Waves in pipes and string

1. a. What is close organ pipe? Discuss various modes of vibration of the air column in close organ pipe and hence write the expression for the frequency of n^{th} mode. 3
   b. What is tone and note in sound? Determine the length of the pipe closed at one end in which the air column will vibrate with fundamental frequency of 160 Hz taking the speed of sound in air to be 340m/s. Also find the frequency of third overtone. [$\mathbf{0.53m, 1120Hz}$] 3
2. a. Explain briefly the phase reversal from the closed end and open end of an organ pipe. 2
   b. What do you understand by 'harmonics' and 'overtones' in the case of organ pipe? 2
   c. Draw the waveform for third harmonics in close organ pipe. If the fundamental frequency is f, what is the frequency of third overtone in close pipe? 2
   d. A close pipe is 0.5m long. What is the fundamental frequency and third Harmonics if velocity of sound is 350 m/s? [**175Hz, 525Hz**] 2
3. Two open organ pipes of equal lengths are resonated with two tuning forks of different frequencies. The waves patterns in the pipes are shown below:
   a. Find the harmonics and overtones in each of the given pipe A and B. 2
   b. If pipe B resonates at a frequency of $288\ Hz$, what can be the resonating frequency in pipe A?

   c. The sound produced by an open organ pipe is of higher quality than that by a closed organ pipe. Explain. Discuss various modes of vibration of the air column in close organ pipe and hence write the expression for the frequency of n^{th} mode. 3
4. a. Fundamental frequency of oscillation of a close pipe is 400 Hz. What will be the fundamental frequency of oscillation of an open pipe of the same length? [$\mathbf{800Hz}$] 2
   b. Name two instruments based on the superposition of waves. 1
   c. For sound waves of frequency 2500Hz, it is found that two nodes are separated by $20cm$, with three antinodes between them. Determine the wavelength and the speed in air.[$\mathbf{0.133m, 330m/s}$]2
5. a. What is resonance? Suggest some examples. 2
   b. The frequency of fundamental note of a closed organ pipe and that of open organ pipe are the same. What is the ratio of their length? 2
   c. An open organ pipe of length 30cm sounding at third harmonics is in unison with a close organ pipe sounding at third overtone. Find the length of close pipe. [$\mathbf{35cm}$] 2
   d. Determine the shortest length of a closed pipe and an open pipe that will resonate in the air at 0^oC with a frequency of 175 vibrations per second. [$Velocity\ of\ sound\ = 330m/s.$] [**0.47m, 0.94m**] 2
6. a. What is end correction? How is end correction related to radius of pipe? 2
   b. In a resonance tube experiment, the first and the second resonance positions were observed at 17cm and 52.6 cm respectively. The frequency of tuning fork is 512Hz and the temperature was 27^oC. Calculate the velocity of sound in air at 0^oC. Calculate the end correction of the tube. 3
   c. A uniform tube, $60cm$ long stands vertically with its lower end dipping into water. When the length above water is $14.8cm$, and again when it is $48cm$, the tube resounds to a vibrating tuning fork of frequency 512Hz. Find the lowest frequency to which the tube will resound when it is open at both ends. [**267Hz**] 3
   d. A cylindrical pipe of length 28cm closed at one end is found to be at resonance when tuning fork of frequency 864Hz is sounded near the open end. Calculate the end correction when the speed of sound is 340m/s. [$\mathbf{1.5cm}$] 2
7. a. An organ pipe is tuned to a frequency of 440Hz when the temperature is 27^oC. Find its frequency when the temperature drops to 0^oC. Assume both ends of the pipe open. [**419.7Hz**] 2
   b. One day when the speed of sound 340m/s, the fundamental frequency of close organ pipe is 220Hz. The second overtone of this pipe has the same wavelength as third harmonic of an open pipe. How long is the open pipe? [**0.31m**] 2
   c. If one end of the open organ pipe is closed, how will the fundamental frequency change? 2
   d. What is resonance tube apparatus, open end or close end pipe? If oil is used instead of water in resonance tube, how does the frequency change? 2
   e. Why tuning fork has two prongs? What type of wave is generated in steam and prongs of the fork? 2
8. a. What type of wave is generated in a stretched string when plucked? Write an expression for velocity of transverse wave in a stretched string. If the tension on the string is increased 4 times, how would the velocity of wave through it change? 3
   c. Discuss various modes of vibration in a stretched string and hence write the expression fir the frequency of n^{th} mode. What happens to the frequency of vibration of a string under tension if,
      i. Thickness of the string is doubled? 1
      ii. Tension on the string is doubled? 1
   e. Calculate the velocity of a transverse wave travelling in a copper wire of radius $1mm$ stretched under a load of $1.4Kg$. (Density of copper= $8.8gm/cm^3$). [**22.4m/s**] 2
   f. A stretched string emits a fundamental note of $256Hz$. Keeping the stretching force constant and reducing the length of the wire by $10cm$, the frequency becomes $320Hz$. Calculate the original length of the wire. [$\mathbf{500cm}$] 3
9. a. State and explain the laws of vibration on stretched string. Sketch necessary graphs. 2
   b. A guitar consists of several strings of different thickness. Why it is made so? Explain. 2
   c. A string $1.5m$ long is made of steel (density $7.7 \times 10^3\ Kg/m^3$ and Young's modulus $2 \times 10^{11}Pa$). It is maintained at a tension that it produces a strain of 1% in the string. What is the fundamental frequency of the transverse vibration of the string? 2
   d. A steel wire of length $40cm$ and diameter $0.25mm$ vibrates transversely in unison with a tube, open at each end and of effective length $60cm$, when each is sounding its fundamental note. The air temperature is 27^oC. Find the tension in the wire. Given, the velocity of sound in air at 0^oC is 331m/s and the density of steel is $7800kg/m^3$. [**20.5N**] 3
   e. A sonometer wire is stretched by a cylinder having a density of $800kg/m^3$ to produce a fundamental frequency of $256Hz$. What will be the new fundamental frequency if the cylinder is completely immersed in water? [**239Hz**] 3
10. Two open pipes of same length produce sounds of different frequencies if their diameters are different. Why? Stringed instruments are provided with hollow boxes. Why? 2+2
11. A wire of linear mass density of $5 \times 10^{-3}Kg/m$ is stretched between two rigid supports with a tension of $450N$. The wire resonates at a frequency of $420Hz$. The next higher frequency at which the same wire resonates is 490Hz. Find the length of the wire. [**2.14m**] 3