PRACTICE FINAL 2

PHYS 1240

Sound and Music

Summer 2019

Name: Solutions

Start Time: 11:00 AM

End Time: 12:35 PM

Total Allotted Time: 1 hour and 35 minutes

Permitted Materials: one $8\frac{1}{2}$"×11" sheet of paper with anything written on both sides, calculator without internet access, pencils, erasers

*Instructions: Write your name on the front page of the exam, but DO NOT open the exam booklet until told to do so. When told to begin, you may open the exam and begin working until time is called. Answer **all** questions in the space provided in the test booklet, and show all your work.*

This exam has four (4) parts, each worth 25% of the total exam grade.

Useful Information

SI Prefixes:

milli (m)	0.001	10^{-3}
centi (c)	0.01	10^{-2}
deci (d)	0.1	10^{-1}
kilo (k)	1,000	10^{3}
mega (M)	1,000,000	10^{6}

Conversion factors:

$1\ \text{m} \approx 3.28\ \text{ft}$

$1\ \text{hr} = 60\ \text{min} = 3600\ \text{s}$

$1\ \text{atm} \equiv 101{,}325\ \text{N/m}^2 \approx 14.7\ \text{psi}$

$1\ \text{Pa} \equiv 1\ \text{N/m}^2$

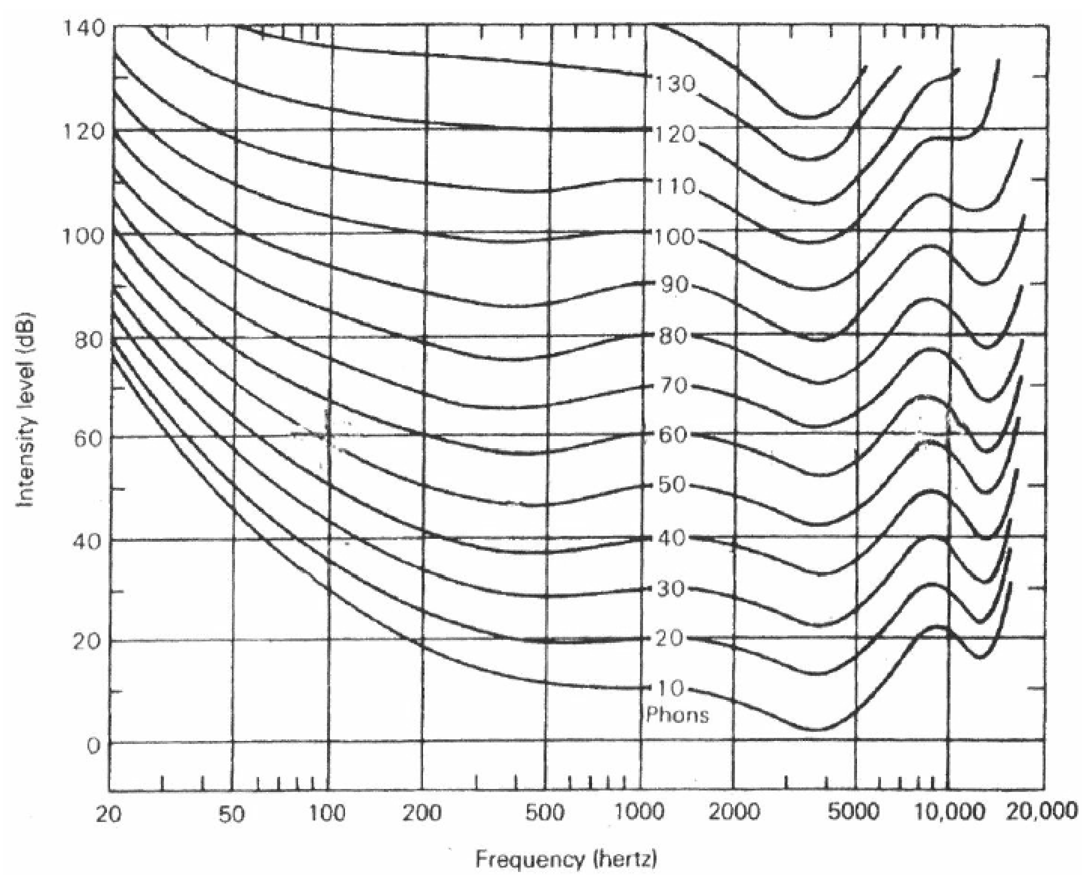
$1\ \text{Hz} \equiv 1\ \text{s}^{-1}$

Formulas:

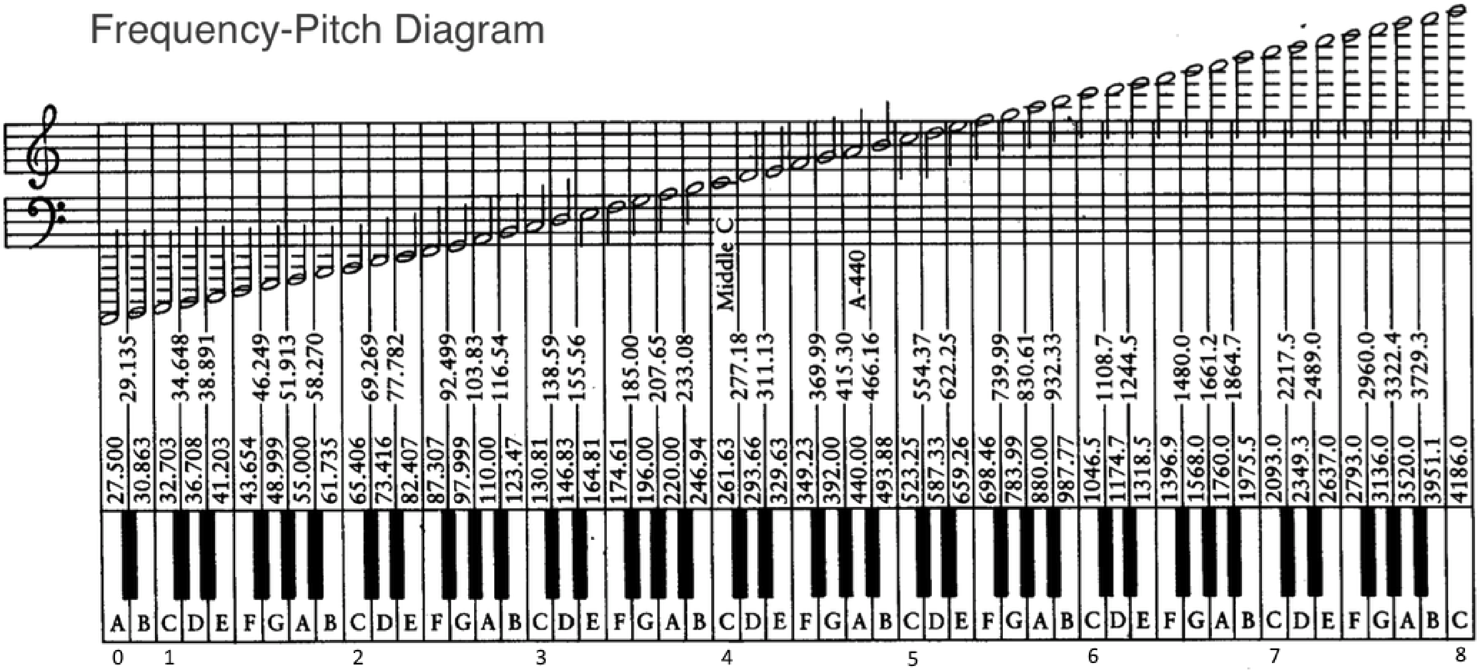
$$v = \lambda f \qquad v[\text{m/s}] = 331 + 0.6\,T[^\circ\text{C}]$$

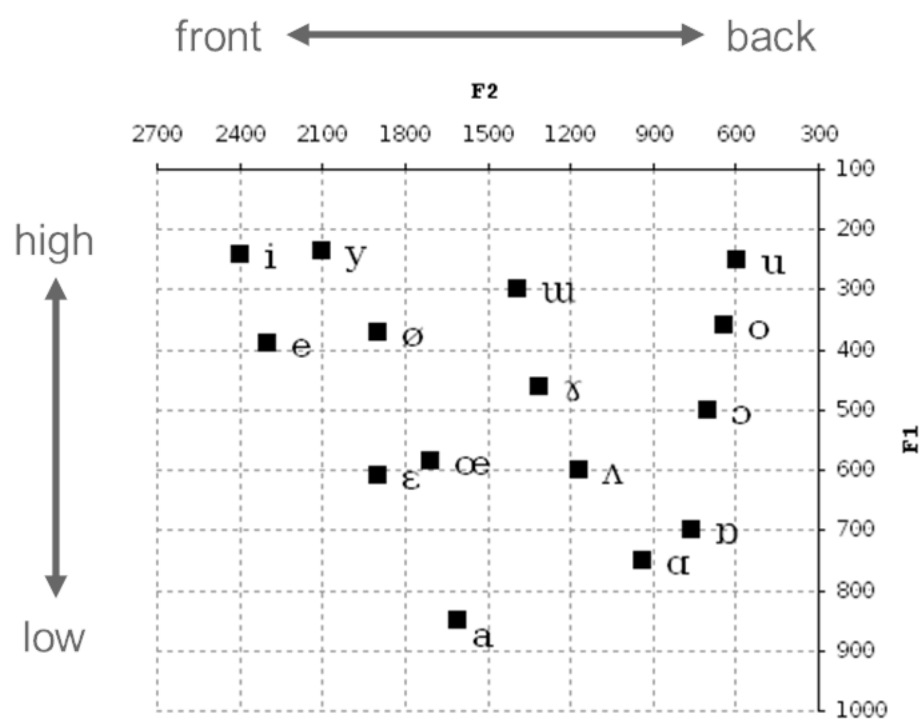
$$f_n^{\text{open-open}} = n\frac{v}{2L} \qquad f_n^{\text{closed-open}} = n\frac{v}{4L}$$

$$f_n^{\text{string}} = \frac{n}{2L}\sqrt{\frac{T}{m/L}} \qquad SIL_1 - SIL_2 = 10\,\log\left(\frac{I_1}{I_2}\right)$$



Frequency-Pitch Diagram





Section 1: Matching

Match the following 7 effects to a real-life example or application of each effect. For each numbered example, write the letter choice of its corresponding effect in the space provided to the left of each question number. All effects match exactly one example.

C	1.	Hearing the bass notes on a piano at the right pitch even though their first harmonic is absent	A. Doppler effect
E	2.	Slip-grip motion of a bow on a string	B. Octave equivalence
F	3.	A flag fluttering in the wind	C. Missing fundamental effect
G	4.	Blowing air into a clarinet	D. Helmholtz resonance
D	5.	Amplification of the sound of a guitar string from the guitar's body	E. Helmholtz motion
B	6.	Hearing a continuously falling Shepard tone as it subtly doubles the falling frequencies	F. Vortex shedding
A	7.	A police radar gun detecting a car's velocity as the reflected sound changes pitch	G. Bernoulli effect

Section 2: Multiple Choice

Answer the following 7 questions with the most correct choice. Write your letter choice in the space provided to the left of each question number.

C 8. You are strolling along Pearl Street during the Fourth of July when off in the distance you begin to see some fireworks. Being a PHYS 1240 student, you decide to figure out how far the fireworks are from you. First, you note that it is about 77°F outside (25°C). What is the speed of sound in the air around you?

A) 337 m/s
B) 343 m/s
C) 346 m/s
D) 349 m/s

E 9. After you see the last firework go off, you count 1 second before you hear its boom. Assuming the speed of light is instantaneous, approximately how far away from you is the fireworks display?

A) 1.7 km
B) 350 km
C) 0.7 km
D) 17 km
E) 0.35 km

A 10. As you keep walking, you notice a street musician with two speakers set up to a keyboard. You remember that two speakers will create interfering sound waves. If you are standing the exact same distance from each speaker, will the sound be louder or quieter than when you stand in other places?

A) Louder
B) Quieter
C) No interference will occur

D 11. In the middle of the street musician's song on the keyboard, they change keys, from F♯ Major to C Major. The song still sounds pretty good to your ears, so what tuning system is likely being used?

A) Just tuning
B) Pythagorean tuning
C) Meantone temperament
D) Equal temperament
E) There is no tuning system – the musician is just that good

A 12. As you stand listening to the street musician, you hear a mosquito flying by, humming in the same key as the street musician's song, with a pitch C_5 (an octave above middle C). How many times is the mosquito beating its wings per second?

A) 523
B) 262
C) 440
D) 1.9
E) None of the above

E 13. The musician ends the song with the highest note on a piano, C_8. What is the period of this note, in milliseconds?

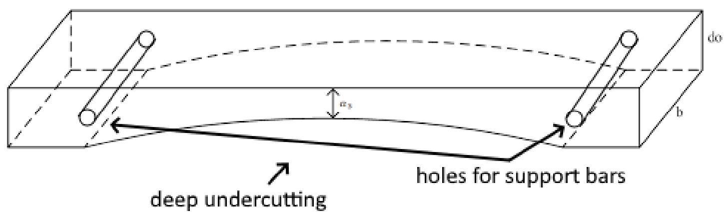
A) 2.4 ms
B) 0.48 ms
C) 1.1 ms
D) 0.11 ms
E) None of the above

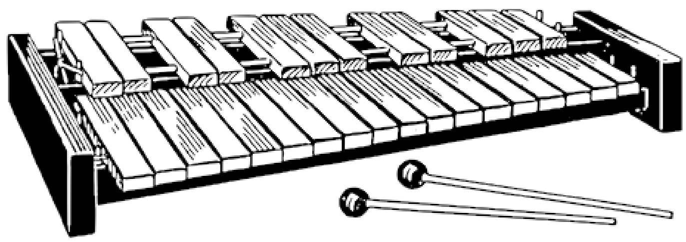
C 14. As the street musician finishes the song and you begin to clap, you notice that there are quite a few people around you clapping as well. If there are 10 people total clapping (including yourself), how many more decibels are being produced than if you were clapping alone?)

A) 3 dB
B) 6 dB
C) 10 dB
D) 100 dB
E) None of the above

Section 3: Instrument

Answer the following 6 short answer questions. If the question requires a sketch, be sure to label all relevant parts and axes, if necessary.





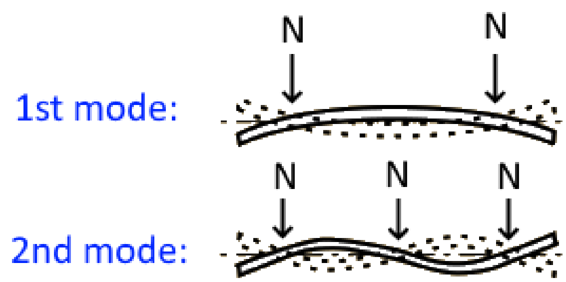
15. The diagram above shows the design of a simple xylophone. To what category of instruments does the xylophone belong (e.g. aerophone, chordophone, etc.)?

Idiophone

16. Explain in no more than a sentence or two how sound is initially produced on this instrument and how a change in pitch is achieved for different notes.

Each bar is struck by the mallet, which causes the bar to vibrate as a free-free beam. Different pitches are achieved by changes in the length/size of the bars - longer bars will produce notes with lower frequencies.

17. Draw the fundamental mode and the second mode of vibration for a xylophone bar, showing the bar at its maximum displacement from equilibrium in each case. Label all nodes in your diagrams.



18. Where should support bars be placed so that the first mode will most effectively be sounded? Indicate this location on your diagram of the first mode above.

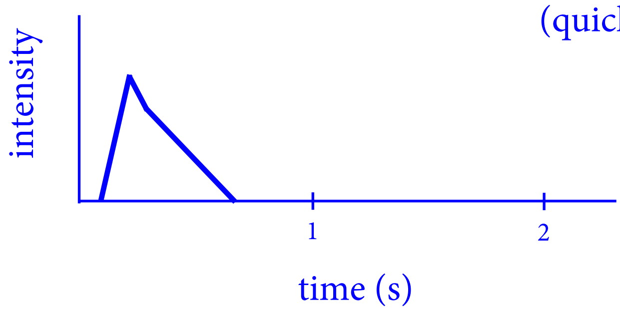
Support bars should be placed at the nodes of the 1st mode.

19. Why does the bottom of a xylophone bar have a deep undercutting? What effect does this have on the spectrum?

An ideal free-free beam has an inharmonic spectrum, but when the shape is modified, the 2nd mode's frequency becomes an integer multiple of the 1st mode's frequency (specifically, f_2=3f_1), so the xylophone can produce tones instead of noise.

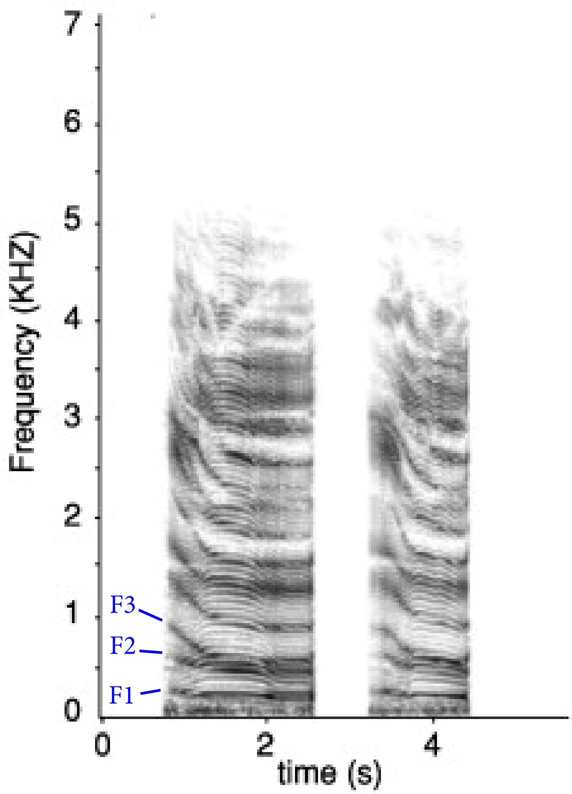
20. Make a plot of the approximate sound envelope for a single note played on the xylophone. Label your axes.

(quick attack and no sustain)



Section 4: Spectrogram

Answer the following 5 short answer questions related to the spectrogram below.



The spectrogram shown above is a recording of two roars from a Scottish red deer (Reby & McComb 2003). Much like a human, the red deer has a vocal tract with a larynx that can produce formants.

21. On the spectrogram above, indicate the location of the first three formants at the beginning of the first roar, labelling them "F1," "F2," and "F3." (Note that there is some noise in the recording below 150 Hz independent of the red deer's roar.)

22. What is the highest frequency that the microphone used for this recording is able to detect?

    About 5 kHz

23. Assume the red deer's vocal tract can be modelled as a closed-open tube. Using the first formant frequency at the beginning of the first roar as the fundamental, estimate the length of this vocal tract. Assume $v_{sound} = 350$ m/s.

$$L = \frac{v}{4 f_1} = \frac{350 \text{ m/s}}{4(250 \text{ Hz})} = 35 \text{ cm}$$

24. Unlike humans, whose larynxes are fixed at the base of the skull, red deer are able to extend the length of their vocal tracts significantly by moving their larynxes down their necks. With the model of a closed-open tube, this will change the formant frequencies. During the course of one roar, does the red deer's vocal tract get larger or smaller?

The frequency decreases, so the length of the vocal tract must increase (the larynx moves farther down as the deer stretches out its head to roar).

25. Find the frequencies of F1 and F2 for the very beginning of the first roar. What vowel would this sound like? Is it likely that we would hear this vocalization as "neee," "raaa," or "mooo?"

F1 has a frequency of about 250 Hz, and F2 has a frequency of about 600 Hz. Looking at the vowel chart on pg 3, this corresponds to the "u" sound. Thus, the red deer's roar sounds most like a "mooo."

——— *End of Examination* ———