Answer #259

We will take the three cases in order.

Case (a): The answer is (b): lower in frequency by a factor of two. Click your mouse on the photograph below to hear the answer. Note that in this case the wavelength is exactly twice as long.

![Photograph of a tube](image)

Case (b): The answer is (a): one octave higher. Click your mouse on the photograph below to hear the answer. Well, almost one octave higher. The difference has to do with the difference in end correction for the two tubes. The actual loop length for the original tube is $L + 2e$, where $L$ is the length of the tube and $e$ is the end correction. For the shorter tube, the end correction is the same, so its loop length is $L/2 + 2e$. Note that the end correction for the shorter tube has a greater relative effect on the loop length

$$L + 2e < 2(L/2 + 2e) = L + 4e,$$

making the wavelength of the shorter tube a bit longer than half that of the longer tube. So the frequency is a bit low - not quite an octave above the original longer tube. In fact, the frequency is about 6% low, one half-step in musical terms.

![Photograph of a tube](image)

Case (c): The answer is (c): the same frequency. Click your mouse on the photograph below to hear the answer. Note that in this case, the length of the original (open) tube is $L + 2e$, and the length of the shorter tube is $L/2 + e$. Thus the loop lengths of the two tubes, respectively, are $L + 2e$ and $2(L/2 + e) = L + 2e$, exactly the same. However, because the shorter tube is a closed tube, it supports only odd harmonics while the longer tube supports all harmonics, so the shorter tube has a timbre that is a bit like that of a square wave.

![Photograph of a tube](image)

Note that for case (a) above the loop lengths are in the ratio of exactly 2 to 1, including the end effect, so the frequencies are exactly a factor of two, or one octave, apart.
For questions and comments regarding the Question of the Week contact Dr. Richard E. Berg by e-mail or using phone number or regular mail address given on the Lecture-Demonstration Home Page.