Creative Computing II

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Autumn 2010, Wednesdays:
10:00–12:00: RHB307 & 14:00–16:00: WB316
Winter 2011, TBC

Sound

What is sound?

- *longitudinal pressure* wave.

Sound

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- *longitudinal pressure* wave.

longitudinal:

- displacement from equilibrium is in direction of wave propagation;
- distinct from **transverse** (perpendicular) waves:
  - water waves;
  - light waves.

Sound

What is sound?

- *longitudinal pressure* wave.

pressure:

- generally, a force applied to a surface;
- in atmosphere, weight of air;
- measured in pascals; 1 atm $\sim$ 100,000Pa = 100kPa.

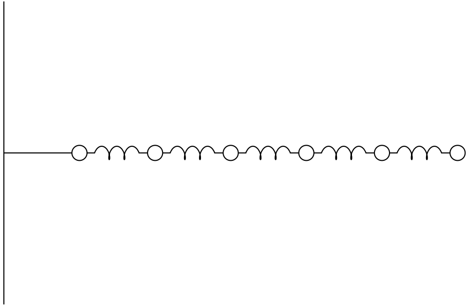
Sound

What is sound?

- *longitudinal pressure* wave.

Ear detects, amplifies and interprets incoming pressure waves.

Balls and springs model of matter:



Sound

Waves

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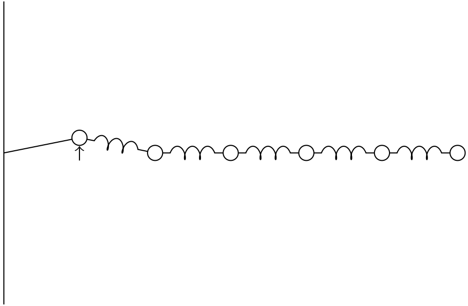

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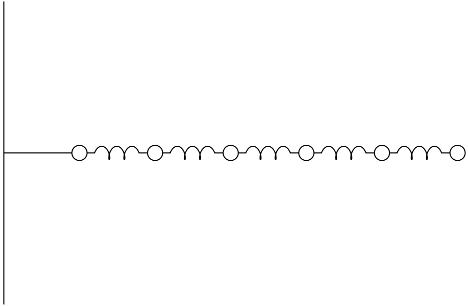

Sound
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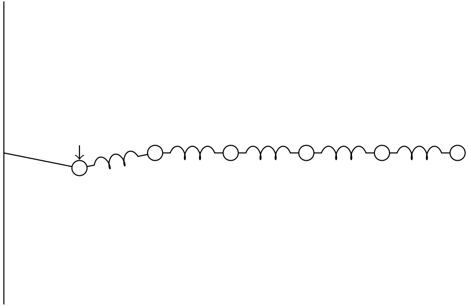

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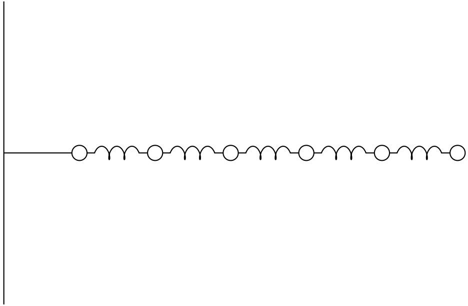

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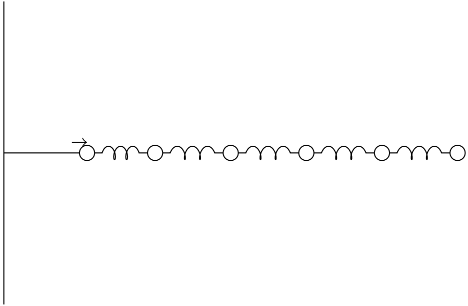

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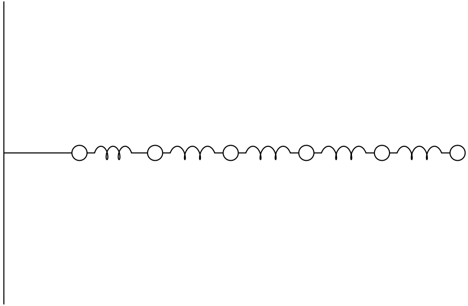

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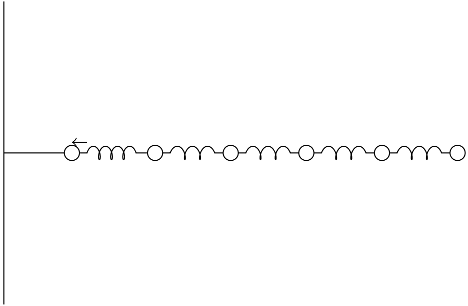

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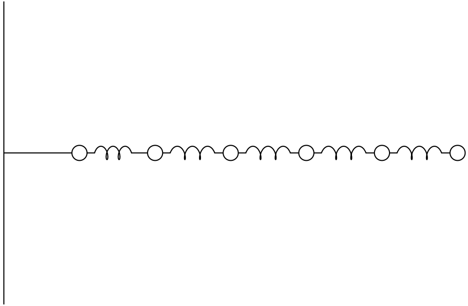

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Wave signal properties

Wave signals have a number of properties:

- *frequency*;
- *amplitude*;
- *phase*.

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$$x(t) = A \sin(2\pi \mathbf{f} t + p)$$

frequency:

- number of cycles per second (hertz);
- audible sound waves in range 20Hz – 20kHz;
- (compare light waves: $\sim 5 \times 10^{12}$Hz).

Sound

Wave signal properties

Wave signals have a number of properties:

- *frequency*;
- *amplitude*;
- *phase*.

$$x(t) = \mathbf{A} \sin(2\pi f t + p)$$

amplitude:

- how large is the displacement;
- (how much signal is present);

Sound

Wave signal properties

Wave signals have a number of properties:

- *frequency*;
- *amplitude*;
- *phase*.

$$x(t) = A\sin(2\pi ft + \mathbf{p})$$

phase:

- the initial ($t = 0$) position of the wave.
- alternative to representation of the signal as a mixture of sin and cos:
  - $\sin(A + B) = \sin(A)\cos(B) + \cos(A)\sin(B)$
  - $\sin(2\pi ft + p) = \sin(2\pi ft)\cos(p) + \cos(2\pi ft)\sin(p)$

Sound Perception

Loudness

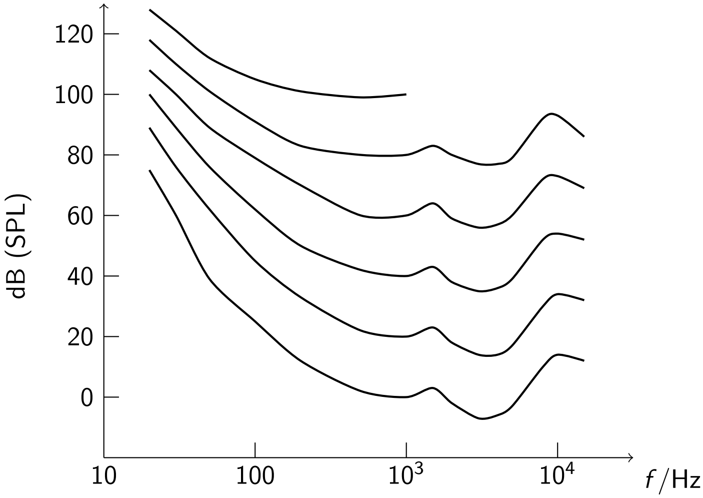
Related to amplitude, but not linearly:

- approximate logarithmic dependency
  - decibel scale: Sound Pressure Level;
  - $L_p = 20 \log_{10}\left(\frac{p}{p_0}\right)$.
- perceived loudness also depends on frequency.
- (ref. CIE LAB colour space for light)

Sound Perception

Loudness

Equal-loudness curves (ISO 226:2003)



Sound Perception

Source Location

How do we know where a sound is coming from? Two principal mechanisms:

- time delay (low-frequency sounds);
- attenuation (high-frequency sounds).

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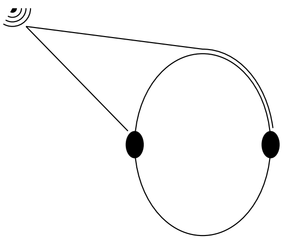

time delay:

- difference in path length from source to each ear;
- gives rise to *phase difference* between ears.

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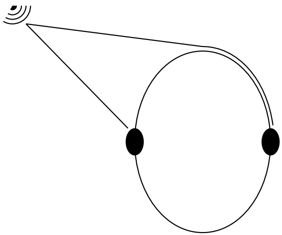

attenuation:

- diffraction around head causes energy to be lost;
- gives rise to *amplitude difference*.