Resonance

Read from **Lesson 4** of the **Sound and Music** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/sound/u11l4a.html
http://www.physicsclassroom.com/Class/sound/u11l4b.html
http://www.physicsclassroom.com/Class/sound/u11l4c.html
http://www.physicsclassroom.com/Class/sound/u11l4d.html

MOP Connection: Sound and Music: sublevel 5

1. Define or describe the significance of the following terms:

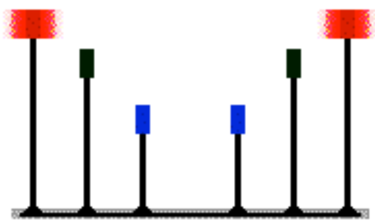
   a. Natural frequency:

   b. Forced vibration:

   c. Resonance:

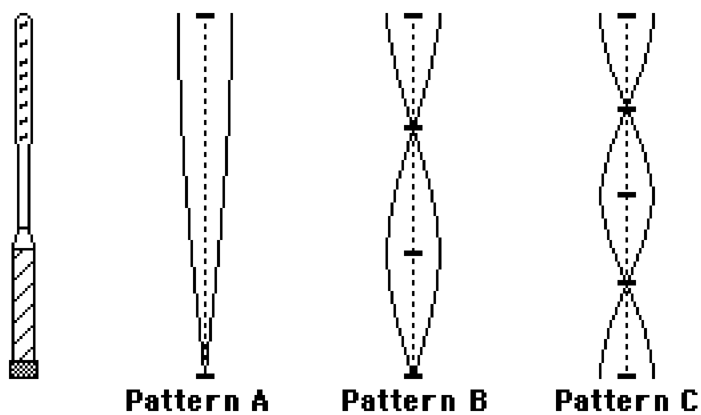
2. Three pairs of wooden dowel rods are mounted on a wooden platform. Small plastic cylinders are attached to their ends; the cylinders are colored red, green and blue. Each pair of dowel rods has a different length. One of the red cylinders is pulled back and let go of, causing it to begin vibrating back and forth with one complete cycle every two seconds. The natural frequency of this dowel rod is ______ Hz.

   a. 0.25 b. 0.50 c. 1.0 d. 2.0



   As the red cylinder vibrates, it forces the other red cylinder to vibrate. This occurs because the two cylinders have the same ___________________ (color, composition, natural frequency). When two objects vibrate together like this ___________________________ is occurring.

3. When a tennis racket strikes a tennis ball, the racket begins to vibrate. There is a set of selected frequencies at which the racket will tend to vibrate. Each frequency in the set is characterized by a particular standing wave pattern. The diagrams below show the three of the more common standing wave patterns for the vibrations of a tennis racket. In each diagram, hash marks are placed at the positions of all nodes and antinodes; label these nodes (**N**) and antinodes (**AN**).



   Compare the wavelength of pattern A to the wavelength of pattern B. Make your comparison both qualitative and quantitative. Repeat for pattern C.

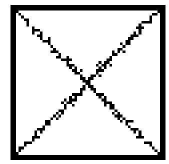
   λ_A _____ λ_B **(<, >, =)** λ_A _____ λ_C **(<, >, =)**

   λ_A = _____ • λ_B **(2, 3, 4, etc.)** λ_A = _____ • λ_C **(2, 3, 4, etc.)**

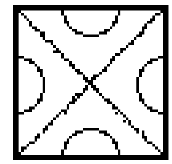
   When the racket vibrates as in pattern A, its frequency of vibration is approximately 30 Hz. Determine the frequency of vibration of the racket when it vibrates as in pattern B and pattern C.

   f_B = ________ **Hz** f_C = ________ **Hz**

4. In a rare moment of artistic brilliance, Mr. Henderson pulls out his violin bow and strokes a square metal plate to produce vibrations within the plate. Often times, he places salt upon the plates and observes the standing wave patterns established in the plate as it vibrates. Amazingly, the salt is aligned along the locations of the plate that are not vibrating and far from the locations of maximum vibration. The two most common standing wave patterns are illustrated at the right. Compare the wavelength of pattern A to the wavelength of pattern B. Place dots along the edge of the plates at all nodal (N) and antinodal (AN) positions; label these positions with an **N** and an **AN**.



Pattern A



Pattern B

When the plate vibrates as in pattern A, its frequency of vibration is nearly 4 000 Hz. Estimate the frequency of vibration of the plate when it vibrates as in pattern B. ______________ Hz

5. A guitar string has a set of natural frequencies at which it vibrates. Each frequency in the set is characterized by a standing wave pattern. The standing wave patterns for a guitar string are characterized by the presence of nodes at the end of the string (where it is clamped down). Each standing wave pattern (and its corresponding frequency) is called a *harmonic*. The first harmonic is the lowest frequency in the set (sometimes termed the *fundamental frequency*), followed by the second harmonic, third harmonic, etc. Draw the standing wave patterns for the first, second, and third harmonics of a guitar string.

1st Harmonic — 2nd Harmonic — 3rd Harmonic

Compare the wavelength of the 1st harmonic to the wavelengths of 2nd and 3rd harmonics.

λ_1 ______ λ_2 (<, >, =) — **λ_1 ______ λ_3 (<, >, =)**

λ_1 = ______ • λ_2 (2, 3, 4, etc.) — **λ_1 = ______ • λ_3 (2, 3, 4, etc.)**

Compare the frequency of the 1st harmonic to the frequencies of the 2nd and 3rd harmonics.

f_2 ______ f_1 (<, >, =) — **f_3 ______ f_1 (<, >, =)**

f_2 = ______ • f_1 (2, 3, 4, etc.) — **f_3 = ______ • f_1 (2, 3, 4, etc.)**

When the guitar string vibrates in the first harmonic ("fundamental frequency"), its frequency of vibration is approximately 200 Hz. Determine the frequency of second and third harmonics.

f_2 = ________ Hz — **f_3 = ________ Hz**

6. Use the diagram below to compare the distance between two adjacent nodes on a standing wave pattern and the wavelength of a wave. Write a sentence comparing these two distances.