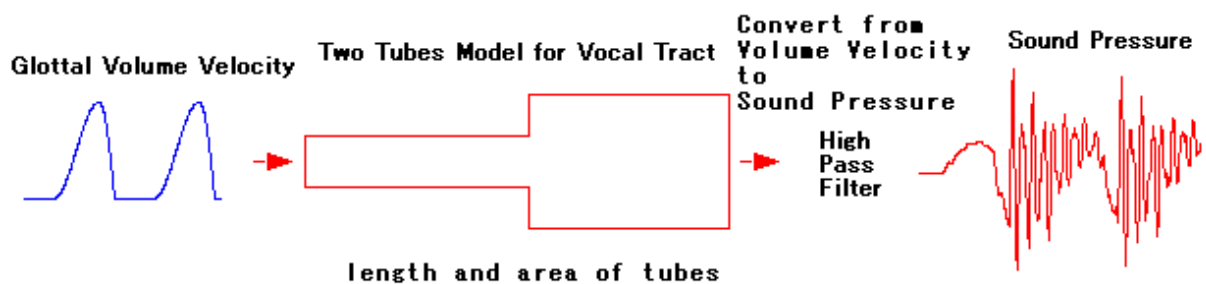


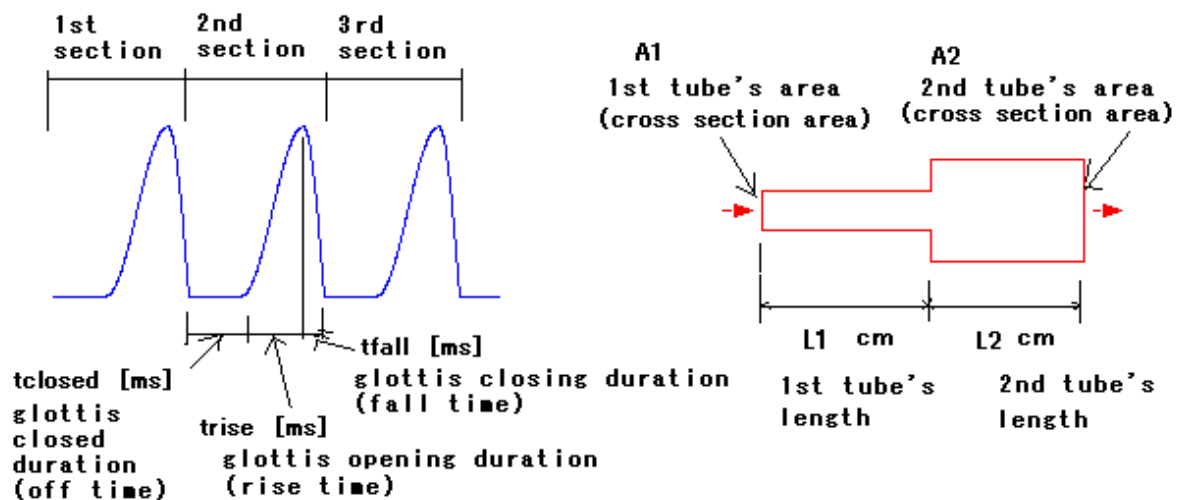
Speech Waveform Generation by Two Tubes Model and Glottal Volume Velocity

To understand the process of human's speech sound generation, a very simplified model which consists of two tubes and similar signal to air flow volume velocity at glottal as sound source, is explained. Simplified speech sound generation process is as follows. To regulate air flow from lungs at glottal, waveform in the left figure below, of which color is blue, is generated as source. And then, the waveform is led to two tubes which is imitated human vocal tract. In this, tubes is supposed to be resonator which has some resonating wave length. In middle figure below, there are combined two box of color red. Box width means tube length and box height means cross section area of tube. At right edge of combined two box of color red, like human mouth, air flow volume velocity is radiated out. To pick sound up with microphone which responses per pressure, air flow volume velocity is converted to sound pressure, that is right figure waveform red color, by a very easy way to do high pass filter. Sound pressure is waveform which imitated to human speech.



Actual human speech generation is more complex and there are many differences from this simplified model. However, this simple model, can make sound even though its quality is bad.

In this model, as a major way, by change of length or cross section area of tubes, you can adjust sound tone like phonetic symbol /a/ or /e/. The figure below which consists of two color red boxes imagines combined two tubes. 1st tube is length is $L1$ cm and cross section area is $A1$ cm^2 . 2nd tube is length is $L2$ cm and cross section area is $A2$ cm^2 . At left edge of 1st tube, comparing with human, connection with glottal, glottal regulated air flow leads into 1st tube. Reflection at each tube edge and air flow movement time of distance of tube length, cause some modes of resonance. At right edge of 2nd tube, comparing with human, mouth or lip, variant air flow radiates out from it.



As glottal regulation, closed duration, opening duration, and closing duration can be set. Sum of these three duration relates to pitch period. If pitch period is short, you will hear higher tone sound, contrariwise period long, lower tone. Repeating close and open of glottis, air flow volume velocity is uncontinuous, showing blue color waveform in the left figure above.