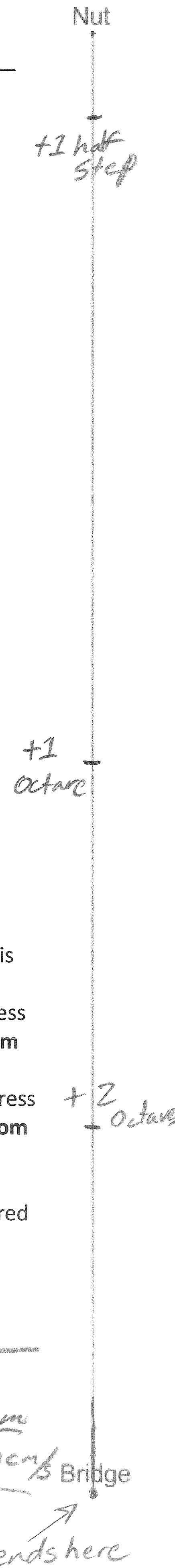
Physics 100 (Stapleton)
Instrument Practice Test
(Answers)

Name: Answers



Formulas and information:

- Ratio of a note's frequency to the frequency of a note one half-step lower ≈ 1.0595
- $v = \lambda f$
- $V_{object} = V_{sound} * (f_{ahead\ of\ source} - f_{behind\ source}) / (f_{ahead\ of\ source} + f_{behind\ source})$
- $V_{object} = V_{sound} * (2^{(\Delta pitch/12)} - 1) / (2^{(\Delta pitch/12)} + 1)$ --- where Δp = absolute value of the drop in pitch, measured in half steps

1. What is the relationship between the frequencies of two notes that are one octave apart?

   The higher note has twice the frequency of the lower note.

2. In the modern music of the Western world, an octave is broken up into __**12**__ equal divisions.

3. To find the exact frequency of a musical note one half-step higher than a known note, you must multiply the known frequency by exactly __**$2^{1/12}$**__.

4. A musical note with a frequency of 130.81Hz is a C.

   a. What is the name of the note that is one half step higher than C? **C sharp ($C^{\#}$)**
   b. What is the frequency of that note? **138.6Hz**

   $$130.81Hz\left(2^{1/12}\right) = 130.81Hz\,(1.0595) = 138.6\,Hz$$

5. The line on the right represents the string of an instrument. The nut and bridge are labeled.
   a. When the string is plucked or strummed, without pressing on the string, what length of string is vibrating? **24cm**
   b. If you want to play a note that is one octave higher than the open string, where should you press the string to the fingerboard? Draw a mark in that location, and label it "+1 octave." **12cm from nut**
   c. If you want to play a note that is two octaves higher than the open string, where should you press the string to the fingerboard? Draw a mark in that location, and label it "+2 octaves." **18cm from nut**
   d. If you want to play a note that is one half-step higher than the open string, where should you press the string to the fingerboard? What is the distance of this location from the nut (measured in cm)? **1.35cm from nut** See solution below (1.3cm is ok.)
   e. Draw a mark in this location, and label it "+1 half-step." **See line**

To go up one octave, move halfway to bridge from current position

* There's a simpler way to do this, but I'm not going to show you. If you can figure it out, congratulations!

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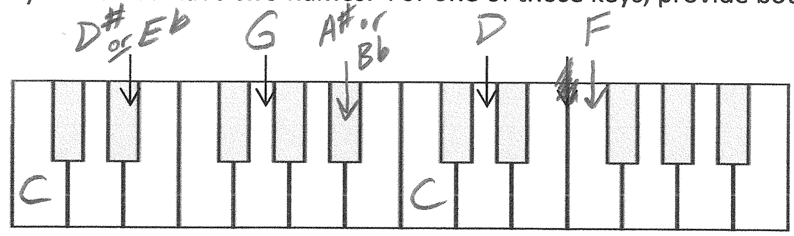
(1) Arbitrarily choose a frequency for the open string → 200hz
(2) Wavelength of standing wave = 2x string length = 2(24cm) = 48cm
(3) Wave speed in this string is → $v = \lambda f = 48cm(200hz) = 9{,}600cm/s$
(4) Frequency one half step higher = (200Hz)(1.0595) = 211.9 Hz
(5) Wavelength for that frequency → $\lambda = \frac{v}{f} = \frac{9600cm/s}{211.9hz} = 45.3cm$
(6) String length = $\frac{\lambda}{2} = \frac{45.3cm}{2} = 22.7cm$ (7) Distance from nut = 24cm − 22.7cm = 1.3cm

6. Label a "C" on the piano keyboard below.
7. Label the other indicated keys.
8. Some of the keys you labeled have two names. For one of those keys, provide both names.



9. If you play a one octave musical scale, how many notes do you play? **8**

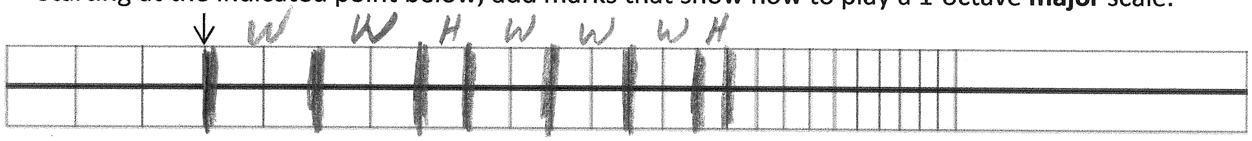
10. Which major scale can be played on a piano without using any black keys? **C major**

11. Which minor scale can be played on a piano without using any black keys? **A minor**

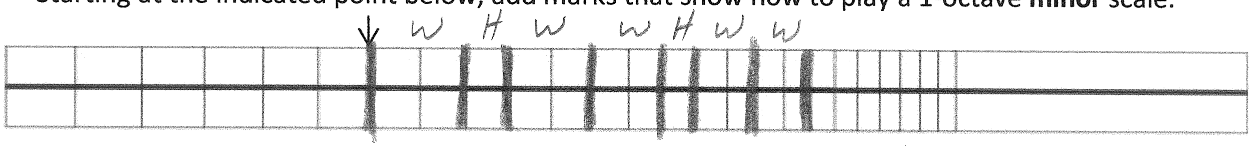
12. The picture below shows how frets are arranged on a guitar. By following the fret marks, a musician can play an ascending chromatic scale of 12 **equal** half-steps. In a sense, the half steps are equal, but the spaces between fret marks are obviously not the same size. What, then, is "even" about these half steps?

The ratio of each frequency to the next frequency is always equal. That ratio is always 1:1.0595.

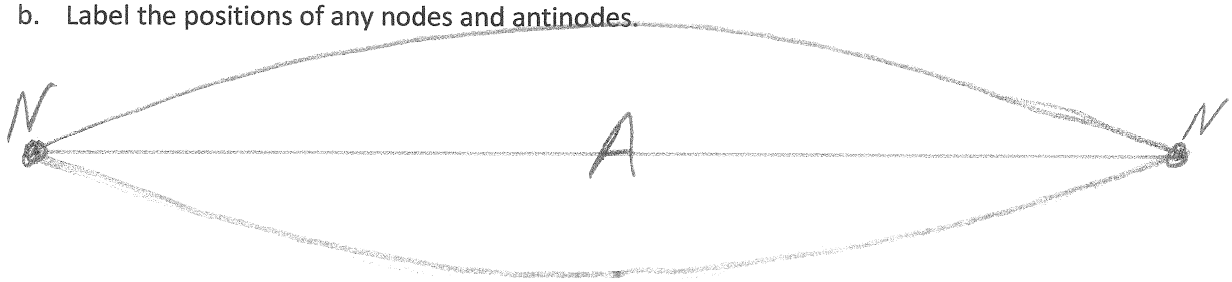
13. Starting at the indicated point below, add marks that show how to play a 1-octave **major** scale.



14. Starting at the indicated point below, add marks that show how to play a 1-octave **minor** scale.

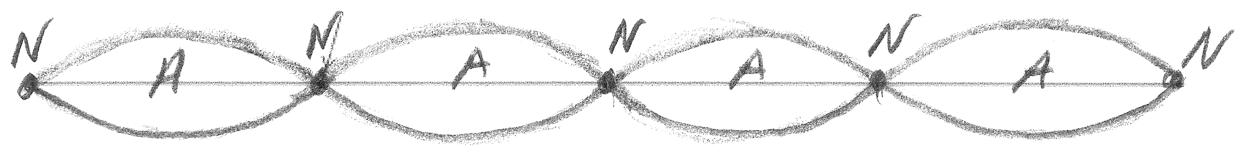


15. The string below is shown in rest position. Assume that the two ends are fixed in position; one end represents the nut, and the other end is the bridge.
   a. Draw the standing wave that will form when you pluck or strum the string, without pressing the string down in any location.
   b. Label the positions of any nodes and antinodes.



16. Again, the diagram below shows an instrument string. The ends are fixed in position (one is the nut and one is the bridge). If you pluck the string and then lightly touch your finger to the point indicated below (without pressing the string against the finger board), you will change the string's frequency.

a. Draw the new standing wave pattern that is produced when you place your finger lightly at point A.
b. Label all nodes and antinodes.
c. What happens to the wave's frequency, compared with the frequency produced in the diagram above? Frequency is 4x as high



17. Describe a nearly fool-proof method of determining the key in which a song is played. **The last note of a song is almost always the "tonic." In other words, if a song ends on a G, the song is probably in the key of G.**

18. The speed of sound in air is about **340** m/s or **760** mph.

19. You are standing by a race track, listening to an approaching car. When you listen to the approaching car, you hear a frequency of 400Hz. You keep listening, and you notice that, after the car passes, the frequency that you hear drops to 200Hz. This is a 12 half-step drop. What was the speed of the car as it passed you?

Method #1

$$V_{object} = V_{sound} \frac{(f_{ahead} - f_{behind})}{(f_{ahead} + f_{behind})} = 760mph \frac{(400Hz - 200Hz)}{(400Hz + 200Hz)}$$

$$V_{object} = 760mph \left(\frac{200Hz}{600Hz}\right)$$

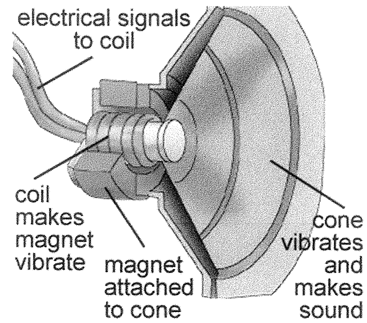
$$V_{object} = 253mph$$

Method #2

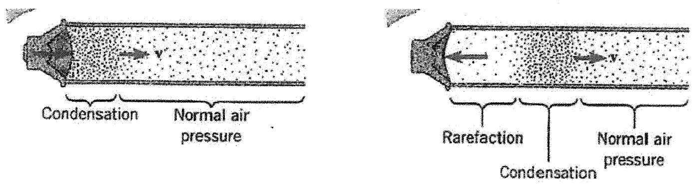
$$V_{object} = V_{sound} \frac{\left(2^{\frac{\Delta p}{12}} - 1\right)}{\left(2^{\frac{\Delta p}{12}} + 1\right)} = 760mph \frac{\left(2^{\frac{12}{12}} - 1\right)}{\left(2^{12/12} + 1\right)} = 760mph \frac{(2-1)}{(2+1)}$$

$$= 760mph \left(\frac{1}{3}\right) = 253mph$$

20. Explain how electricity causes a speaker cone to move in and out.



- **When electric current flows in a coil of wire, the coil of wire will push or pull a nearby magnet.**
- **When the current flows one way, the coil pulls the magnet; when it switches directions, the coil pushes the magnet.**
- **The speaker cone pushes and pulls the nearby air, creating compressions and rarefactions. *[Compressions are called "condensation" in the diagram below.]***



21. Explain how a magnetic guitar pickup sends signals to an amplifier.

- **When a magnet moves near a coil of wire, it makes electric current flow through the coil of wire.**
- **In the case of the pickup, the moving magnet is the string, which is magnetized by the magnet in the pickup.**
- **As the string moves back and forth, the direction of electric current switches.**

22. What does an amplifier do?
It takes the tiny voltage coming from the pickup, and it multiplies that voltage to provide enough power to drive the speakers.

23. Why is the pickup wire coated with enamel? **Enamel does not conduct electricity. The enamel coating ensures that electricity flows through the length of the wire, instead of jumping straight to the next coil, causing a "short circuit."**

24. Why does the pickup wire need to be wound so many times? **Each coil increases the voltage of the electric current that is produced.**

25. Why does the pickup wire need to be so thin? **So it can be wound many, many times.**

26. Why won't the pickup work if the wire gets broken? **Current won't flow if the wire breaks**