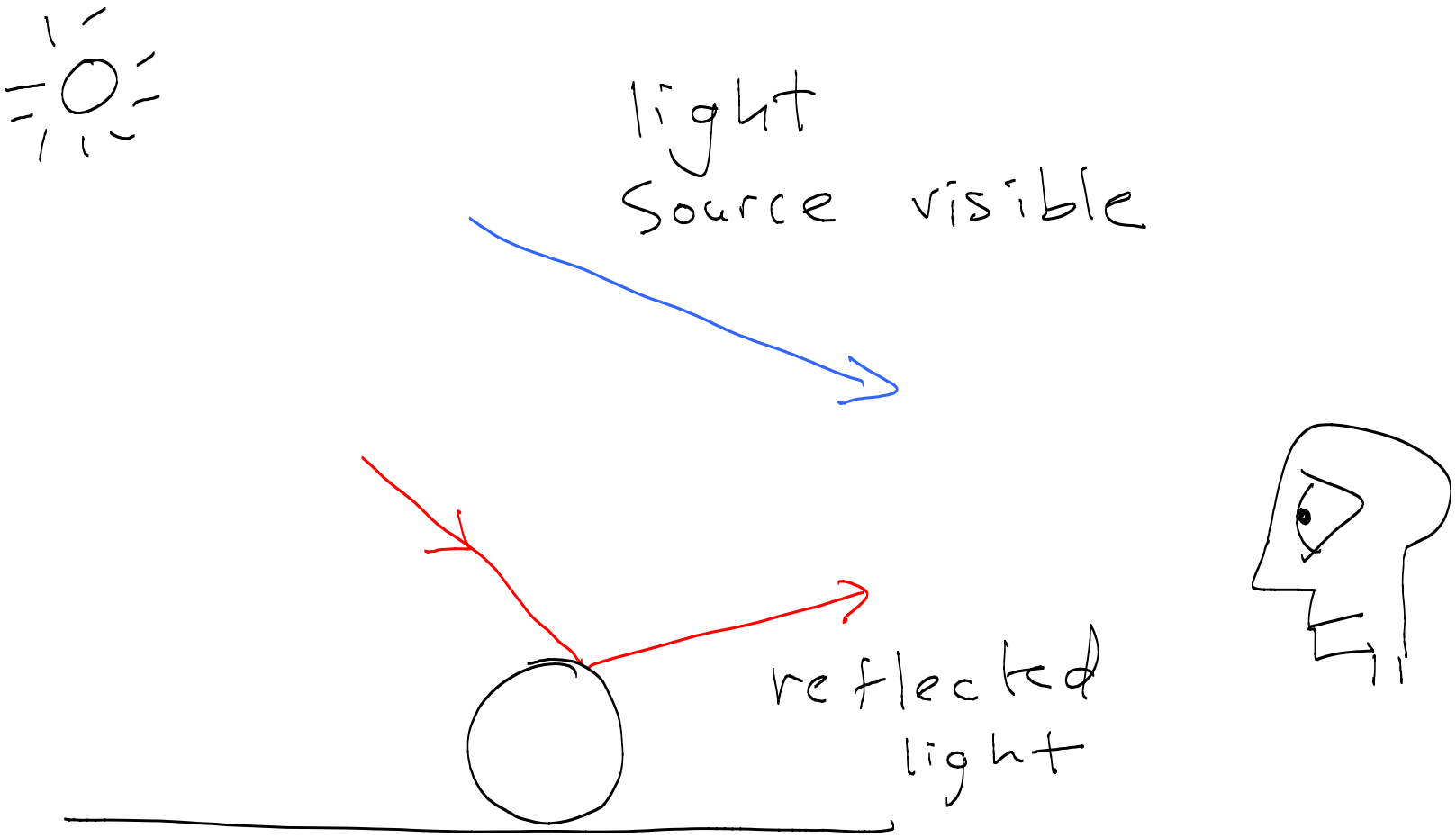
COMP 546

Lecture 18

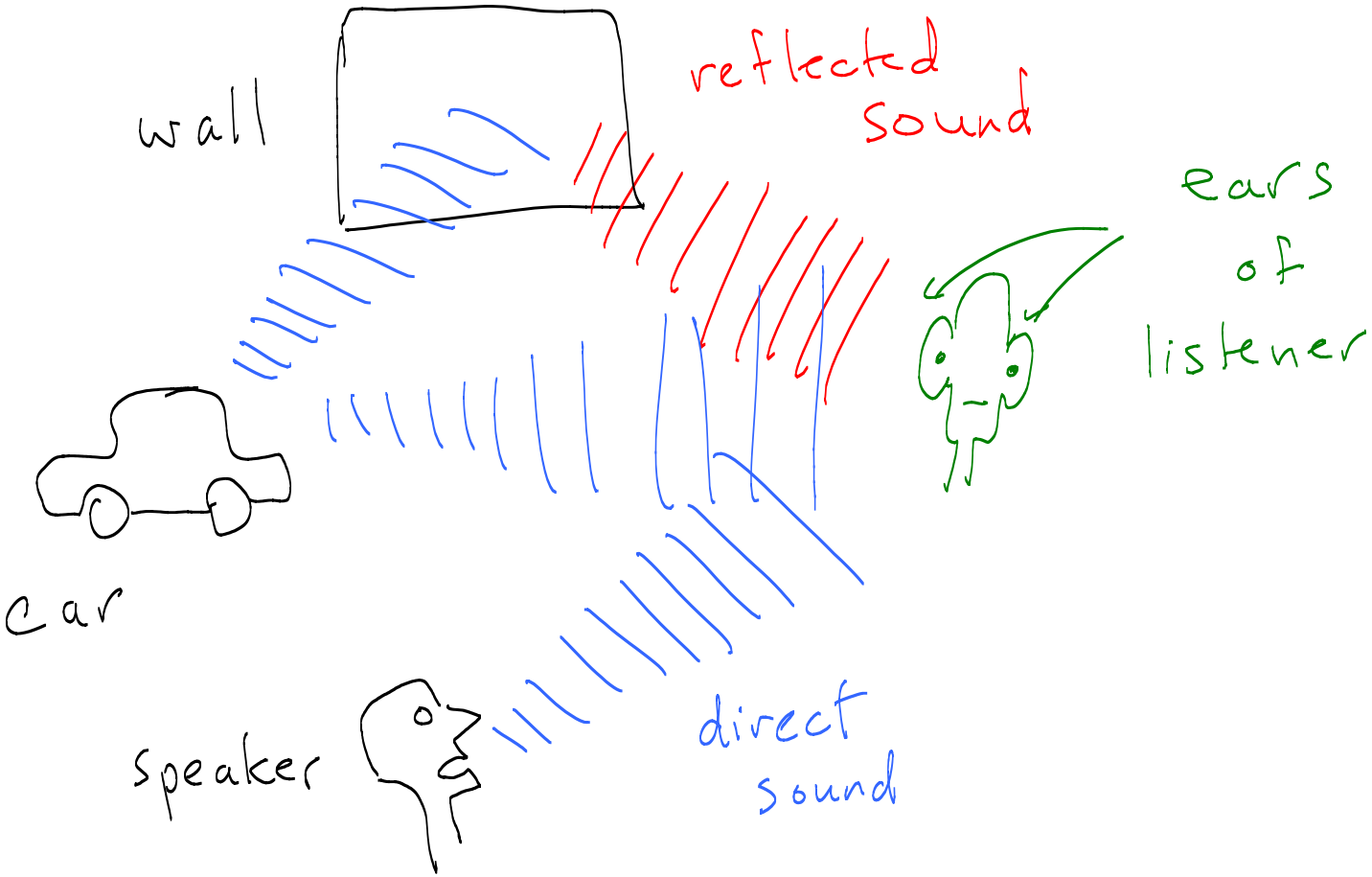
Sound 1

Thurs. March 22, 2018

I spent the first hour today finishing off the previous lecture. See lecture 17 slides and notes.



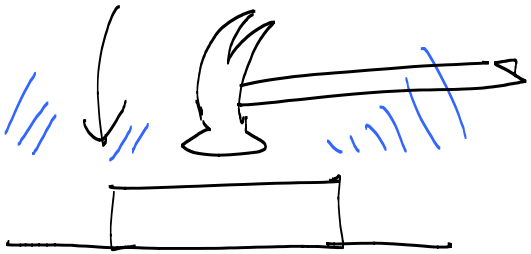
For vision, *reflected* light is more important than *direct* light.



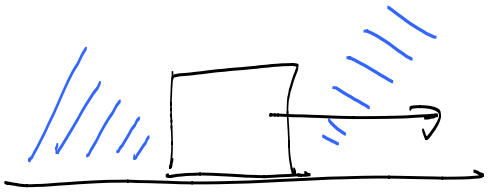
For audition, *direct* sound is more important than *reflected* sound.

Types of sounds

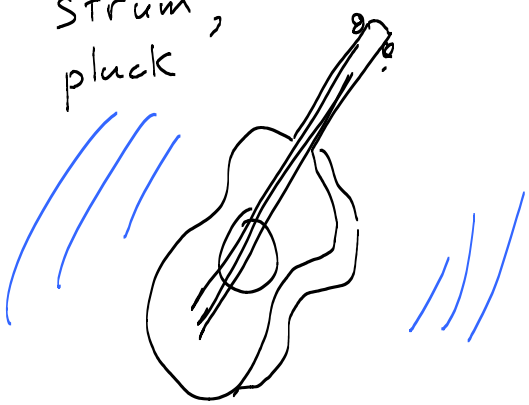
impact



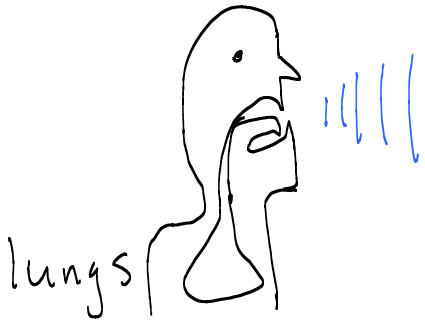
scrape



strum, pluck



speak



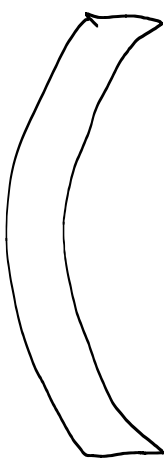
What determines a sound?

- Force: where does the sound energy come from?
- Oscillator: what vibrates
- Resonator: what cavity reshapes the sound ?

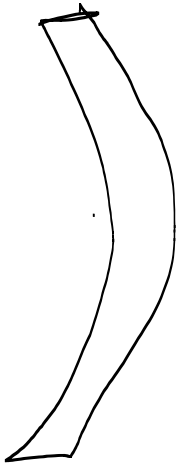
Vibration: basic mechanics

Total energy = Kinetic energy + Potential energy

Kinetic low
Potential high



Kinetic high
Potential low

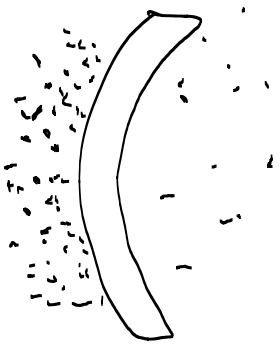


Kinetic low
Potential high

$t - \Delta t$ t $t + \Delta t$

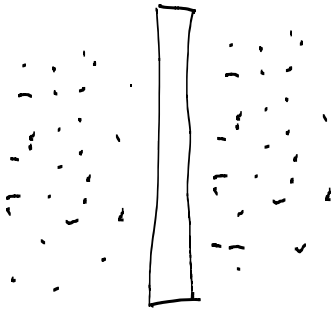
Air pressure: longitudinal wave

high low



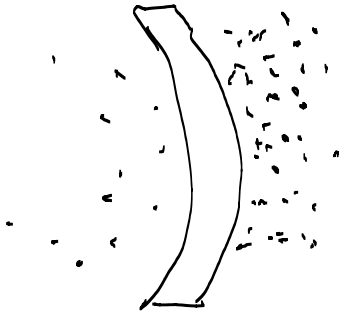
$t - \Delta t$

medium medium



t

low high

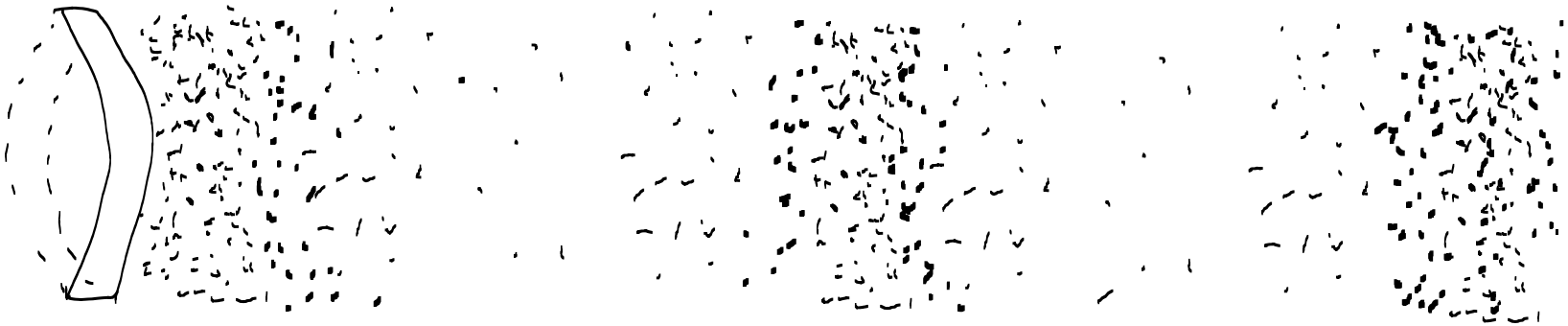


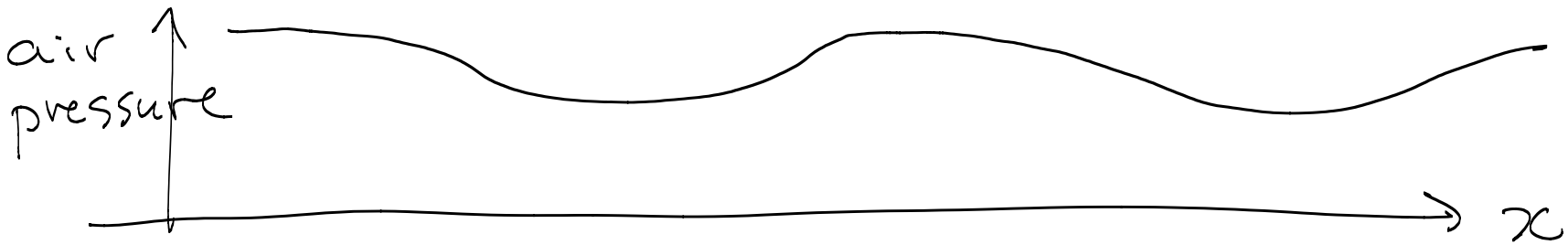
$t + \Delta t$

At any point in 3D space, the air pressure oscillates over time.

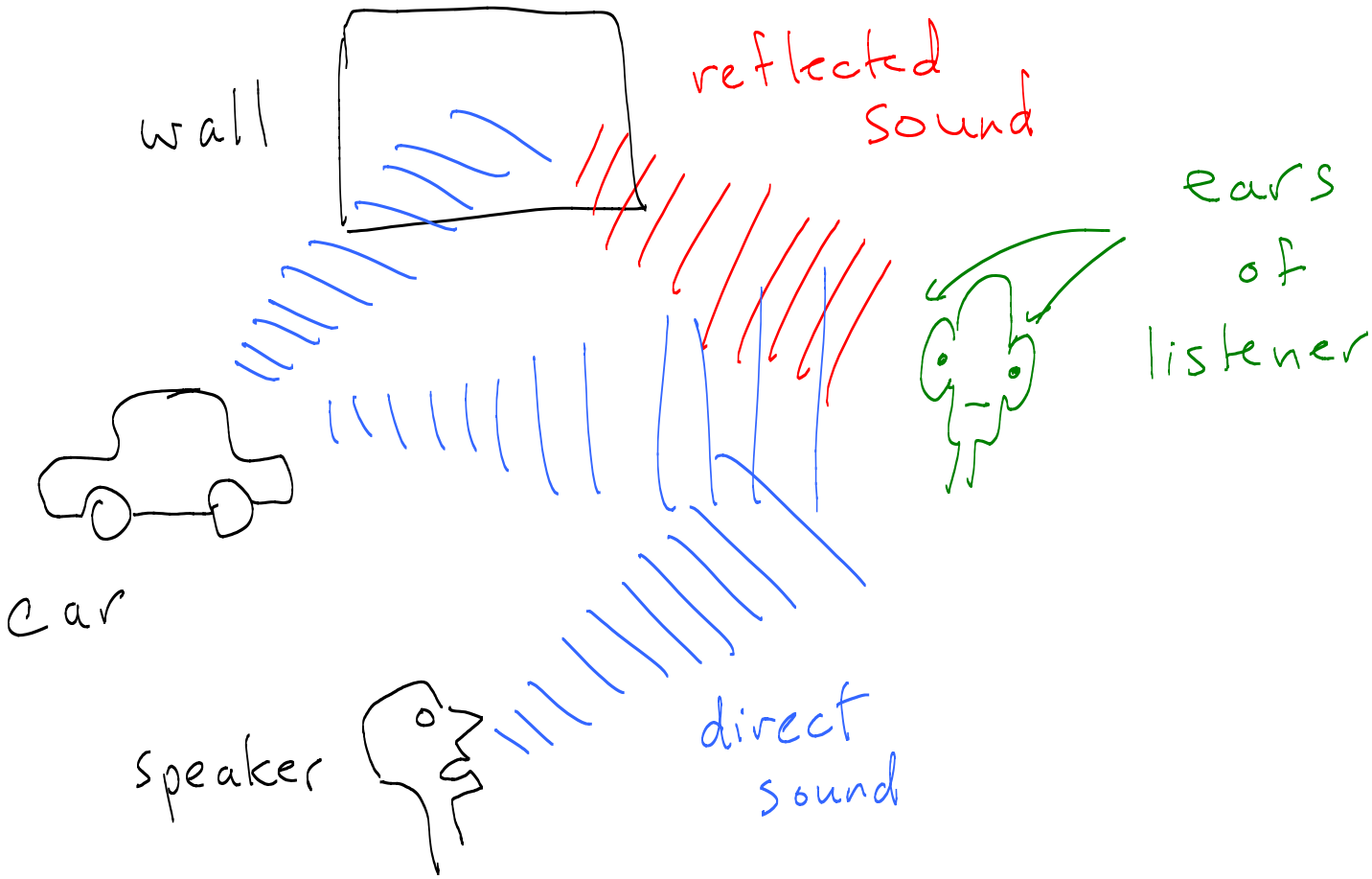
Time Snapshot

high low high low high



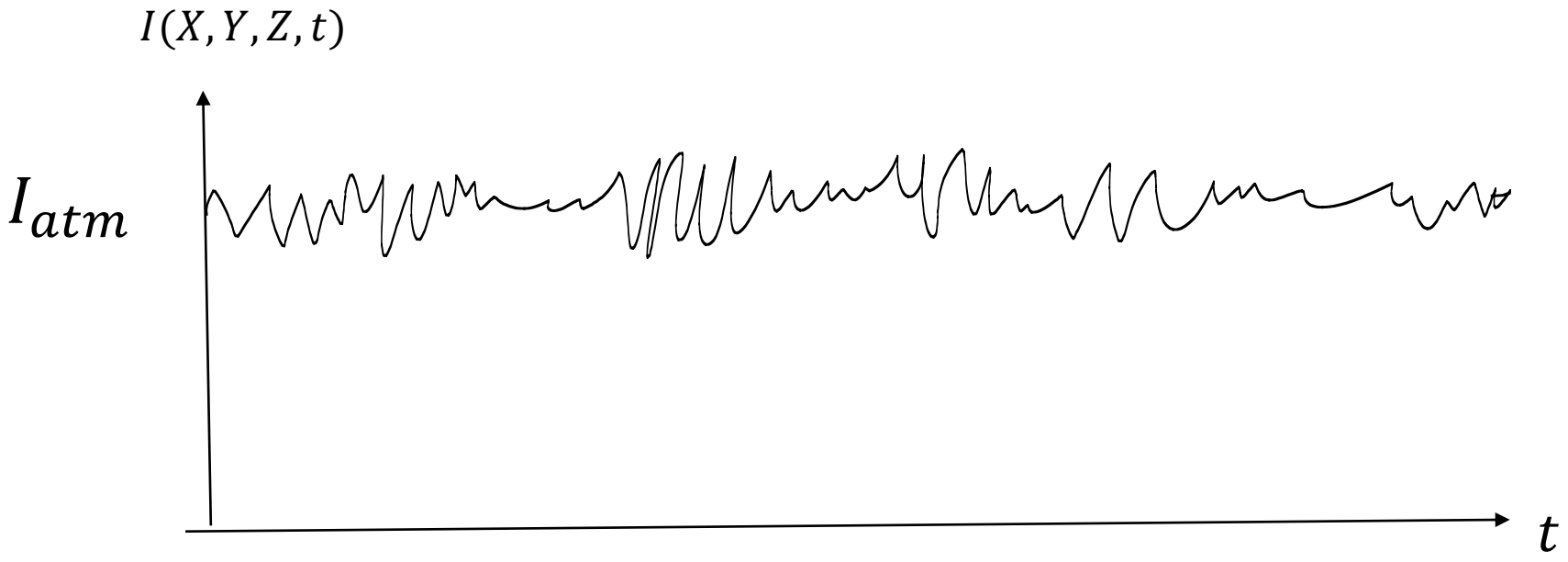


The sound that we hear is the *sum* of many sounds waves.



$$P(X,Y,Z,t) = I_{atm} + I(X,Y,Z,t)$$

$I(X,Y,Z,t)$ is called the *sound pressure*.



Atmospheric pressure I_{atm} varies a bit with temperature, altitude, weather.

Absolute threshold of hearing I_0

$$\frac{I_0}{I_{atm}} = 10^{-9}$$

Pain threshold

$$\frac{I_{pain}}{I_{atm}} = 10^{-3}$$

I_0 and I_{pain} refer to a pressure *deviation* around I_{atm}

Physics tells us that energy density per unit volume of $I(X, Y, Z, t)$ varies with $I(\ldots)^2$.

(Work done to compress or expand.
Units omitted – this isn't a physics course.)

Root mean square (RMS) of sound pressure:

$$I \equiv \sqrt{\frac{1}{T}\sum_{t=1}^{T} I(X, Y, Z, t)^2}$$

“Sound pressure level” (SPL): dB

$$log_{10} \frac{I^2}{I_0^2}$$ Bels (B)

$$10 \ log_{10} \frac{I^2}{I_0^2} = 20 \ log_{10} \frac{I}{I_0}$$ decibels (dB)

Why a log scale? We are sensitive to ratios of sound pressure, not differences.

Why dB and not B ? “Just noticeable difference” (threshold) is typically around 1 dB.

Examples of SPL (dB)

Jet plane	120
Noisy traffic	90
Voice in conversation	60
Quiet room	30
Recording studio	10
Absolute threshold	0

If you double the sound pressure *I(X,Y,Z,t)* over some time interval, what is the increase in dB ?

Doubling $I(X, Y, Z, t)$ doubles I.

$$20\ log_{10}\frac{2\,I}{I_0} = 20\,(\,log_{10}\,2 + log_{10}\frac{I}{I_0}\,)$$

So the increase in SPL is $20\ log_{10}\,2 \approx 6\,dB$