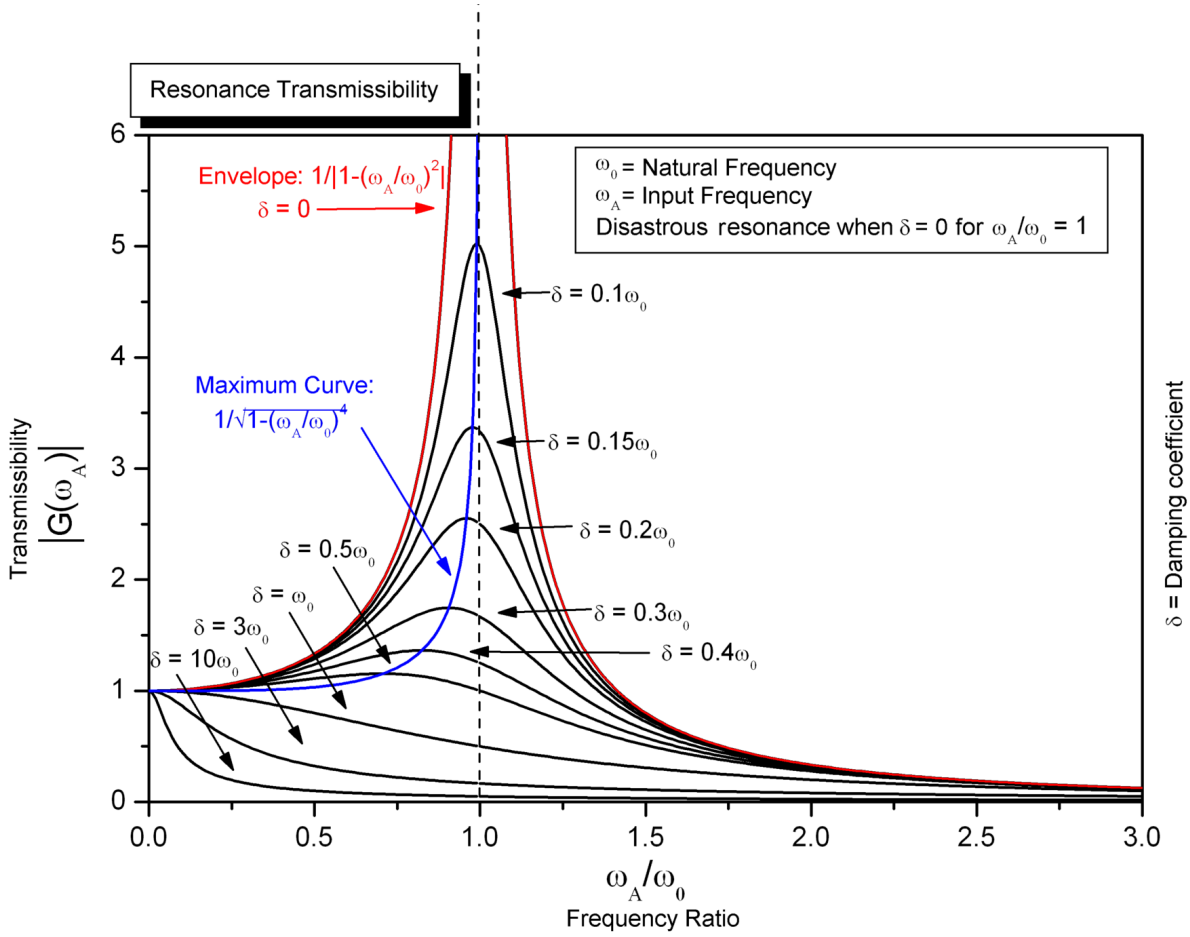
GLITTERS: RESONANCE LECTURE

1. Temperature of water with ice cubes in water demo
2. Brownian Motion demo
3. question: how might masses of molecules inform resonance?
4. question: what's holding the water together?
5. resonance



fit

> resonance is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at a specific preferential frequency. [1]

questions

1. What happens when a material resonates?

2. How do you find the resonance of a material?
3. How does crystal packing inform resonance?
4. Do all materials have a resonance point?
5. Why do some materials resonate better (or longer) than others?
6. Can you talk about the resonance we see in archival films on the Tacoma Narrows bridge failure?
7. It was recently discovered that conversations vibrate thin films like the ones used in potato chip bags. How would you listen in on these conversations?
8. Can you describe the different kinds of waves produced by an earthquake?
9. Some (earthquakes) waves are more destructive then others. Can you demonstrate why?
10. Where does a cat's purr come from?

lecture

All things resonate and everything has natural frequency of vibration, aka its **resonant frequency**. Many sounds we hear are caused by resonant vibrations in the object. Examples:

1. Timekeeping mechanisms of modern clocks and watches, e.g., the balance wheel in a mechanical watch and the quartz crystal in a quartz watch
2. pendulums and swings
3. Acoustic resonances of musical instruments including the human vocal tract
4. attering of a crystal wineglass when exposed to a musical tone of the right pitch (its resonant frequency)
5. resonance of columns of air in flutes, clarinets and pipe organs

Demo

Debate

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1. wikipedia ↩

GLITTERS DEBATE: Mach vs. Boltzmann, Kinetic Theory

Ludwig Boltzmann (1844–1906) was a mathematician, defender of women in academia and in 1890 the Chair of Theoretical Physics at the University of Munich. He spent 14 years developing a statistical concept of nature that included a kinetic theory of gases.

Ernst Mach (1838–1916) was famous for his work on shock waves and a strict application of phenomenalism that recognized only sensations as real.

Mach attended a lecture given by Ludwig Boltzmann on the kinetic theory of gases at the Imperial Academy of Science in Vienna. Mach famously said to Boltzmann “I don’t believe atoms exist.” So began the debate.

The kinetic theory of gases is the study of the microscopic behavior of molecules and the interactions which lead to macroscopic relationships and behaviors.

Boltzmann lays out these ideas about the behavior of tiny bodies based on their macro effects:

1. a large number of small bodies (molecules) separated by space which is large compared to the size of the bodies
2. the bodies move randomly and with a speed distribution that does not change while the temperature is stable
3. the bodies collide with others but otherwise do not exert significant forces on others
4. the bodies obey Newton’s laws of motion

Mach insists that only things that can be seen and experienced are real. He does not allow for the inductive leap from macro behavior to accepting the existence of atoms and molecules.

TOPIC TEAMS

1A. TEAM MACH, AFFIRMATIVE: experience is the source of ideas and knowledge. There is no reality beyond what we can see and touch.

1N. TEAM BOLTZMANN, NEGATIVE: Wrong – there must be smaller components that make up the world we see and touch.

2N. TEAM MACH,, NEGATIVE: Atoms do not exist.

2A. TEAM BOLTZMANN, AFFIRMATIVE: We can study the macroscopic behaviors of atoms and molecules and make conclusions about these masses of tiny bodies. The kinetic theory of gases predicts the speed of diffusion based on the temperature of a medium.

PROCEDURE

Research the issue together and come up with lists of examples to support your topic and position. Prepare logical arguments. You may not subscribe to the view you have been assigned. You don’t need to believe in a cause to argue for (or against) that cause.
Everyone isexpected to participate in the research and strategy of the debate. Decide who who will do most of the talking during the debate and support your team with examples and other support.

SCHEDULE

1A: two minutes, present case.
1N: two minutes, present case.
Two minute break to prepare rebuttals and summaries
1N: two minutes, rebuttal. Defend opposing arguments and defeat supporting arguments without adding new information.
1A: two minutes, rebuttal and summary.

2A: two minutes, present case.
2N: two minutes, present case.
Two minute break to prepare rebuttals and summaries
2N: two minutes, rebuttal and summary. Defend opposing arguments and defeat supporting arguments without adding new information.
2A: two minutes, rebuttal and summary.

DISCUSSION

Present your judgements. the winner is the one who has presented the strongest case. Ask yourself:

who communicated clearly?
who refuted the opponent's arguments best?

Final note:

Einstein paper on Brownian Motion in 1905 that the statistical fluctuations of atoms allowed measurement of their existence without direct individuated sensory evidence. This marks the turning point in the acceptance of atomic theory and subsequent work in quantum theory.

GLITTERS: What attractive force holds water together?

but first:

plot the temperature of water with ice cubes.

need: a pint glass, timer, water, ice cubes, quick-read thermometer

time	temp.	note
0:00		add ice cubes
0:05		
0:10		
0:15		
0:20		
0:25		

Use the cold water for the Brownian Motion demo (below).

Brownian motion demo

1. two pint glasses filled with water: one cold, the other hot
2. drop some ink into the cold water. observe.
3. now drop some ink into the warm water. observe.

questions

1. what force is kicking the ink particles around?
2. what does temperature have to do with it?
3. is there anything special about the ink? (try cigarette smoke)
4. what does the heat do?
5. what kind of force is this? (mechanical, magnetic, electrostatic, gravitational, van der waals, or ???)
6. can you characterize the behaviors of both glasses *qualitatively?*

Segue: How do these observations aboiut molecules inform your thoughts about resonance?

GLITTERS: DEMO I find the natural resonant frequency of several objects

1. drinking glasses with a damp finger (~glass organ)
2. a kid on a swing (or a bob on a pendulum)
3. tuning forks with a violin bow
4. singing to a wine glass
5. a column of air

Compare the resonance examples to blowing through a blade of grass held between your thumbs. Compare to a flute.

Let's talk about the flute. What is driving the oscillations in the air? How does it compare to the PVC experiment we saw earlier?

Separate the drivers from the oscillator and make connections.

drivers
tuning fork
steady wind
moistened finger
violin bow
singing voice

bodies
wine glass
air column
bridge
violin string
tuning fork

connect the drivers and bodies

The reading gives The Tacoma Narrows Bridge collapse as the ultimate example of the destructive power of driven oscillations. Let's talk about it.

Tacoma narrows bridge 1940

The original Tacoma Narrows Bridge roadway twisted and vibrated violently under 40-mile-per-hour (64 km/h) winds on the day of the collapse