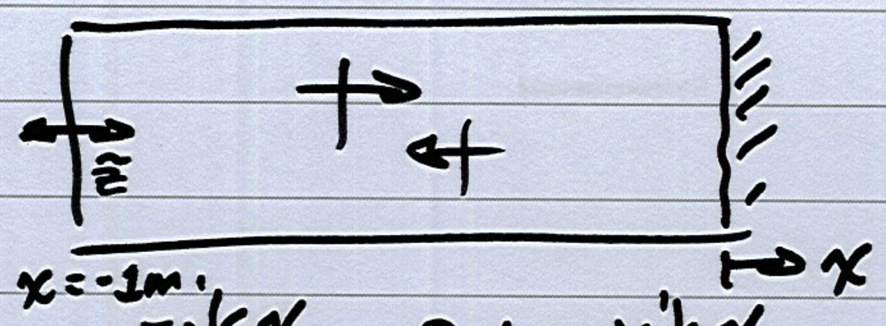
Homework Hints

1.



$$\tilde{z} = \left.\frac{\tilde{p}}{\tilde{u}_x}\right|_{x=-1m}$$

$$\tilde{p} = e^{-jkx} + 0.6\,e^{+jkx}$$

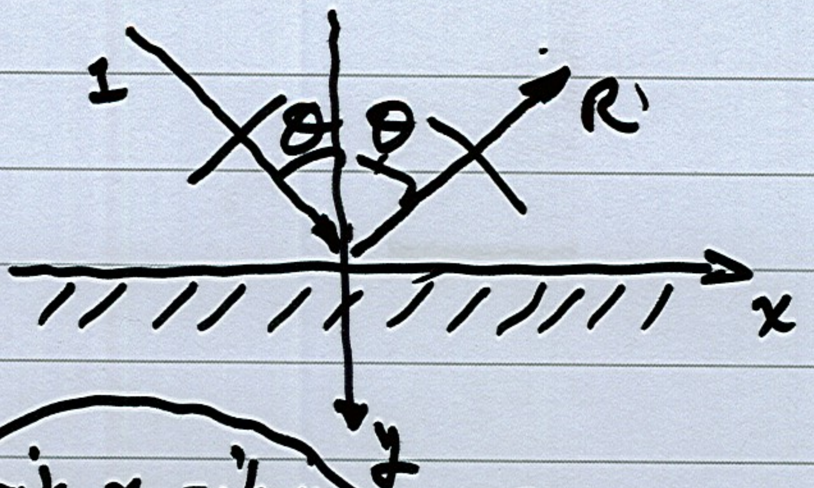
$$p_{rms}^2 = \frac{\tilde{p}\,\tilde{p}^*}{2}$$

$$\tilde{u}_x = -\frac{1}{j\omega\rho_0}\frac{\partial \tilde{p}}{\partial x} \qquad \tilde{u}_{x_{rms}}^2 = \frac{\tilde{u}_x\,\tilde{u}_x^*}{2}$$

$$I_x = \frac{1}{2}\mathrm{Re}\{\tilde{p}\,\tilde{u}_x^*\}$$

$$W = I_x S$$

2.



$\tilde{p} = e^{-jk_x x} e^{-jk_y y} + R$ ______

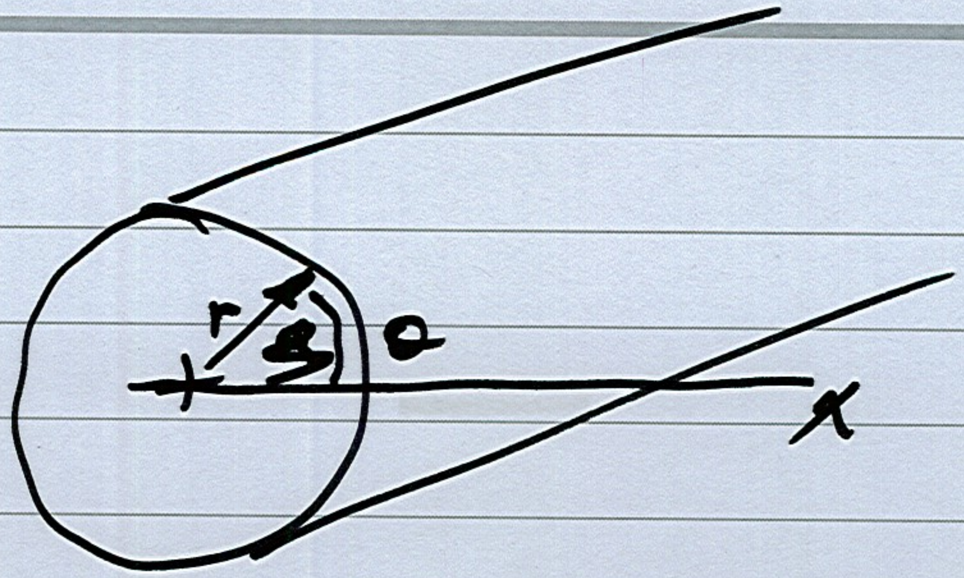
incident

$\tilde{u}_y = -\frac{1}{j\omega\rho_0}\frac{\partial \tilde{p}}{\partial y}$

$I_y = \frac{1}{2} Re\{\tilde{p}\, \tilde{u}_y^*\}$ at $y = 0$

$\alpha = \frac{I_{y\,total}}{I_{y\,incident}}$ expression featuring R

3.



$$\tilde{p}(r,\theta) = \frac{A}{r^{1/2}} \sin\theta \, e^{-jkr}$$

$$\tilde{u} = -\frac{1}{j\omega\rho_0} \nabla\tilde{p}$$ ~~#~~ page 520

$$\tilde{u} = u_r \bar{r} + u_\theta \bar{\theta} \qquad \tilde{z}_r = \frac{\tilde{p}(r)}{\tilde{u}_r(r)}$$

$$I_r = \frac{1}{2} \mathrm{Re}\{\tilde{p}\,\tilde{u}_r^*\} \qquad kr \to \infty$$

foc

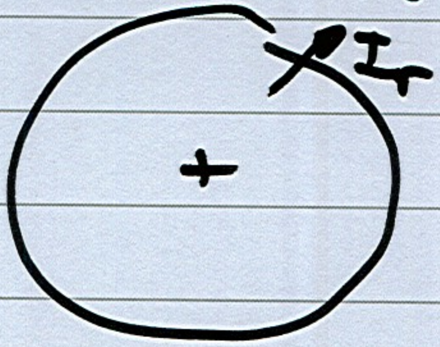
$$\tilde{z} = r + jx$$

Acoustic Intensity

$$\underset{\sim}{\bar{I}} = \frac{1}{2} \mathrm{Re}\{\tilde{p}\, \tilde{\bar{u}}^*\}$$

for free propagation

$$\underset{\sim}{I} = \frac{p_{rms}^2}{\rho c}$$

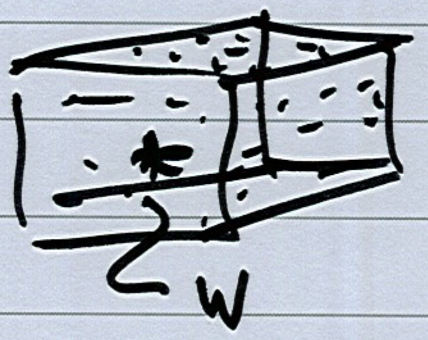


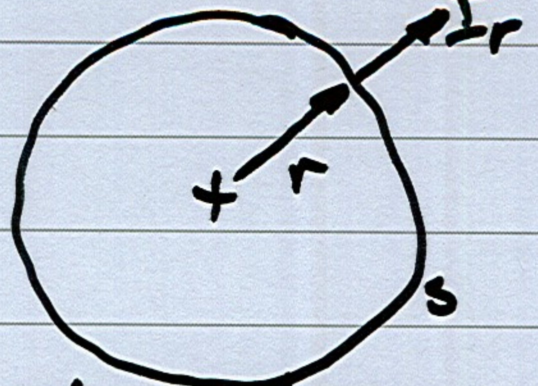
$$I_r = \frac{p_{rms}^2}{\rho c} \propto \frac{1}{r^2}$$

$$p_{rms} \propto \frac{1}{r^2}$$

Intensity = $\dfrac{\text{Sound Power}}{\text{Unit Area}}$

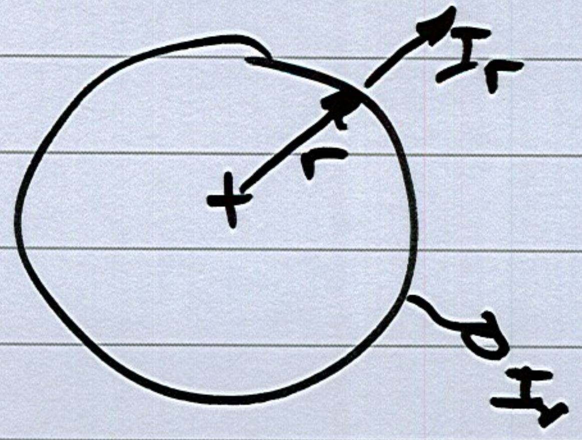
Sound Power - by integrating the normal intensity over a surface enclosing the source





$$W = \int_S I_r \, dS$$

- spherically symmetric
- freely propagating



$$W = \int_S I_r \, dS$$

$$= I_r \int_S dS$$

$$= I_r \, 4\pi r^2$$

$$\boxed{W = (4\pi r^2) I_r}$$

$$I_r = \frac{W}{4\pi r^2}$$

free field $\quad I_r = \dfrac{p_{rms}^2}{\rho_0 c}$

<u>Inverse Square Law</u>

3.6 Decibels

- sound pressure covers an enormous range

Very loud sound 120 dB → 20 Pa

Very quiet space 30 dB 6×10^{-4} Pa

20 0.0000

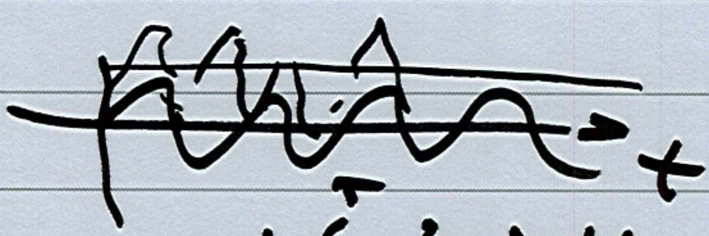
humans respond on a logarithmic scale.

- convenience

Level - always referring to a decibel quantity

Sound Pressure Level

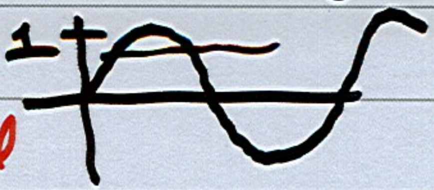
$$L_p = 10 \log_{10} \frac{p_{rms}^2}{p_{ref}^2}$$



$$msp = \frac{1}{T}\int_0^T p^2(t)\,dt$$

$p_{ref} = 2 \times 10^{-5}\ Pa$ note error in original note

$= 20\ \mu Pa$



$p_{rms} = 0.7$

minimum audible ~~of~~ sound pressure by a healthy young adult.

$L_p = 87 \text{ dB re } 20\,\mu\text{Pa}$

$$= 10 \log_{10} \left(\begin{array}{l} \text{ratio of} \\ \text{power} \\ \text{related} \\ \text{quantities} \end{array} \right)$$

$$10 \log_{10} \frac{p_{rms}^2}{p_{ref}^2}$$

$$= 20 \log_{10} \frac{p_{rms}}{p_{ref}}$$

Sound Intensity Level

$$L_I = 10 \log_{10} \frac{I}{I_{ref}} \quad dB \quad re\ I_{ref}$$

$$I_{ref} = 1 \times 10^{-12} \quad W/m^2$$

for a freely propagating plane wave

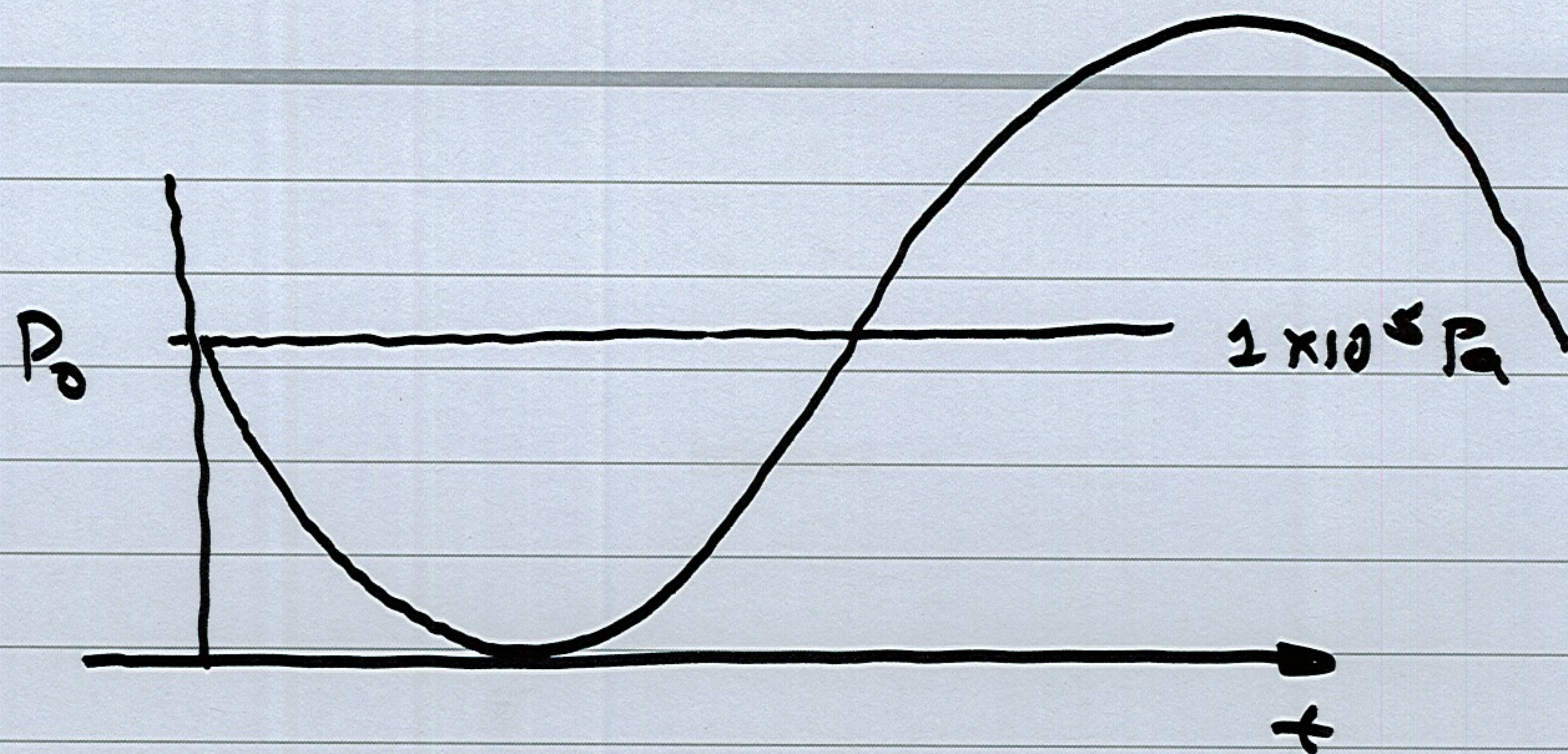
$$I = \frac{p_{rms}^2}{\rho_0 c} = \frac{p_{ref}^2}{\rho_0 c} = I_{ref}$$

for a freely propagating wave L_P & L_I are numerically equal because of this choice

Sound Power Level

$$L_W = 10 \log_{10} \frac{W}{W_{ref}} \quad dB \quad re \quad W_{ref}$$

$$W_{ref} = 1 \times 10^{-12} \quad Watts$$



$$L_p \simeq 10 \log_{10} \frac{1 \times 10^{10}}{4 \times 10^{-10}}$$

$$= 194 \text{ dB re } 20\,\mu\text{Pa}$$

$$0 \leq L_p \leq 194$$

above 120 dB - non-linear effects

$$70\,dB + 70\,dB = 73\,dB$$

$$\neq 140$$

Adding decibels

- add the corresponding msp's under the assumption that signals are statistically uncorrelated