Name: Key

Date:

Section C D F

The Masters School
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Physics

Waves III: Calculation of Harmonics

Harmonic Series of standing waves on a vibrating string

1. What are the first three harmonics of a note produced on a 31 cm long violin string if waves on this string have a speed of 274.4 m/s? (3 pts)

$f_n = n\frac{v}{2L}$

$f_1 = (1)\frac{274.4\ m/s}{2(.31)} = 443\ Hz$

$f_2 = (2)\frac{v}{2L} = 2f_1 = 886\ Hz$

$f_3 = (3)\frac{v}{2L} = 3f_1 = 1329\ Hz$

Harmonic Series of a pipe closed at both ends

2. A pipe that is open at both ends has a fundamental frequency of 320 Hz when the speed of sound in air is 331 m/s.
   a. What is the length of this pipe? (1 pt)

$f_1 = 1\frac{v}{2L}$

$2L f_1 = v$

$L = \frac{v}{2f_1} = \frac{331}{2(320)} = .517\ m$

   b. What are the next two harmonics? (1 pt)

$f_1 = 320\ Hz$

$f_2 = 2f_1 = 640\ Hz$

$f_3 = 3f_1 = 960\ Hz$

   c. What is the fundamental frequency of this pipe when the speed of sound in air is increased to 367 m/s due to a rise in temperature of the air? (1 pt)

$f_1 = (1)\frac{v}{2L} = \frac{367}{2(.517)} = 355\ Hz$

3. A flute is essentially a pipe open at both ends. The length of a flute is approximately 66 cm. If all the keys are closed, making the vibrating air column approximately equal to the length of the flute, what is the value of the third harmonic? Assume the speed of sound in the flute is 340 m/s. (3 pts)

$$f_3 = 3\frac{v}{2L} = 3\frac{340}{2(.66)} = 773 \text{ Hz}$$

Harmonic Series of a pipe closed at one end

4. If you blow across the open end of a soda bottle and produce a tone of 250 Hz, what will be the frequency of the next harmonic heard if you blow much harder? (3 pts)

$$f_n = n\frac{v}{4L} \qquad n = 1, 3, 5, 7 \ldots$$

$$f_1 = 250 \text{ Hz}$$

$$f_3 = 3f_1 = 750 \text{ Hz}$$