**MODULE 3: WAVES AND THERMODYNAMICS**

**Worksheet – Sound Waves**

Diagram

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 Diagram From: [Wikimedia Commons](https://www.google.com/search?q=wikimedia+commons+diagram+of+longitudinal+wave+no+labels&tbm=isch&ved=2ahUKEwjLls7HlaPxAhVFm0sFHTzdAgwQ2-cCegQIABAA&oq=wikimedia+commons+diagram+of+longitudinal+wave+no+labels&gs_lcp=CgNpbWcQA1CIwQhYvPEIYJH3CGgAcAB4AIABpAGIAf4LkgEEMC4xMJgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclient=img&ei=9JvNYMvMLsW2rtoPvLqLYA&rlz=1C1GCEU_enAU874AU874#imgrc=hD25X91Np9NG_M&imgdii=pSBcj1LLZazPyM)  
  
 Define each of the variables in the diagram of a longitudinal wave above.

1. Examine the animations below showing the displacement-distance and pressure-distance graphs for the longitudinal wave set up in the pipe closed at one end in the top animation.

Qr code

Description automatically generated  
 Diagram From: [Wikimedia Commons](https://www.google.com.au/search?q=wikimedia+commons+graphs+comparing+pressure+and+displacement+waves+for+sound&safe=strict&tbm=isch&source=iu&ictx=1&fir=ikvhiTbHz_OT9M%252CdnIW8M-4weZv3M%252C_&vet=1&usg=AI4_-kQlhZgaqmjRxbnowY9TJxPybVeHTA&sa=X&ved=2ahUKEwjM8IO5yJ3xAhWtyTgGHc4oCm0Q9QF6BAgLEAE#imgrc=Yl-l19_psbao1M) **-** Animation courtesy of Dr

Dan Russell, Grad. Prog. Acoustics, Penn State – Additional

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Describe what is happening in the bottom animation – the pressure-distance graph.

1. A wire of length 140 cm and mass 52.0 g is stretched by hanging a load of mass 16.0 kg on it. Calculate the frequency of the fundamental mode of vibration of the wire.
2. A pipe open at both ends is 40 cm long. Find the frequencies of the 2nd and 3rd harmonics, taking the speed of sound in air as 340 m/s.
3. A pipe closed at one end is 1.20 m long. This pipe is sounded on a day when the speed of sound is 336 m/s. Calculate the frequency of its fundamental and first overtone.
4. Two organ pipes, one open and one closed, when producing their fundamental modes are giving the same note. What is the ratio of their lengths?
5. Two open organ pipes, one of which is 0.60 m long and the other 0.61 m long, produce 19 beats in 4.00 second when sounded together. Find the velocity of sound.
6. Define the term reverberation as it is used in reference to sound.
7. Find the frequency of the note heard by the station master standing at rest on a train station as a train travelling at 22.2 m/s (a) approaches and (b) recedes from the station. The frequency of the train whistle is 750 Hz and the speed of sound is 330 m/s.
8. A high-quality loudspeaker is advertised to reproduce at full volume, frequencies from 30 Hz to 18,000 Hz with uniform sound level ±3 dB. That is, over this frequency range, the sound level output does not change by more than 3 dB for a given input level. By what factor does the sound intensity change for the maximum change of 3 dB in output sound level? (**Hint:** Let the average sound intensity be **I1** and the average sound level be **b**1. Then the maximum intensity, **I2**, corresponds to a sound level **b**2 = **b**1 + 3 dB. We can then use our equation that relates sound level and sound intensity.)