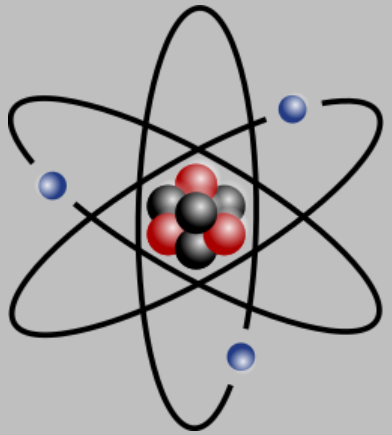
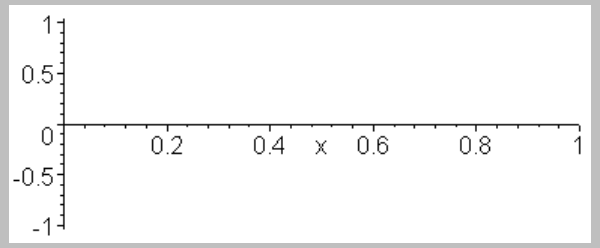
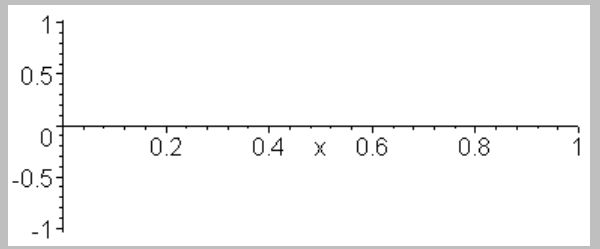
International House Tashkent
Subject: Physics
Department: ES, Course 1
Lesson 12. Resonance





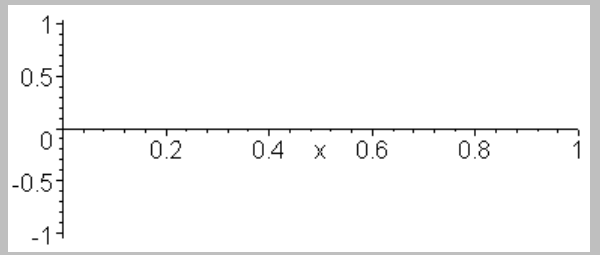
1st Harmonic

- Frequency = 1 x Natural Frequency
- $\lambda = \frac{length\ of\ material}{(0.5\ x\ harmonic)}$
- $\lambda = \frac{1}{(0.5\ x\ 1)}$ = 2 units



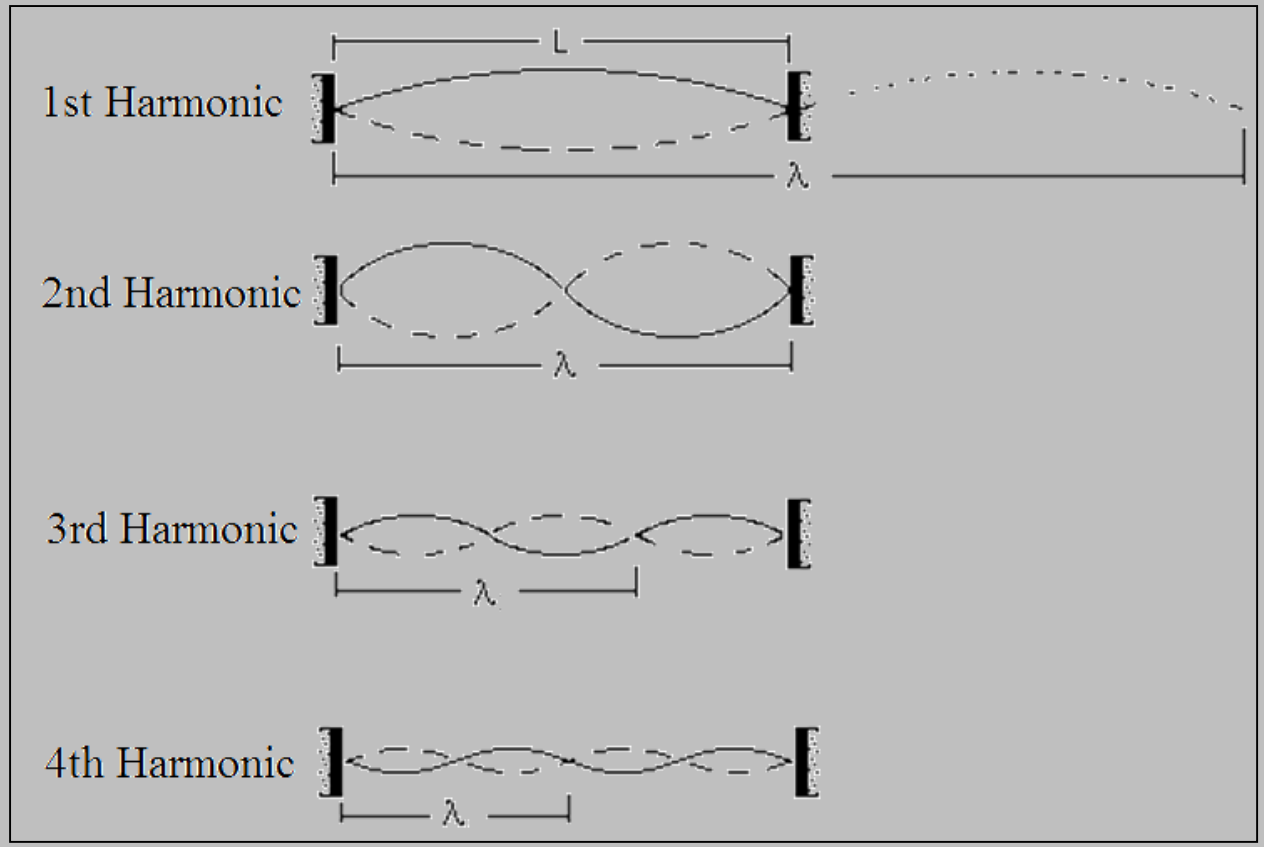
2nd Harmonic

- Frequency = 2 x Natural Frequency
- $\lambda = \frac{length\ of\ material}{(0.5\ x\ harmonic)}$
- $\lambda = \frac{1}{(0.5\ x\ 2)}$ = 1 unit



3rd Harmonic

- Frequency = 3 x Natural Frequency
- $\lambda = \frac{length\ of\ material}{(0.5\ x\ harmonic)}$
- $\lambda = \frac{1}{(0.5\ x\ 3)} \approx 0.7$ units


1st Harmonic
L
λ
2nd Harmonic
λ
3rd Harmonic
λ
4th Harmonic
λ

- In an English context, to “resonate” means to “agree with harmoniously” – as in “Gen. Smith’s speech on national defense resonated with the audience of graduating army cadets”.
- **Resonance** – the ability of an object to vibrate by absorbing energy at its natural frequency.
- **Resonance** is also the ability of objects to oscillate at a higher amplitude at some frequencies than at others.
- An object will resonate, or vibrate at its natural frequency – or at one of its harmonics - whenever something delivers energy to it at that frequency.
- A singer like Jamie Vendera is able to use resonance to break a glass when he sings at the resonant frequency (the fundamental) of the glass at a high enough volume (amplitude) so that the brittle glass shakes apart.

Natural Frequency and Resonance

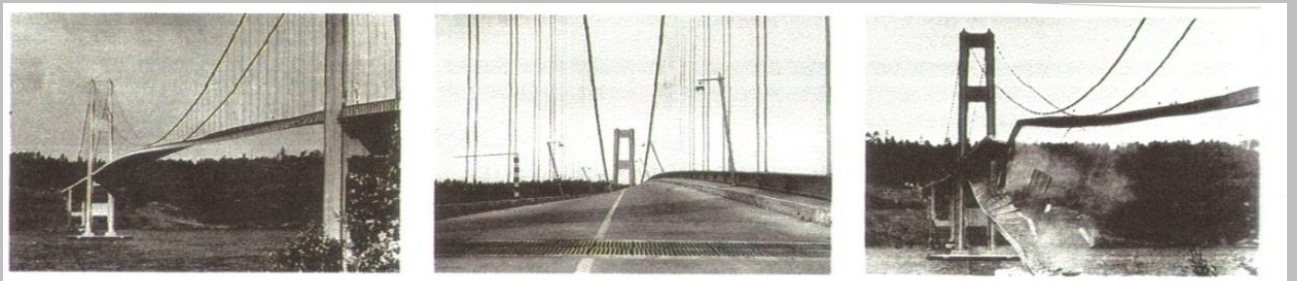
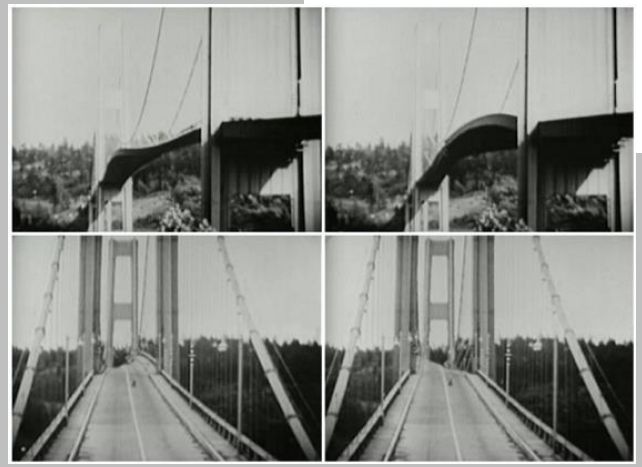


Figure 26.12 ▲
In 1940, four months after being completed, the Tacoma Narrows Bridge in the state of Washington was destroyed by a 40-mile-per-hour wind. The mild gale produced a fluctuating force that is said to have resonated with the natural frequency of the bridge, steadily increasing the amplitude over several hours until the bridge collapsed.



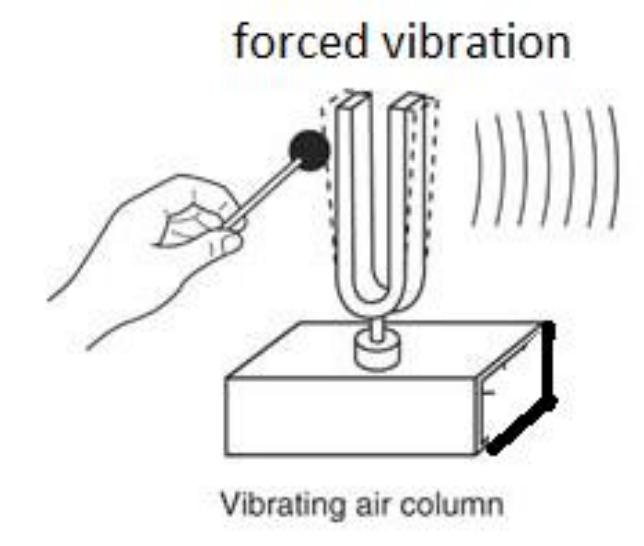
[Galloping Gertie]

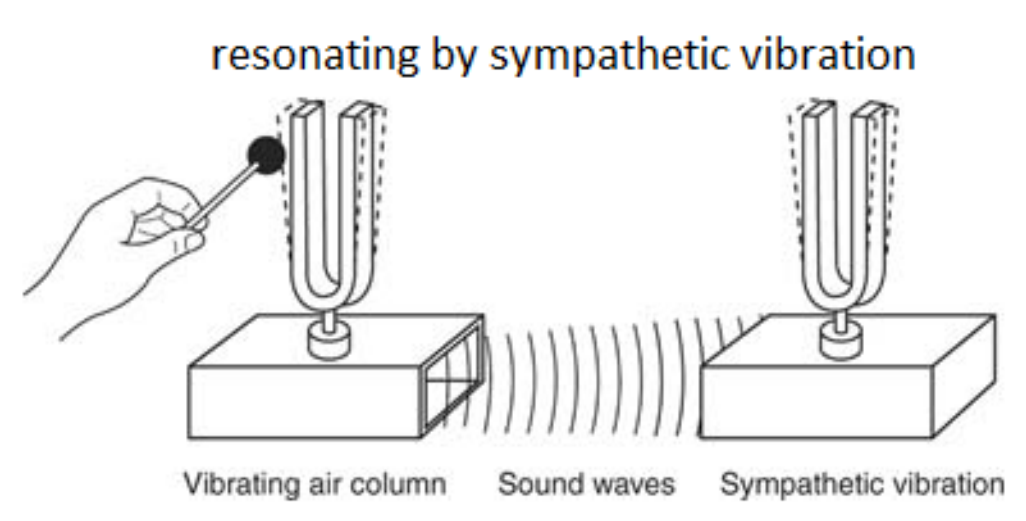
Figure 26.10 ▲
Pumping a swing in rhythm with its natural frequency produces larger amplitudes.

Natural Frequency and Resonance

- When any object composed of an elastic material is disturbed, it vibrates at its own special set of frequencies.
- An object's ***natural frequency*** depends upon its elasticity and its shape.
- Most things from planets to atoms and almost everything else in between – have a springiness to them and vibrate at one or more natural frequencies
- A **natural frequency** is one at which minimum energy is required to produce forced vibrations
- Applying energy to an object at its natural frequency produces larger amplitudes.

Resonance: Forced vs. Sympathetic Vibration





- If you physically come in direct contact with an item and cause it to vibrate – it will vibrate at its natural frequency. This is a forced vibration.
- Resonance is when one object, vibrating at the natural frequency of a second object, forces that 2nd object into vibrational motion.
- Since resonance is accomplished through a third party or proxy (like a singer's vocal chords sending energy through air particles at the natural or resonant frequency to a glass) we call the vibrations cause by resonance sympathetic vibrations