Relationship of acoustic quantities associated with a plane progressive acoustic sound wave

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

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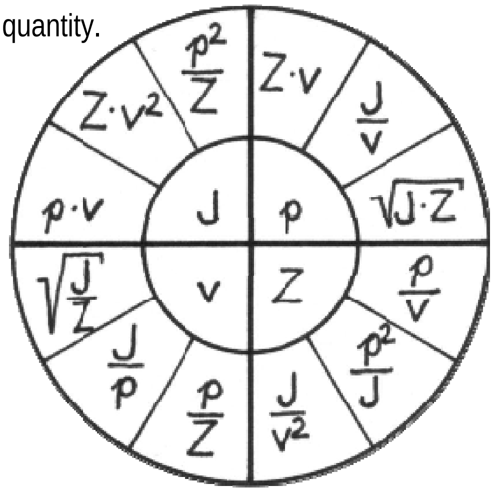
Sound quantities	ξ	v	a	p	I	E	P_{ac}
Particle displacement ξ	–	$\frac{v}{\omega}$	$\frac{a}{\omega^2}$	$\frac{p}{\omega \cdot Z}$	$\frac{1}{\omega}\sqrt{\frac{I}{Z}}$	$\frac{1}{\omega}\sqrt{\frac{E}{\rho}}$	$\frac{1}{\omega}\sqrt{\frac{P_{ac}}{Z \cdot A}}$
Particle velocity v	$\xi \cdot \omega$	–	$\frac{a}{\omega}$	$\frac{p}{Z}$	$\sqrt{\frac{I}{Z}}$	$\sqrt{\frac{E}{\rho}}$	$\sqrt{\frac{P_{ac}}{Z \cdot A}}$
Particle accelera-tion 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 quantity and gray = squared sound energy quantity.



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

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

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

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

Area through a unit area normal to the direction A in $\mathrm{m^2}$

Displacement of air particles (excursion amplitude) ξ in m

Particle velocity (velocity amplitude) v in $\frac{\mathrm{m}}{\mathrm{s}}$

Particle acceleration a in $\frac{\mathrm{m}}{\mathrm{s^2}}$

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

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

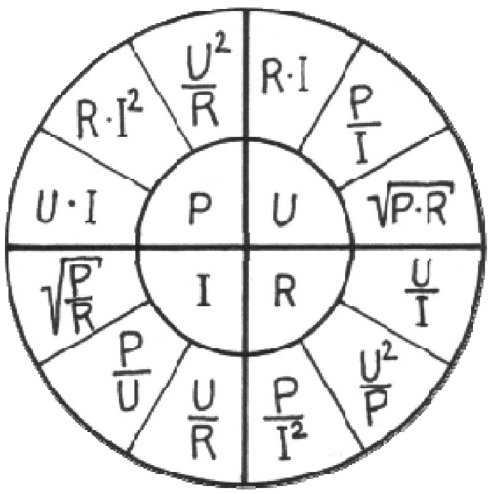
Sound energy density E or $w = \frac{I}{c}$ in $\frac{\mathrm{W \cdot s}}{\mathrm{m^3}}$

Here is 1 Joule J = W · s = N · 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)

To the comparison: U means here V



Because 1 W · s = 1 N · m, the sound energy density is 1 W · s / m³ ≡ 1 N·m / m³ = 1 N / m² and that is the unit of a sound pressure in pascals! To remember: W · s = N · m = J (joule).