sound sources with different acoustic levels, the resulting total pressure level is obtained using the following relationship:

$$L_{Ptotal} = 10 \log \left[\sum_{i=1}^{n} 10^{\frac{Li}{10}} \right] \text{ (dB)}$$

EQUIVALENT CONTINUOUS ACOUSTIC LEVEL L_{eq}

Exposure to a loud sound for 3 hours is more bothersome than exposure to the same sound for one hour; therefore, the equivalent continuous sound level Léq is defined, which takes the time factor into account and is calculated using the formula:

$$L_{éq} = 10\log\left[\frac{\int_0^T 10^{\frac{LT}{10}}\,dt}{T}\right] \quad (dB)$$

Example :

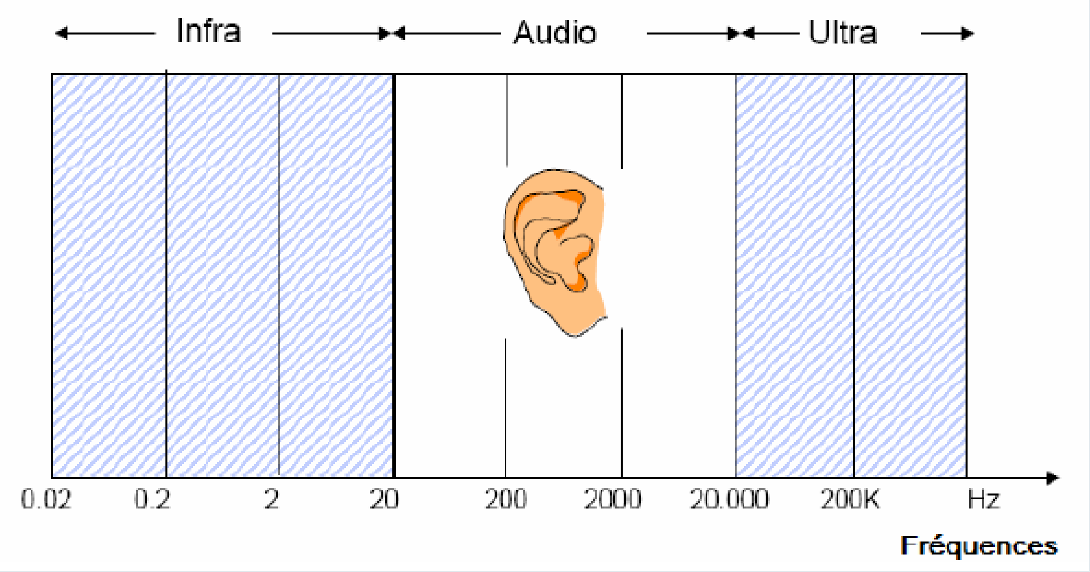
Consider a workshop operating for 2 hours at 90 dB (at 1000 Hz) and 7 hours at 70 dB (at 1000 Hz). Determine the equivalent continuous sound level $L_{éq}$

$$L_{éq} = 10\log\left[\frac{10^{\frac{90}{10}}.2 + 10^{\frac{70}{10}}.7}{2+7}\right] = 83{,}6\ \text{dB}$$

SOUND PARAMETERS

Frequencies audible to humans

Human audible frequencies range from 20 to 20,000 Hz. These figures can vary depending on age and individual.



The noise in the building

Noise is a mixture of several different sounds; it presents an unpleasant and bothersome sensation. Sound doesn't necessarily have to be loud to be bothersome (a dripping tap, for example).

Airborne noise

This refers to the noise produced by a sound source whose energy is transmitted to the surrounding air.
We distinguish between:
- Indoor airborne noise, generated by conversations, television, radio, etc.
- Outdoor airborne noise, generated by road traffic, sirens, airplanes, etc.

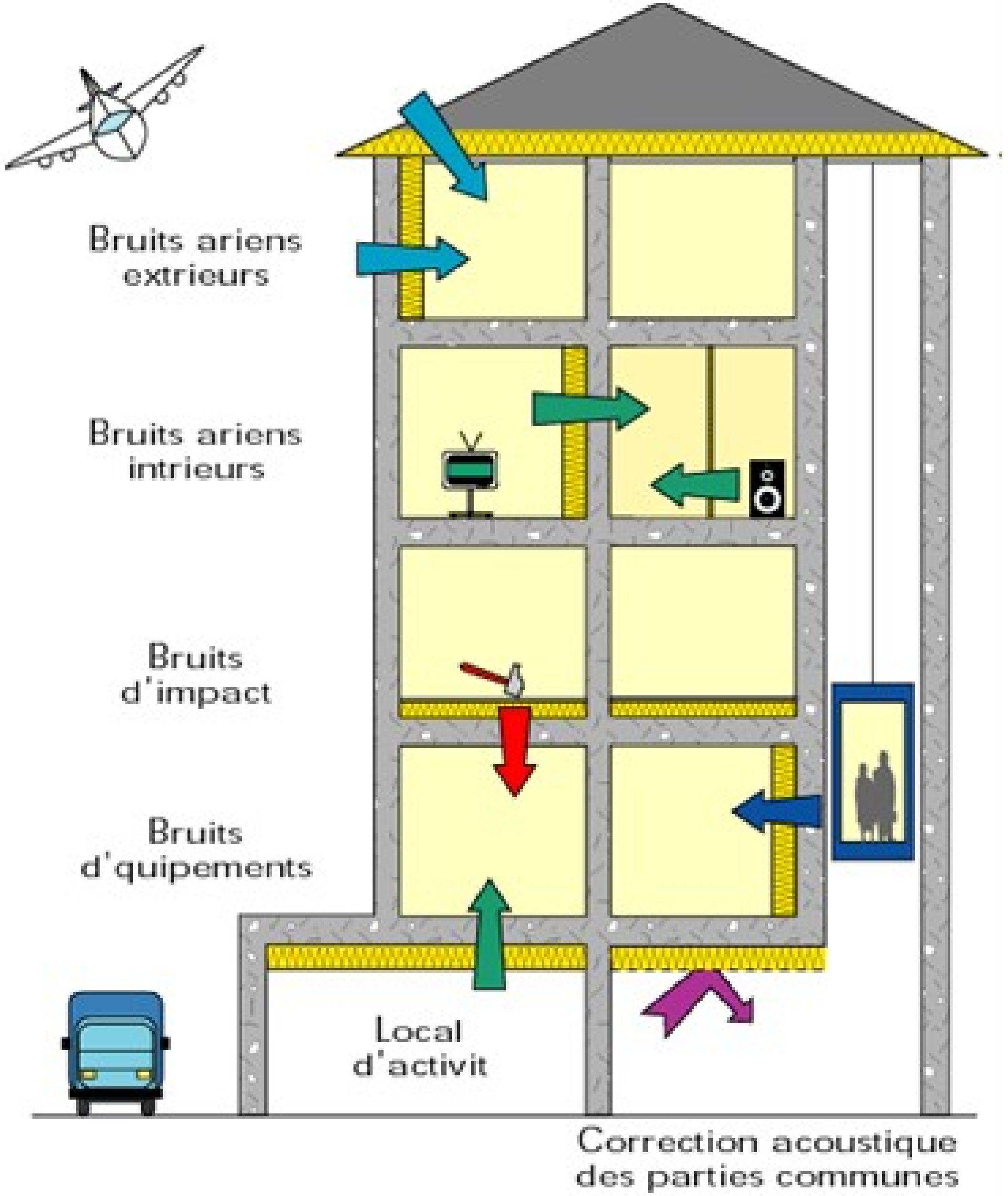
Structure-borne noise

This is a noise whose vibrations are created within solids.

We distinguish between:

- Equipment noise created by elevators, plumbing fixtures, etc.

- Collision or impact noise created by the movement of people, furniture, or falling objects.


Bruits ariens
extrieurs
Bruits ariens
intrieurs
Bruits
d'impact
Bruits
d'quipements
Local
d'activit
Correction acoustique
des parties communes

OCTAVE, OCTAVE BAND AND THIRD OF AN OCTAVE

Octaves

Since the frequencies audible to humans represent a very large range from 20 Hz to 20,000 Hz, these frequencies have been divided into intervals called octaves.
An octave is a frequency band centered at the frequency f, with a minimum frequency of f1 and a maximum frequency of f2, such that:

$$f_1 = \frac{f}{\sqrt{2}}$$

$$f_2 = f\sqrt{2}$$

Octave bands

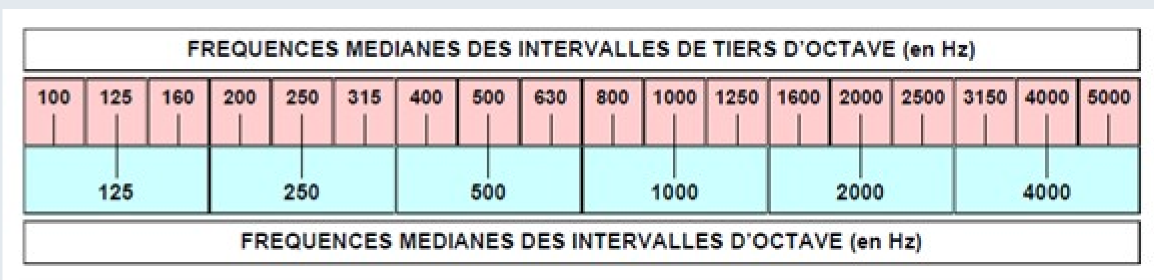
The octave bands used in buildings are: 125, 250, 500, 1000, 2000 and 4000Hz.

Fréquence f	Fréquences extrêmes		Nature du son
	f_1	f_2	
125 Hz	88	176	Grave
250 Hz	176	354	
500 Hz	354	707	Médium
1000 Hz	707	1414	
2000 Hz	1414	2828	Aigu
4000Hz	2828	5657	

Third of an octave

Le tiers d'octave consiste à diviser l'octave en trois intervalles tels que :

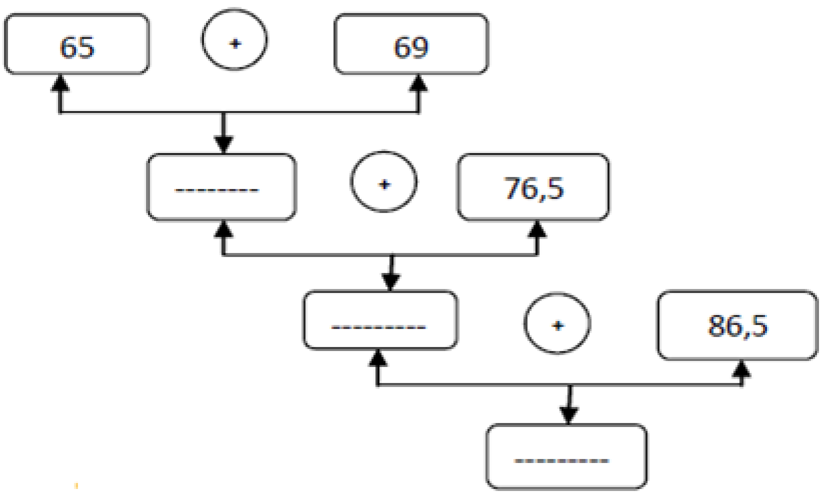
$$\frac{f_2}{f_1} = 2^{\frac{1}{3}}$$



Exercice 1 :

Un local est soumis à quatre bruits dont les niveaux sonores sont 65dB ; 69dB ; 76,5dB ; et 86,5dB.

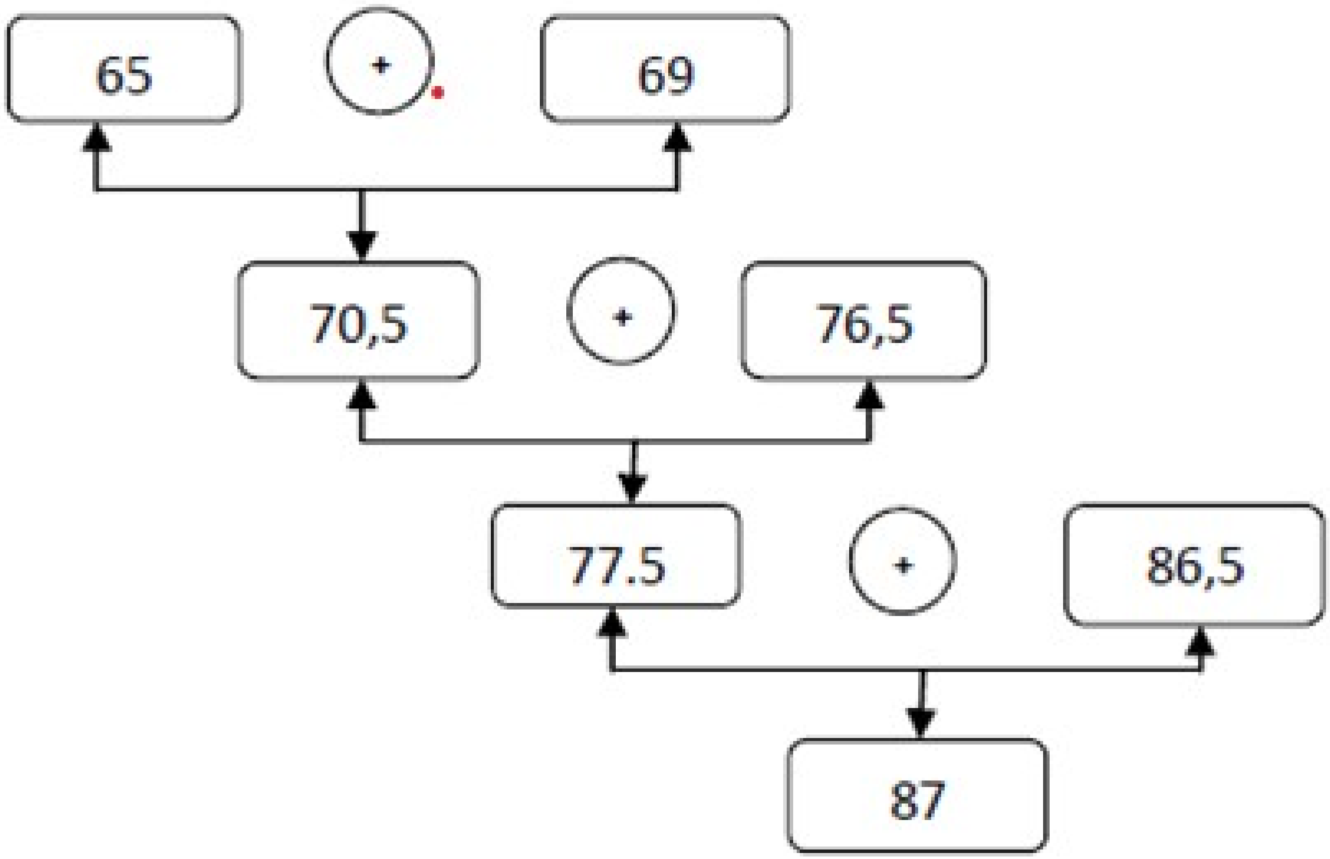
Compléter le diagramme suivant pour déterminer le niveau sonore total résultant des niveaux sonores (calcul théorique en utilisant le tableau ci-dessous).



Addition des niveaux sonores :

Différence DL entre les deux niveaux sonores	0	1	2	3	4	5	6	7	8	9	10
Valeur n en dB à ajouter au niveau le plus fort	3	2.6	2.1	1.8	1.5	1.2	1	0.8	0.6	0.5	0.4

Le niveau sonore total résultant en utilisant le tableau :



Exercice 2 :

Soit un bruit dont le spectre un tiers d'octave est le suivant :

f (Hz)	100	125	157	200	250	315	400	500	630
L_p (dB)	70	65	67	75	60	70	72	72	72
f (Hz)	800	1000	1250	1600	2000	2500	3150	4000	5000
L_p (dB)	77	75	70	65	62	57	55	55	50

1- Donner le spectre du bruit par bande d'octave

2- Calculer le niveau de pression total du bruit

3- Calculer le niveau de pression total pondéré en dB(A)

1- Le spectre du bruit par bande d'octave est déterminé par la formule suivante :

$$L_P = 10\log\left(10^{\frac{LP_1}{10}} + 10^{\frac{LP_2}{10}} + 10^{\frac{LP_3}{10}}\right)$$

f (Hz)	125	250	500	1000	2000	4000
L_p (dB)	72,6	76,3	76,8	79,6	67,2	58,6

2- Le niveau de pression total du bruit : Lp_{total} = 83,1 dB

Exercice 3 :

Un signal sonore relevé à 10 m d'une machine possède une période $T = 4.10^{-3}$ s

1- Déterminer la fréquence de ce signal

2- Sur le chantier sans aucun obstacle, à 10 m de la source, l'intensité acoustique du signal est de 5.10^{-4} W/m². Calculer le niveau sonore produit par la machine à cette distance.

3- Calculer la puissance acoustique de la source puis déduire le niveau sonore à 20 m de celle-ci.

Calcul de la fréquence

$f = 1/T = 1 /4\ 10^{-3} = 250$ Hz

$I = 5\ 10^{-4}$ w/m^2

Calcul du niveau d'intensité acoustique à 10m

$L_I = 10 \log (I/I_0) = 10 \log (5\ 10^{-4} / 10^{-12}) = 10 \log (5\ 10^{8}) = 86.98$ dB $= 87$ dB

$I = P/S = P/ 4\pi r^2$

Calcul de la puissance

$P = I\ 4\pi r^2 = 5\ 10^{-4}\ 4\ \pi\ 10^2$

$P = 0.628$ w

Calcul de l'intensité à 20m

$I_2 = P/S_2 = P/ 4\pi r_2^2$

$I_2 = 0.628 /4 \pi \ 20^2$

$I_2 = 1.24 \ 10^{-4} \quad w/m^2$

Calcul du niveau d'intensité acoustique à 20m

$L_{I2} = 10 \log (I_2/I_0) = 10\log (1.24 \ 10^{-4} \ /10^{-12}) = 81 \text{ dB}$