17.17

The graphs show the periods of the two sound waves. Since frequency f is the inverse of period T,

$$f = \frac{1}{T} \quad \#1$$

Beat frequency f_{Beat} is the difference of two frequencies. Therefore,

$$f_{Beat} = f_2 - f_1 \quad \#2,$$

and from eq #1,

$$f_{Beat} = \frac{1}{T_2} - \frac{1}{T_1} = \frac{1}{0.020\,s/cycle} - \frac{1}{0.024\,s/cycle} = 8\tfrac{1}{3}\ cycles/s.$$

Rounded to two significant figures,

$$f_{Beat} = \boxed{8.3\ Hz.}$$

$\boxed{17.19}$

A beat frequency is the difference between two frequencies

$$f_{beat} = f_2 - f_1$$

and can be positive or negative.

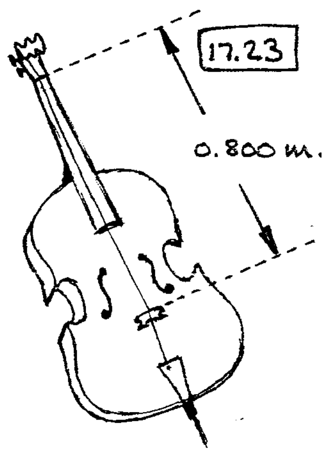
In the first case, when $f_2 = 440\ Hz$ and $f_{beat} = \pm 5\ Hz$,

$$\pm 5\ Hz = 440\ Hz - f_1 \longrightarrow f_1 = 440\ Hz \pm 5\ Hz. = \begin{cases} 445\ Hz \\ 435\ Hz \end{cases}$$

In the second case, when $f_2 = 436\ Hz$ and $f_{beat.} = \pm 9\ Hz$,

$$\pm 9\ Hz = 436\ Hz - f_1 \longrightarrow f_1 = 436\ Hz \pm 9\ Hz = \begin{cases} 445\ Hz \\ 427\ Hz \end{cases}$$

Since the first case requires the guitar string vibrate at either 445 Hz or 435 Hz, and the second case requires that it vibrate at either 445 Hz or 427 Hz, the string must vibrate with a frequency of $\boxed{445\ Hz}$



$f_{fund.} = 65.4\ Hz.$

$m/L = 1.56 \times 10^{-2}\ kg/m.$

$F = ?$

Since $v = \left(\frac{F}{m/L}\right)^{1/2} \rightarrow F = v^2 (m/L)$ #1

we can use eq #1 to determine the tension in the string F if we can find v, the speed of propagation.

$v = \lambda f$ #2

when the string vibrates in its fundamental mode, the portion of the string in vibration is one half of a wavelength. Thus,

$$\frac{\lambda_{fund}}{2} = 0.800m \rightarrow \lambda_{fund.} = 2(0.800m) = 1.60\ m/cycle$$

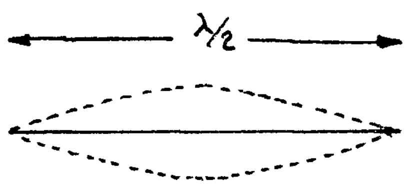
when this value is substituted into eq #2 along with the value for f_{fund}, we obtain

$$v = \lambda_{fund} f_{fund.} = (1.60\ m/cycle)(65.4\ cycles/s) = 104.64\ m/s$$

Now this can be used in eq #1, and

$$F = (104.64\ m/s)^2 (1.56 \times 10^{-2}\ kg/m) = \boxed{171\ N}$$

$\boxed{17.27}$



we will need two formulas to work this problem:

$$v = \sqrt{\frac{F}{m/\ell}} \quad \#1 \quad \text{and} \quad v = \lambda f \quad \#2$$

Substituting eq #2 into eq #1 and squaring both sides of the equation, we obtain

$$(\lambda f)^2 = \frac{F}{m/\ell} \quad \#3 \longrightarrow m/\ell = \frac{F}{(\lambda f)^2} \quad \#4$$

The left side of eq #4 is the linear density of the string and is related to the tension F in the string, the wavelength λ of the standing wave, and the frequency f.

From the information given in the problem,

$(m/\ell)_G = ?$
$(m/\ell)_E = 3.47 \times 10^{-4}\ \mathrm{kg/m}$
$F_G = F_E$
$\lambda_G = \lambda_E$, $f_G = 196.0\ \mathrm{Hz}$, and $f_E = 659.3\ \mathrm{Hz}$

Let's use eq #4 to describe each string:

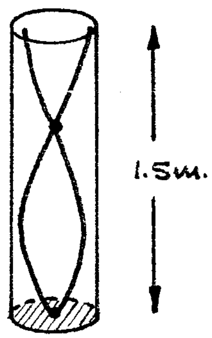
$$(m/\ell)_G = \frac{F_G}{(\lambda_G f_G)^2} \quad \#5 \qquad \text{and} \qquad (m/\ell)_E = \frac{F_E}{(\lambda_E f_E)^2} \quad \#6$$

Dividing eq #5 by eq #6

$$\frac{(m/\ell)_G}{(m/\ell)_E} = \frac{F_G / (\lambda_G f_G)^2}{F_E / (\lambda_E f_E)^2} = \left(\frac{f_E}{f_G}\right)^2$$

$$\therefore (m/\ell)_G = (m/\ell)_E \left(\frac{f_E}{f_G}\right)^2 = \left(3.47 \times 10^{-4}\ \mathrm{kg/m}\right)\left(\frac{659.3\ \mathrm{Hz}}{196.0\ \mathrm{Hz}}\right)^2 = \boxed{3.93 \times 10^{-3}\ \mathrm{kg/m}}$$

$\boxed{17.35}$



In a tube open at only one end, the third harmonic corresponds to the first overtone – which means that the length of the tube sustains $3\lambda/4$ (i.e. three-fourths of a wavelength).

$$\therefore \quad \frac{3\lambda}{4} = 1.5\text{m.} \longrightarrow \lambda = 2.0\text{m.}$$

Since the distance between adjacent node & antinode is $\frac{\lambda}{4}$, the answer is $\boxed{0.5\text{m}}$

$\boxed{17.49}$

$f_{fund.} = 400\text{ Hz}.$

a. For a vibrating string,

$$f_{1st\,o.} = f_{2nd\,h.} = 2f_{fund.} = 2(400\text{ Hz}) = 800\text{ Hz}.$$
$$f_{2nd\,o.} = f_{3rd\,h.} = 3f_{fund.} = 3(400\text{ Hz}) = 1200\text{ Hz}.$$
$$f_{3rd\,o.} = f_{4th\,h.} = 4f_{fund.} = 4(400\text{ Hz}) = 1600\text{ Hz}.$$

b. The relationship between overtones & harmonics is the same for a cylindrical pipe open at both ends and a vibrating string. Therefore the answers for part b are the same as for part a.

c. For a cylindrical pipe that is open at only one end,

$$f_{1st\,o.} = f_{3rd\,h.} = 3f_{fund.} = 3(400\text{ Hz}) = 1200\text{ Hz}.$$
$$f_{2nd\,o.} = f_{5th\,h.} = 5f_{fund.} = 5(400\text{ Hz}) = 2000\text{ Hz}.$$
$$f_{3rd\,o.} = f_{7th\,h.} = 7f_{fund.} = 7(400\text{ Hz}) = 2800\text{ Hz}.$$