Section 9.4: Damping and Resonance

Section 9.4 Questions, page 432

1. (a) Damping describes the reduction in a wave's amplitude, either because of energy absorption or destructive interference.

(b) The resonant frequency is the frequency at which a medium vibrates most easily.

(c) Resonance is the condition in which the frequency of a wave equals the resonant frequency of the wave's medium.

2. (a) The two causes of damping are energy absorption by a medium and destructive interference between two or more waves.

(b) Damping can be caused by a medium absorbing wave energy, causing the amplitude of the wave to get smaller. Damping can also occur when destructive interference from superimposed waveforms results in a wave whose resultant amplitude is smaller.

3. The motion of a mass–spring system eventually stops because air resistance and friction in the system reduces the wave energy. This damping reduces the amplitude to zero.

4. Answers may vary. Sample answer:

The purpose of shock absorbers is to quickly dampen any up-and-down motion and keep the car tires from lifting off the road. Shock absorbers work in a similar way to pistons. As the shocks are compressed, energy is absorbed and thermal energy is generated in the compressed air and fluid inside them. This thermal energy can be released as exhaust.

5. Standing waves are a result of an interference pattern of a series of reflected waves. Standing waves occur at one of a medium's harmonics, and since the resonant frequency is one of the medium's harmonics, standing waves are an example of resonance.

6. Answers may vary. One example of damping is bungee jumping where the person hanging by a bungee rope bounces for a while but eventually comes to a stop due to damping. Another example of damping is an echo produced in open air that dies down after a few reflections.

7. Answers may vary. Sample answer:

(a) The Millennium Bridge in London, England was built in 2000. It was quickly renamed the "Wobbly Bridge" as engineers had failed to take into account that pedestrians tended to walk in step. This social coherence created an input frequency acting on the bridge which then started to oscillate. It was quickly closed down until dampening systems were put in place. It reopened again in 2002.

When a tuning fork is struck and brought in contact with the strings inside a piano, the piano starts playing at a resonant frequency.

(b) In the case of the bridge, there is damping due to energy lost as a result of air resistance and the fixed ends of the bridge. In the case of the tuning fork, there is damping due to energy lost as a result of air resistance and the tuning fork.

8. (a) Yes, resonance occurs at one of the harmonics, so the amplitude is maximized.

(b) Yes, I would expect multiple resonant frequencies because there are multiple harmonics.