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.

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 lonnger tube. In fact, the frequency is about 6% low, one half-step in musical terms.

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.

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.

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