



Relationship of acoustic quantities associated with a plane progressive acoustic soundwave

Deutsch: Zusammenhang der akustischen Größen <http://www.sengpielaudio.com/ZusammenhangDerAkustischenGroessen.pdf>

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Acoustic quantities	ξ	v	a	p	I	E	P_{ac}
Particle displacement ξ	-	$\frac{v}{\omega}$	$\frac{a}{\omega^2}$	$\frac{p}{\omega \cdot Z}$	$\frac{1}{\omega} \sqrt{\frac{I}{Z}}$	$\frac{1}{\omega} \sqrt{\frac{E}{\rho}}$	$\frac{1}{\omega} \sqrt{\frac{P_{ac}}{Z \cdot A}}$
Particle velocity v	$\xi \cdot \omega$	-	$\frac{a}{\omega}$	$\frac{p}{Z}$	$\sqrt{\frac{I}{Z}}$	$\sqrt{\frac{E}{\rho}}$	$\sqrt{\frac{P_{ac}}{Z \cdot A}}$
Particle acceleration a	$\xi \cdot \omega^2$	$v \cdot \omega$	-	$\frac{p \cdot \omega}{Z}$	$\omega \sqrt{\frac{I}{Z}}$	$\omega \sqrt{\frac{E}{\rho}}$	$\omega \sqrt{\frac{P_{ac}}{Z \cdot A}}$
Sound pressure p	$\xi \cdot \omega \cdot Z$	$v \cdot Z$	$\frac{a \cdot Z}{\omega}$	-	$\sqrt{I \cdot Z}$	$c \sqrt{\rho \cdot E}$	$\sqrt{\frac{P_{ac} \cdot Z}{A}}$
Sound intensity I $= P_{ac} / A = p \cdot v$	$\xi^2 \cdot \omega^2 \cdot Z$	$v^2 \cdot Z$	$\frac{a^2 \cdot Z}{\omega^2}$	$\frac{p^2}{Z}$	-	$E \cdot c$	$\frac{P_{ac}}{A}$
Sound energy density E or w	$\xi^2 \cdot \omega^2 \cdot \rho$	$v^2 \cdot \rho$	$\frac{a^2 \cdot \rho}{\omega^2}$	$\frac{p^2}{Z \cdot c}$	$\frac{I}{c}$	-	$\frac{P_{ac}}{c \cdot A}$
Sound power P_{ac} $= I \cdot A$	$\xi^2 \cdot \omega^2 \cdot Z \cdot A$	$v^2 \cdot Z \cdot A$	$\frac{a^2 \cdot Z \cdot A}{\omega^2}$	$\frac{p^2 \cdot A}{Z}$	$I \cdot A$	$E \cdot c \cdot A$	-

White = linear sound field size and gray = squared sound energy size. **J = sound intensity**

Specific acoustic impedance $Z = \rho \cdot c = \frac{p}{v} = \frac{I}{v^2} = \frac{p^2}{I}$ in $\frac{N \cdot s}{m^3}$

Density of air ρ in $\frac{kg}{m^3}$ is 1.204 kg/m³ at 20°C

Angular frequency $\omega = 2 \cdot \pi \cdot f$

Frequency f in Hz = $\frac{1}{s}$ in air of 20°C: $Z = 413 \frac{N \cdot s}{m^3}$

Area through a unit area normal to the direction A in m²

Displacement of air particles (excursion amplitude) ξ in m

Particle velocity (velocity amplitude) $v = s/t$ in $\frac{m}{s}$

Particle acceleration $a = F/m$ in $\frac{m}{s^2}$

Sound pressure (excess pressure) $p = \frac{F}{A}$ in $\frac{N}{m^2} = Pa$

Sound intensity I or $J = p \cdot v = \frac{P_{ac}}{A}$ in $\frac{W}{m^2}$

Sound energy density E or $w = \frac{I}{c}$ in $\frac{W \cdot s}{m^3}$

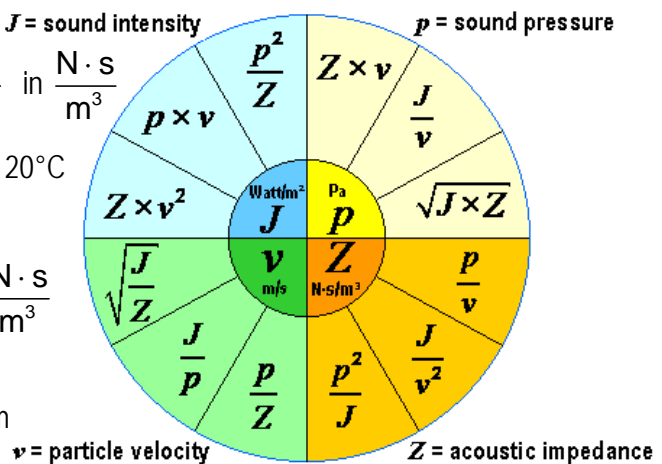
Here is 1 Joule $J = W \cdot s = N \cdot m$

Sound power $P_{ac} = I \cdot A$ in W

Speed of sound c in m/s (at 20°C is $c = 343$ m/s)

Because $1 W \times s = 1 N \times m$, the sound energy density is $1 W \times s / m^3 \equiv 1 N \cdot m / m^3 = 1 N / m^2$ and that is the unit of a sound pressure in pascals!

To remember: $W \times s = N \times m = J$ (joule).



To the comparison:

