Phys 341 Midterm   Name SOLUTIONS

Friday 2018.02.16   11:00-11:50

Attempt all 10 questions. Write on this paper.

The midterm is "closed book", except for one page of *handwritten* notes. Both sides OK.

Obey all UBC's usual examination rules.

For questions 1 to 3, fill in the gaps in each paragraph, choosing from the set of words/phrases at the start of each question (each of which may be used more than once) to form the most correct, precise statements.

1. **amplitude, medium, frequency, gas, liquid, longitudinal, medium, solid, transverse, wavelength.**

   A sound wave is a longitudinal disturbance, generated by something vibrating, propagated through a medium. The speed of the wave depends entirely on the medium. The original vibration frequency is preserved throughout the wave, but the Wavelength will vary if the medium changes. Our perception of loudness depends on both the amplitude and the frequency of the wave.

2. **acoustic pressure, acoustic velocity, amplitude, energy, frequency spectrum, integers, pattern, pressure, sound waves, velocity, voltage, wavelength.**

   The output of a microphone is a Voltage that is proportional to acoustic pressure. The analog-digital converter in a computer converts this signal into a time-ordered sequence of integers, which a Fast Fourier Transform (FFT) code converts into another sequence that represents the frequency spectrum of the original signal.

3. **acoustic displacement, acoustic energy, acoustic pressure, acoustic velocity, amplitude, decreases, even, frequency, half, increases, integer, numbers, odd, radiate, signal, sound waves, spectrum, voltage, wavelength, whole.**

An acoustic standing wave exists in a uniform tube, closed rigidly at each end. At each end there must be an acoustic velocity node and an acoustic pressure antinode. Thus the length of the tube must be an integer number of half wavelengths of the standing wave. If the tube is opened at one end, the fundamental frequency decreases and the open end is an approximate acoustic pressure node. The last sentence can only be an approximation, because the open end of the tube can now radiate acoustic energy to the environment.

For questions 4 to 6, circle all correct statements.

4. A siren in the middle of an open field produces a pure tone at 3 kHz. You listen at the edge of the field. Now the tone changes frequency to 10 kHz with no change in acoustic power. What you hear is:

[✓ **(a)**] Quieter

(b) Louder

(c) Neither quieter nor louder

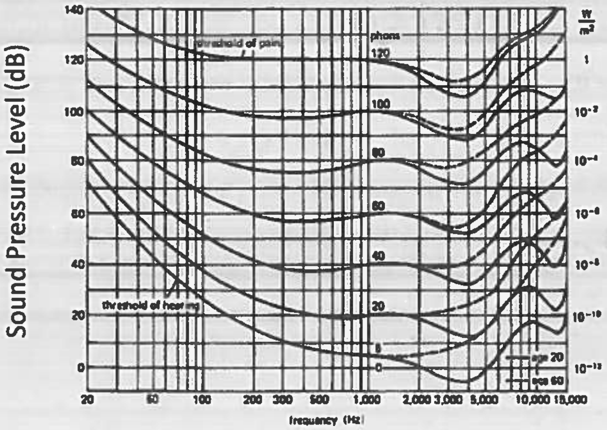


FIGURE 10–1 Curves of equal sound level loudness over the entire audio range of frequencies. Vertical scales of sound intensity levels, in decibels (far left); loudness levels, in phons (middle)

Intensity in W/m^2 (right)

(4. continued) The tone changes back to the original 3 kHz, and then moves to 100 Hz, again with no change in acoustic power. What you hear is:

[✓ **(d)** Quieter]

(e) Louder

(f) Neither quieter nor louder

5. A taut uniform string, length *L*, is held rigidly at each end, mounted on a soundboard. The string is plucked with a plectrum in the centre of the string. The sound spectrum:

(a) has two harmonics.

(b) has one frequency, twice the fundamental frequency.

(c) has one frequency, half the fundamental frequency.

[✓ **(d)** has a harmonic spectrum of frequencies 1,3,5,7... times the fundamental frequency.]

(e) has a harmonic spectrum of frequencies 2,4,6,8... times the fundamental frequency.

6. Circle all true statements about the concept of acoustic velocity in a wind instrument:

(a) It is the speed of airflow caused by a player blowing into a wind instrument.

(b) It is the thermal motion of air molecules; this is why wind instruments are out of tune if played cold.

[✓ **(c)** It is the small collective motion of air molecules at audible frequencies superimposed on motions (a) and (b).]

[✓ **(d)** It has to be zero at the rigid end of a pipe.]

(e) It has to be zero at the open end of a pipe.

For questions 7-10, draw a simple diagram to illustrate your answer, as clearly and precisely as you can.

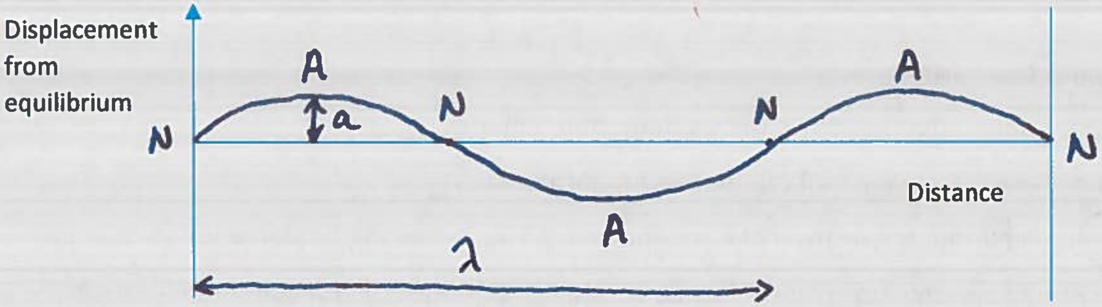
7. Draw a diagram of a standing wave on a taut string that has three times the fundamental frequency. Indicate:

   (a) The nodes (with arrows and letter "N"s)

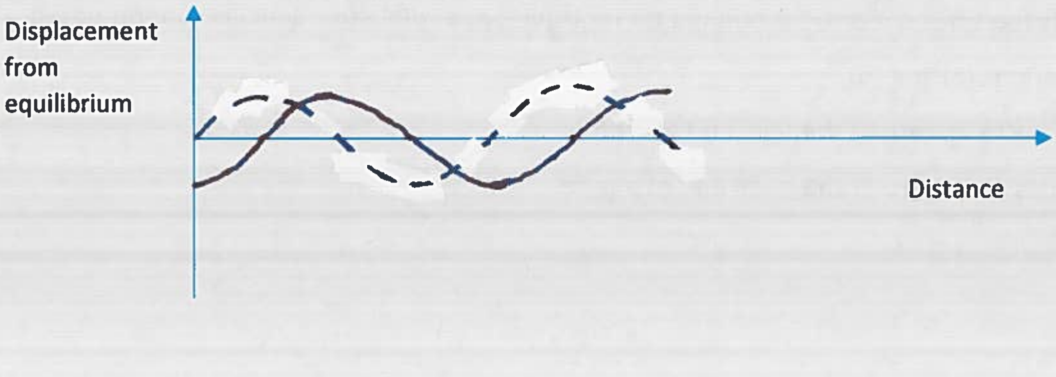
   (b) The antinodes (with arrows and letter "A"s)

   (c) The wavelength (with the length of a double-ended arrow and the Greek letter "λ")

   (d) The amplitude (with the length of a double-ended arrow and the letter "a")

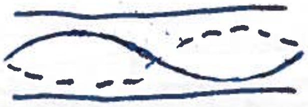


8. Draw a diagram of a sinusoidal transverse travelling wave at an instant in time. Use a solid line. Show with a dashed line, superimposed on the same diagram, the same wave a quarter of a period later, if the wave is moving toward the left.



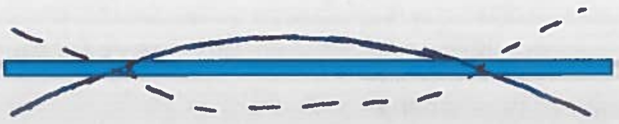
9. Below is an illustration of the acoustic velocity in a tube open at both ends when the air is vibrating at its fundamental frequency. The solid blue line shows the velocity at one maximum, and the dotted line shows the other maximum, half a period later.

(a) Draw a similar picture illustrating the acoustic pressure for the first two standing waves inside a uniform tube, open at both ends.



(b) Repeat for acoustic velocity in a tube closed at one end and open at the other.

10. Draw simple pictures illustrating the shapes of the first two bending vibration modes of a uniform, flat wooden bar (like the piece of spruce I showed in class). Superimpose the shapes on the diagrams of non-vibrating bars shown edge-on below. Show the two extreme displacements, half a period apart.



Mode 1

Mode 2