Sounds of Music - Key

Allen Chang and Klebb Chiang

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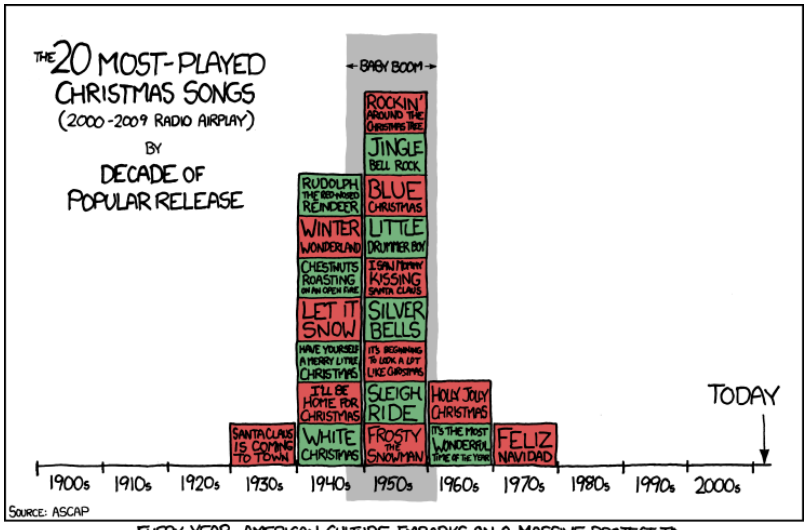

Directions:

- You will have about 50 minutes.
- A scientific calculator, a binder, writing utensils, and your brain are permitted. No graphing calculators, cell phones, or other electronic devices are allowed during the test.
- Assume conditions are 1 atm and 20°C unless otherwise specified; that is, that the speed of sound is 343 m/s.
- For calculations, always use significant figures.
- You may use any third-party application, such as Discord or Zoom, to communicate with your partners. Voice/video call is permitted.

Page:	2	3	4	5	6	7	Total
Points:	15	16	14	13	13	4	75
Score:							

1 Multiple Choice - 15 Points

1. (1 point) Which of the following is the length of time that it takes for a wave to complete one cycle?

   A. Wavelength B. Amplitude **C. Period** D. Frequency

2. (1 point) Which of the following is defined as the number of cycles of a wave per second?

   A. Wavelength B. Amplitude C. Period **D. Frequency**

3. (1 point) Which of the following is defined as the range of frequencies above the limit of human hearing?

   A. Infrasonic **B. Ultrasonic** C. Supersonic D. Subsonic

4. (1 point) Which of the following are longitudinal waves?

   A. P-Waves **B. Sound Waves** C. Light Waves D. Waves on a String

5. (1 point) Approximately, which of the following is the longest wavelength of wave that a human can hear?

   A. $0.017m$ B. $0.17m$ C. $1.7m$ **D.** $17m$

6. (1 point) Convert 12 dB to intensity, in $\frac{W}{m^2}$.

   A. $1.585 \cdot 10^{-11} \frac{W}{m^2}$ B. $3.170 \cdot 10^{-11} \frac{W}{m^2}$ C. $1.585 \cdot 10^{-12} \frac{W}{m^2}$ D. $3.170 \cdot 10^{-12} \frac{W}{m^2}$

7. (1 point) Sound would travel the fastest in which of the following mediums?

   A. Steel B. Water C. A vacuum D. Air

8. (1 point) What is the relationship between sound intensity and sound pressure?

   A. $I \propto \sqrt{p}$ B. $I \propto p$ **C.** $I \propto p^2$ D. $I \propto p^3$

9. (1 point) Which of the following correctly describes the range of notes of a typical piano?

   A. C0-A7 **B. A0-C8** C. C1-A8 D. A1-C9

10. (1 point) A typical piano has how many keys?

    A. 82 B. 84 C. 86 **D. 88**

11. (1 point) "Sol" in fixed do solfege corresponds to which of the following notes?

    A. A B. C C. E **D. G**

12. (1 point) Which of the following correctly describes the D Dorian scale?

    A. D, E, F, G, A, B, C, D
    B. D, E, F♯, G, A, B, C♯, D
    C. D, E, F, G, A, B♭, C♯, D
    D. C, D, E, F, G, A, B, C

13. (1 point) What is the kazoo, according to the Hornbostel-Sachs system of instrument classification?

    A. Idiophone B. Aerophone **C. Membranophone** D. Chordophone E. Electrophone

14. (1 point) A clarinet can best be described as having what kind of air column?

    A. Cylindrical, Open at Both Ends **B. Cylindrical, Closed at One End** C. Cylindrical, Closed at Both Ends D. Cone, Open at Both Ends E. Cone, Open at One End

15. (1 point) Which of the following is a compound time signature?

    A. $\overset{3}{4}$ B. $\overset{4}{4}$ C. $\overset{2}{2}$ **D.** $\overset{12}{8}$

2 Definitions - 10 points

Write a definition for each of the following terms.

16. (2 points) Arpeggio

Solution: An arpeggio is a chord whose notes are played separately rather than at the same time.

17. (2 points) Hemiola

Solution: A hemiola is a three-to-two beat pattern, where three beats are played against two.

18. (2 points) Dal Segno

Solution: Dal Segno is a sign that tells the musician to go back to the dal segno sign and play to the end.

19. (2 points) Stringendo

Solution: To play stringendo is to play faster.

20. (2 points) Ruhig

Solution: Ruhig means calm.

3 Short Answer - 20 Points

A man is alive. This is what happened to his ear.

JC is a 33 year old man ☝, presenting to the doctor's office with a fever, headache, muffled hearing, trouble walking, and insomnia. He hadn't slept for the past 2 days. He tells the doctor that he started having symptoms a few days prior, after waking up from a nap. The doctor quickly concludes that he likely does not have COVID-19 due to the absence of a sore throat, dry cough, and other relevant symptoms. It is concluded that he likely has an ear infection. The man is not amused.

21. (2 points) Based on this information, what part of the ear is infected - inner, middle, or outer ear?

Solution: Inner Ear

22. (2 points) What crystals are generally responsible for a proper sense of balance?

Solution: Otoconia

The man takes some antibiotics, but comes back to the doctor in three months, complaining that he's still hearing a G in one ear and a D sharp in the other ear when listening to music. The doctor is taken aback to see he has an infection in his other ear, which is experiencing draining.

23. (2 points) Through what should the fluid be draining through instead?

Solution: Eustachian Tube/Auditory Tube/Pharyngotympanic Tube

24. (2 points) What specific part of his ear is probably afflicted?

Solution: Eardrum/Tympanic Membrane/Myringa

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25. (2 points) The standing wave of a violin string, 33.0cm long, travels at $504\frac{m}{s}$. What is the frequency of the sixth harmonic of the string?

Solution: 4580 Hz

26. (2 points) The length of an open-ended tube is 88.0cm. What is the fundamental frequency of the tube?

Solution: 195 Hz

27. (2 points) Amazingly, Jacob's point-mass glider travels at a speed of $700\frac{m}{s}$ during launch. At this point in time, what is the angle between the Mach wave and the glider?

Solution: 29.3°

28. (2 points) Consider a 1L water bottle, which is an ideal Helmholtz resonator. If its neck is 12.00cm long and its neck has an area of 5.000 cm^2, what frequency does it vibrate at?

Solution: 111.4 Hz

29. (2 points) Consider a 632°C room filled with pure Argon gas, with molar mass 40.0 amu. What is the speed of sound in this room?

Solution: $560\frac{m}{s}$

30. (2 points) A 10-watt speaker sits on a table in front of Allen. If Allen sits 8.000m away from the speaker, how loud is it to him in dB?

Solution: 100.9 dB

4 Free Response - 30 Points

There are lots of different ways you can tune.

31. (3 points) Using 12-tone equal temperament, compute the pitch of an F5, given that A4 is 440.00 Hz. Then, compute it using Pythagorean tuning. Compare the two values and describe why they're different.

Solution: 12T ET: 698.46 Hz, Pythag: 695.31 Hz. They're different because ET uses the same ratio ($\sqrt[12]{2}$) between each half step while Pythagorean uses whole number ratios built from 3/2, or perfect fifths. The A to F would be a minor sixth, $2^{8/12}$ in ET and 128/81 in Pythagorean.

+1 for each frequency, +1 for distinguishing the two tuning systems (additive)

32. (3 points) Just intonation is famous for being horrendously out of tune if you tried to scale it. Use the ratios 3/2 (or 2/3) for perfect 5ths, 4/3 (or 3/4) for perfect 4ths, and 5/4 (or 4/5) for major 3rds to play C4 G4 D5 A4 E4 C4. Compute the ratio between the 2nd C4 and the 1st: $C4_2 : C4_1$. What phenomenon is this? Why does it occur?

Solution: The answer is $\boxed{81/80}$. This is a syntonic comma (or comma pump), which occurs because the ascending and descending intervals multiplied together are not the same. Another way to think about it is that a perfect 4th down should be the same as a perfect 5th up, but it clearly isn't in this case.

+1 for answer, +1 for "syntonic comma" or "comma pump", +1 for explaining why it happens. (additive)

33. (4 points) Allen plays first violin in an orchestra. It is perfectly in tune on an open string on a A4 (440.00 Hz). In orchestra, he plays with the second violins, who are playing an A4 (440.00 Hz). Allen plays an equal tempered C#5 (554.37 Hz) on the A string, which is 32.50 cm long. How many millimeters must Allen shift his finger in order to be in tune with 5-limit just intonation relative to the second violins? In which direction? Justify your answer.

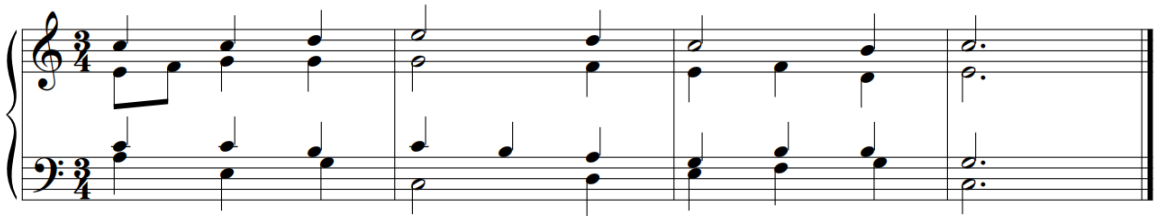
Solution: The answer is $\boxed{2.05\text{mm}}$.

5-limit just intonation tells us that our desired frequency is $440.00 \times \frac{5}{4} = 550.00$ Hz. $550 < 554.37$, so he needs to increase the effective length of the string (ie. shift away from the bridge, or something similar).

The original effective length of the string was $\frac{440}{554.37} \times 32.50 = 25.795$ cm.

The new length we want is $\frac{4}{5} \times 32.50 = 26.00$ cm. Thus he needs to shift by their difference or, 2.05 mm.

Consider the following progression, taken from a Bach chorale, but with some voice leading errors.



34. (3 points) Identify the key (ie. "F# Major"), and the cadence in the last two chords. Cite specific parts of the chorale to justify your answer.

Solution: C Major (+1); clear by cadence

Perfect Authentic (+2); It's a V-I in C, chords are root position, C's in the soprano and bass of I chord.

Points awarded if and only if justification is included.

35. (5 points) Identify/correct the errors in voice leading in this exercise. You may want to analyze Roman Numerals first, though it is not required.

Solution: Doubled leading tone in penultimate chord, easy fix is drop the tenor down to G.

Parallel 8ths between alto & bass in meas. 3 beats 1-2, and there is an augmented 4th between the tenor and bass. You can fix by dropping the alto to a D and tenor to an A.

+1 for each error, +1 suggestion on how to fix each error; +1 extra for getting both

Some grading notes: "tritone" or "diminished 5th" or similar is not correct, and they aren't errors on their own in the first place! A missing note in a chord is not an error. Answers must be precise to receive credit.

36. (2 points) What kind of nonharmonic tone is shown in the tenor line in measure 2? How do you know?

Solution: Unaccented passing tone (+1); the major 7th doesn't really make sense, and it bridges the C to A, both of which are functional/harmonic. (+1 for an accurate reason)

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37. (3 points) You probably know that the beat frequency between two tones f_1 and f_2 is $|f_1 - f_2|$, usually a small number. What happens to the *amplitude* of the composite sound as $f_1 \to f_2$?

Solution: The amplitude $\boxed{\text{increases}}$. This is primarily due to *resonance*, which increases the amplitude through constructive interference. //

+1 for answer, +1 for resonance (describe and/or name), +1 for constructive interference (describe and/or name) //

(+1 bonus if you do this like a crazy person) For those curious, mathematically speaking, beat phenomena is described by the differential equation $mx'' + kx = F_0 \cos \omega t$, which has solution

$$x = \frac{2F_0}{m(\omega_0^2 - \omega^2)} \sin \frac{(\omega_0 - \omega)}{2} t \sin \frac{(\omega_0 + \omega)}{2} t$$

if we choose our initial conditions carefully. Notice that as $\omega \to \omega_0$, the coefficient $\frac{2F_0}{m(\omega_0^2 - \omega^2)}$ grows without bound, giving us a wave that continuously increases in amplitude.

38. (3 points) Briefly describe the name and how of each of the three pedals on a typical grand piano, from left to right, change the overall sound of the instrument. Explain how each pedal modifies the piano specifically to achieve the new sound.

Solution: Award points for mentioning each of the following things:

1/3 - Soft Pedal/Una Corda

1/3 - Makes it softer/changes timbre

1/3 - Moves the hammers to the side, so fewer strings are hit

1/3 - Sostenuto Pedal

1/3 - Lets pianist select specific notes to sustain

1/3 - Bar that holds specific hammers up

1/3 - Sustaining Pedal/Damper Pedal

1/3 - Makes strings continue vibrating even after the pianist has let go of the key

1/3 - Releases dampers from strings

39. (4 points) First, explain the phenomenon of missing fundamentals. Then, outline the process of creating a missing fundamental of 449 Hz.

Solution: A missing fundamental is where a sound's overtones imply a certain fundamental frequency but doesn't contain the fundamental itself. To produce a missing fundamental of 449 Hz, we could play pure frequencies that are integer multiples of 449, such as 898 Hz, 1347 Hz, etc.

+2 for correct definition, +2 for describing process of making one

5 Tiebreaker

Klebb sometimes [tries to] play alto saxophone. What is the loudest that Klebb can play, to the nearest 0.01 dB? Your score will be $\min\{\frac{\beta}{10G}, \frac{G}{10\beta}\}$, where β is the actual loudness and G is your guess.

Solution: 115.36 dB is the answer!