2019.11.27

Relevant reading:
Kesten & Tauck ch.13.1-13.4

Ref. (re images):
Wolfson (2007), Knight (2017)
117. Coin Squares 3

How many squares of any size and orientation can you find in the shape above? To count, a square must have four coins whose centers lie exactly at its four corners.
Announcements & Key Concepts (re Today)

→ Online HW #9: Posted and due 12/6

→ Lectures end Monday (no tutorial on 12/4)

→ Review sessions re final exam to be announced soon

Some relevant underlying concepts of the day...

➢ What is a wave?

➢ Examples of waves

➢ Basic considerations of waves

➢ Standing waves
What is a “wave”?

A traveling wave is a broad term, but in a general sense can be defined as occurring when a “condition of some kind is transmitted from one place to another by means of a medium, but the medium itself is not transported”
Examples of waves → EM waves (i.e., light)

Reminder:
A testable prediction stemming from Einstein’s theory of General Relativity

→ And it worked like a charm! Tested in Sept. 1919, Einstein became a rockstar afterwards!
Examples of waves ➔ Gravitational waves

Two black holes collide and form a ripple in spacetime (➔ Gravitational Waves)
“The event” occurred on Sept.14, 2015

Can listen to this! (https://www.youtube.com/watch?v=TWqhUANNFXw)
Examples of waves ➔ Chemical waves

- “BZ reaction” = *Belousov–Zhabotinsky reaction*

“... is one of a class of reactions that serve as a classical example of non-equilibrium thermodynamics, resulting in the establishment of a nonlinear chemical oscillator. The only common element in these oscillating is the inclusion of bromine and an acid.”

https://www.youtube.com/watch?v=3JAqrRnKFHo
Examples of waves → Sound waves

The “speech chain”

→ You create waves when you speak!
Examples of waves → Cochlear waves

Basilar membrane traveling waves
Examples of waves \rightarrow Seeing babies

This ultrasound image is an example of using high-frequency sound waves to “see” within the human body.

\rightarrow Modern ultrasound can image in 3-D

Actually acoustic (i.e., pressure) waves!
Examples of waves ➔ Action potentials

Neurons ("fibers")
= Information highway

➔ Action potentials (or spikes) is a primary means for information to propagate through the body

Key Ideas
- Electrical properties of cells are important
- Diffusion sets foundation for transport across cell membrane

➔ Action potentials

Figure 1.22
Examples of waves ➔ Action potentials

“Neural code”
Types of waves

- So now we have seen some examples of waves, but more generally, what “types” of waves are there?

- **Longitudinal/Compression**

- **Transverse**

- **Electromagnetic** (Note: No “medium”)

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1. A sinusoidal wave with frequency $f$ and wavelength $\lambda$ travels with wave speed $v_{em}$.

2. $\vec{E}$ and $\vec{B}$ are perpendicular to each other and to the direction of travel. The fields have amplitudes $E_0$ and $B_0$.

3. $\vec{E}$ and $\vec{B}$ are in phase. That is, they have matching crests, troughs, and zeros.
Acoustic communication in Panthera tigris: A study of tiger vocalization and auditory receptivity revisited
Edward Walsh¹, Douglas L. Armstrong², Julie Napier³, Lee G. Simmons⁴, Megan Korte⁵ and Joann McGee⁶

Preliminary findings reported at the 145th meeting of the Society suggested that confrontational tiger roars contain energy in the infrasonic portion of the electromagnetic spectrum. This discovery generally supported the proposition that free ranging individuals may take advantage of this capability to communicate with widely dispersed conspecifics inhabiting large territories in the wild. Preliminary ABR findings indirectly supported this view suggesting that although tigers are most sensitive to acoustic events containing energy in the 0.3 to 0.5 kHz band, they are most likely able to detect acoustic events in the near-infrasonic and infrasonic range based on the assumption that felid audiograms exhibit uniform shapes. In this study, the spectral content of territorial and confrontational roars was analyzed and relevant features of ABR based threshold-frequency curves were considered in relation to the acoustical properties of both roar types. Unlike the confrontational roar, infrasonic energy was not detected in the territorial roar; however, like the confrontational roar, peak acoustic power was detected in a frequency band centered on 0.3 kHz. In addition, ABR recordings acquired in a double walled sound attenuating chamber recently installed at the Henry Doorly Zoo suggest that acoustic sensitivity is significantly underestimated under "field" conditions.

→ What is wrong here?
Types of waves

Longitudinal wave

Transverse wave

https://en.wikipedia.org/wiki/Longitudinal_wave
https://en.wikipedia.org/wiki/Transverse_wave
Types of waves

A **transverse wave** is a wave in which the displacement is *perpendicular* to the direction in which the wave travels. For example, a wave travels along a string in a horizontal direction while the particles that make up the string oscillate vertically. Electromagnetic waves are also transverse waves because the electromagnetic fields oscillate perpendicular to the direction in which the wave travels.

In a **longitudinal wave**, the particles in the medium move *parallel* to the direction in which the wave travels. Here we see a chain of masses connected by springs. If you give the first mass in the chain a sharp push, a disturbance travels down the chain by compressing and expanding the springs. Sound waves in gases and liquids are the most well known examples of longitudinal waves.
What kind of waves are ocean waves?
Looking ahead: Standing Waves

- Consider that in 1-D, there can be two waves on a string: one going *forward* and one going *backward*

The superposition of two sinusoidal waves traveling in opposite directions.

- Their combination leads to interference (or *superposition*)

- Sometimes the waves interfere (i.e., add up) *constructively*, other times it is *destructively*
Looking ahead: Standing Waves

... but is much more readily apparent via a movie

Blue is the left-going wave
Red is the right-going wave
Black is the sum of the two (i.e., the “standing” wave)

Note: Locations where the amplitude stays zero are called nodes
How to describe a wave?

A snapshot graph of a wave pulse on a string.

This is a wave pulse traveling along a string. Wave speed $v$

Trailing edge Leading edge

This is a graph of the string’s displacement as a function of position at time $t_1$.

Wave height versus position

The string’s displacement as a function of time at position $x_1$

Leading edge Trailing edge

Earlier times Later times

Wave height versus time

Note: Wave shape appears “flipped” between the two....