For a progressive plane wave the RMS value of the sound pressure $p = 0.05 \text{ N/m}^2$ or 0.05 Pa is found.

$$Z_0 = \frac{p}{v} = \rho \times c$$

a) What is the particle velocity $v$? The acoustic impedance $Z_0 = p / v = \rho \times c = 413 \text{ N} \cdot \text{s/m}^3$.

$$v = \frac{p}{Z_0}$$

$$v = 0.05 \text{ N/m}^2 / 413 \text{ N} \cdot \text{s/m}^3 = 1.21 \times 10^{-4} \text{ m/s} = 0.121 \text{ mm/s}$$

b) What is the particle displacement $\xi$ for the frequencies $f = 100 \text{ Hz}$ and $f = 1000 \text{ Hz}$?

$$\xi = \frac{v}{\omega} = \frac{v}{2\pi \times f}$$

This maximum displacement of the air particles is often expressed by amplitude.

$$\xi$$ at 100 Hz = $1.21 \times 10^{-4}/(6.283 \times 100) = 1.926 \times 10^{-7} = 0.1926 \mu\text{m}$$

$$\xi$$ at 1000 Hz = $1.21 \times 10^{-4}/(6.283 \times 1000) = 1.926 \times 10^{-8} = 0.01926 \mu\text{m}$$

c) What is the sound intensity $I$?

$$I = p \cdot v \quad \text{W} = \text{N} \cdot \text{m} / \text{s}$$

$$I = 0.05 \text{ N/m}^2 \times 1.21 \times 10^{-4} \text{ m/s} = 0.00000605 \text{ N} \cdot \text{m/m}^2 \cdot \text{s} = 6.05 \times 10^{-6} \text{ W/m}^2$$

d) What is the sound power $P$, passing through an area of $A = 4 \text{ m}$?

$$P = \int I \, dA$$

$$P = I \times A = 6.05 \times 10^{-6} \text{ W/m}^2 \times 4 \text{ m}^2 = 0.00000242 \text{ W} = 24.2 \times 10^{-6} \text{ W}$$

e) What is the sound pressure level $L_p$?

$$L_p = 20 \times \log \left( \frac{P}{P_0} \right) \text{ in dB}$$

$$L_p = 20 \times \log \left( 5 \times 10^{-2} / 2 \times 10^{-5} \right) \text{ dB} = 67.96 \text{ dB}$$

f) What is the sound intensity level $L_I$?

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

$$L_I = 10 \times \log \left( 6.05 \times 10^{-6} \text{ W/m}^2 / 1 \times 10^{-12} \text{ W/m}^2 \right) \text{ dB} = 67.82 \text{ dB}$$

g) What is the sound power level $L_W$ for above calculated sound power?

$$L_W = 10 \times \log \left( \frac{P}{P_0} \right) \text{ in dB}$$

$$L_W = 10 \times \log \left( 24.2 \times 10^{-6} \text{ W} / 1 \times 10^{-12} \text{ W} \right) \text{ dB} = 73.84 \text{ dB}$$