Q- A shower stall measures 86.0 cm x 86.0 cm x 210cm long. When you sing in the shower, which frequencies will sound the richest (because of resonance)? Assume the stall acts as a pipe closed on both ends, with nodes at opposite sides. Assume also that the voices of various singers range from 130 Hz to 1500 Hz. Let the speed of sound in the hot shower stall be 355 m/s.

Two waves with equal amplitude and frequency traveling in opposite direction in a medium produces standing waves. The limited medium between two walls behaves as a pipe closed at both ends and the natural frequency of the standing wave can produced between then will be such that there are nodes at the two walls and anti-node at the center. Hence the distance between the walls will be equal to $\lambda/2$ where λ is the wavelength of the standing waves. This gives the wavelength of the standing wave will be 2*L where L is the distance between the two opposite walls. As we know that the wave velocity is given by $c = n\lambda$ where n is the frequency, we have the natural frequency of the standing waves can be produced between two opposite walls will be

$$n = c/2L = 355/ (2*0.86) = 206.4 \text{ Hz}$$

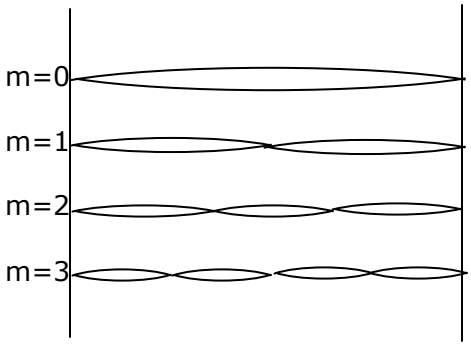
The different overtones in a pipe closed at both ends are given by

$$n_m = (m+1)*n$$

When the sound of frequency which is equal to the natural frequency or one of the overtones is produced, it will create the standing waves of the same frequency and due to resonance the intensity of the sound will increase a lot.

Such frequencies for the walls distant 86 cm = 0.86 m will be

Natural frequency	n = 206.4 Hz.
First overtone	$n_1 = 2*206.4 = 412.8$ Hz
Second overtone	$n_2 = 3*206.4 = 619.2$ Hz
Third overtone	$n_3 = 4*206.4 = 825.6$ Hz
Fourth overtone	$n_4 = 5*206.4 = 1032$ Hz
Fifth overtone	$n_5 = 6*206.4 = 1238.4$ Hz
Sixth overtone	$n_6 = 7*206.4 = 1444.8$Hz



Next overtone will have frequency more than 1500 Hz.

Similarly for the standing waves between the floor and ceiling the neural frequency of the standing wave will be

$$n = c/(2L') = 355/(2*2.10) = 84.5 \text{ Hz}$$

This is less then the minimum 130 Hz of the range and will not produce any resonance

The different overtones will be give by again $n_m = (m+1)*n$

First overtone	$n_1 = 2*84.5 = 169$ Hz
Second overtone	$n_2 = 3*84.2 = 253.5$ Hz
……	
……..	
Seventeenth overtone	$n_{17} = 17*84.2 = 1431.4$ Hz

The next frequency will be grater then the maximum on the range and hence any note with frequency equal to first to seventeenth overtones will produce resonance.