

matches the frequency of the pendulum that was initially set in motion. This system is said to be in **resonance**. Because energy is transferred from one pendulum to the other, the amplitude of vibration of the first blue pendulum will decrease as the second blue pendulum's amplitude increases.

A striking example of structural resonance occurred in 1940, when the Tacoma Narrows bridge, in Washington, shown in **Figure 11**, was set in motion by the wind. High winds set up standing waves in the bridge, causing the bridge to oscillate at one of its natural frequencies. The amplitude of the vibrations increased until the bridge collapsed. A more recent example of structural resonance occurred during the Loma Prieta earthquake near Oakland, California, in 1989, when part of the upper deck of a freeway collapsed. The collapse of this particular section of roadway has been traced to the fact that the earthquake waves had a frequency of 1.5 Hz, very close to the natural frequency of that section of the roadway.

resonance

a phenomenon that occurs when the frequency of a force applied to a system matches the natural frequency of vibration of the system, resulting in a large amplitude of vibration

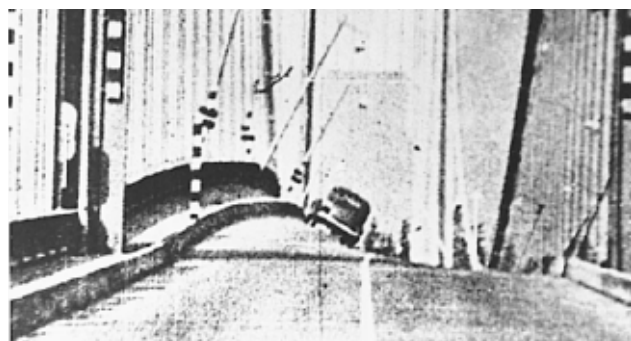


Figure 11

On November 7, 1940, the Tacoma Narrows suspension bridge collapsed, just four months after it opened. Standing waves caused by strong winds set the bridge in motion and led to its collapse.

Why it Matters

Conceptual Challenge

1. Concert If a 15-person musical ensemble gains 15 new members, so that its size doubles, will a listener perceive the music created by the ensemble to be twice as loud? Why or why not?

2. A Noisy Factory Federal regulations require that no office or factory worker be exposed to noise levels that average above 90 dB over an 8 h day. Thus, a factory that currently averages 100 dB must reduce its noise level by 10 dB. Assuming that each piece of machinery produces the same amount of noise, what percentage of equipment must be removed? Explain your answer.

3. Broken Crystal Opera singers have been known to set crystal goblets in vibration with their powerful voices. In fact, an amplified human voice can shatter the glass, but only at certain fundamental frequencies. Speculate about why only certain fundamental frequencies will break the glass.

4. Electric Guitars Electric guitars, which use electric amplifiers to magnify their sound, can have a variety of shapes, but acoustic guitars all have the same basic shape. Explain why.

