C - Sounds of Music C Exam - Scilympiad Practice - Nov 7 Country-wide SO Practice - 11-07-2020

Welcome to the Sounds of Music exam! The exam will be 50 minutes long.

This test was written by Allen Chang (builderguy135, AC) and Caleb Chiang (Klebb). If you have any questions or feedback, please contact allenchangscioly@gmail.com or calebrong@gmail.com.

This exam contains an aural section. Teams must make sure that they have a method of listening to music, such as headphones or speakers.

Please follow directions! Enter only numerical answers for calculations unless otherwise specified (i.e. no units, 3 decimal places, etc
This is to streamline the grading process. **You will be penalized for formatting your answers incorrectly.**

A device portion of the event will be run, but is completely optional. The device portion will be scored separately and will not impact the team's exam score. Teams will record and uploa videos of their build portion during the day of competition. A codeword will be announced at the beginning of the competition **here** at 8:00 AM PT. Students will have until 4:30 PM PT to record and submit one video. The pitch score will be graded using regional level rules. Thus, a pitch that is 10 cents away from the target frequency will receive full points.

While playing the scale or the song, the person playing the instrument, as well as the instrument itself, must be on the camera. It is also preferable that the camera shows how the instrument is being played - for example, the camera should show the student's fingers if playing on a violin.

If needed, a parent, supervisor, or other person may record the video for the student.

Video instructions:

1) At the beginning of the video, teams will speak the codeword out loud.

2) Teams will verbally answer the following questions regarding the construction of their device:

- What is the name of the instrument?

- How does the instrument produce sound?

- How is the instrument played?

- How was the instrument built? Provide a general description of the tools and materials used to build the device.

3) Teams will announce the scale that they are playing and the note that they will start on.

4) Teams will play the scale, holding each note for at least five seconds each.

5) If the team decides to attempt the bonus, the bonus note will be announced.

6) The bonus note will be played and held for at least five seconds.

7) Teams will play "Twinkle Twinkle Little Star".

8) Complete the Google Form, https://forms.gle/EgR63VdcpQWJj9uM7 (https://forms.gle/EgR63VdcpQWJj9uM7) (https://forms.gle/KqFjFqb8PKRkppGt7)

The codeword for the Sounds of Music device submission is "THE LICK". You may say "the lick" or you can sing it out loud, if you'd like. We will give you 1 bonus point if you play **The Lick** on your instrument!

v = 343 m/s
γair = 1.4
ρair = 1.225 kg/m3
Universal gas constant R = 8.31 J/mol*K

Good luck!

Section 1: General Sound Principles
The hills are alive...with the sound of ...uh...sound.

- The Sounds of Music, or something

For questions 1-3, use the following information.

Sophia sings a middle C with an intensity of 73dB.

1. (1.00 pts) What is the wavelength of this note?

- A) 264cm
- B) 2.64cm
- C) 132cm
- D) 1.32cm

2. (2.00 pts) What is the intensity of this note in W/m^2?

- A) 2.0 * 10^-5 W/m^2
- B) 2.0 * 10^-6 W/m^2
- C) 3.0 * 10^-5 W/m^2
- D) 3.0 * 10^-6 W/m^2

3. (2.00 pts) What is the pressure amplitude of this note?

- A) 0.103 Pa
- B) 0.130 Pa
- C) 0.301 Pa
- D) 0.310 Pa

4. (1.00 pts) Which of the following terms is best defined as a segment of a wave with low pressure?

- A) Compression
- B) Crest
- C) Rarefaction
- D) Trough

5. (2.00 pts) In a standing wave, a(n) [1] is a point on the wave of maximum displacement and a(n) [2] is a point on the wave of minimum displacement.

antinode | node

6. (2.00 pts)
Andrew releases two pendulums. If the second pendulum has a period five times that of the first, what is the ratio between the length of the second pendulum and the length of the first?

- A) 1/25
- B) 1/5
- C) 1
- D) 5

E) 25

7. (3.00 pts)
A conical pendulum rotates with a constant speed in a circle around the rod. What is the period of a conical pendulum with length 5m if the angle between the string and the center rod is 30°? Express your answer to the nearest 0.01. Do not include units.

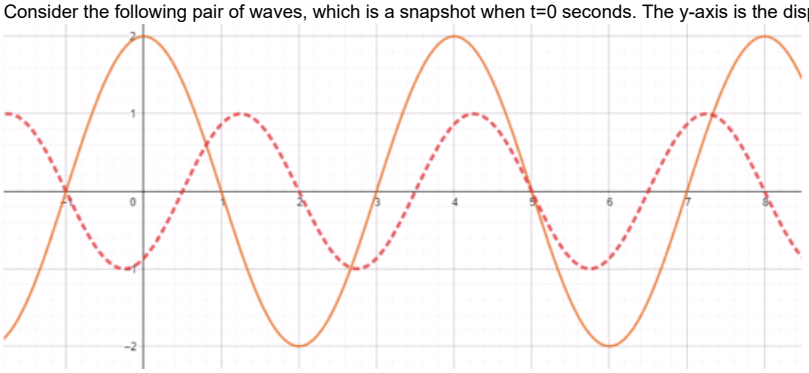
4.18

8. (2.00 pts)
Allen and Jason are chucking a speaker around. On one particular throw, Allen throws the speaker, which is playing a pure tone of frequency *f*, at a speed of 10 m/s directly towards Jason, but his aim is a bit off. As a result, Jason runs forward towards the speaker at a speed of 6 m/s before catching it. Then, the frequency that Jason hears while running can be written as *(m/n)f* Hz, where *m* and *n* are relatively prime positive integers. Compute *m+n*.

682

For questions 9-11, use the following information.

Consider the following pair of waves, which is a snapshot when t=0 seconds. The y-axis is the displacement in mm, and the x-axis is the position along the wave itself in m.



9. (2.00 pts) The angular wavenumber *k* of the solid/orange wave can be written as *(m/n)π*, where *m* and *n* are unitless relatively prime positive integers. Compute *m+n*.

3

10. (2.00 pts) Find the smallest positive **integer** position (x-value) on the graph such that the sum of the two waves' displacement is zero.

5

11. (1.00 pts) Compute the beat frequency between the red and orange waves. Do not enter units.

1

For questions 12-15, use the following information.

Speaker A, facing directly north, plays a sound at 300 Hz that emits a power level of 5.0 W. Meanwhile, speaker B, facing directly north 5.0 m to the west of speaker A, plays a sound at 300 Hz that emits a power level of 3.0 W.

12. (2.00 pts)

Suppose you turn speaker B off and stand exactly 5.0 m north of speaker A. Then the intensity level you hear can be written as $m/(n\pi)$ W/m^2, where m and n are unitless relatively prime positive integers. Compute $m+n$.

21

13. (2.00 pts)
The air conditioning in the room breaks, and because it's November, the temperature rapidly decreases. After a few minutes, the speaker's pitch has dropped by 20 Hz. Call the new speed of sound v_new and the speed of sound at room temperature (343 m/s) v. Then the ratio v/v_new can be written as m/n, where m and n are unitless relatively prime positive integers. Compute $m+n$.

29

14. (4.00 pts)
After fixing the air conditioning, you decide to turn on speaker B and stand due north of it. Luckily, you turn it on so that the two speakers are perfectly in phase. Find the shortest distance in m at which you can stand in front of speaker B where you hear complete destructive interference. Express your answer as a decimal with no unit to the nearest tenths place.

21.6

15. (4.00 pts)
You then turn the speakers to face each other and stand in between them. It just so happens that you hear the softest possible sound based on where you're standing. Let the point you're standing on be X. Compute AX. Express your answer as a decimal with no unit to the nearest hundredths place.

2.71

For questions 16-20, use the following information.

Please do not attempt this problem if you are not already finished with everything else; it isn't worth it! :^)

Below is the wave equation in one dimension.

$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$$

Consider a string of length L and let u be the vertical displacement as a function of x, the position along the string, and t, the time after the string is released.
Assume the boundary conditions $u(0,t) = 0$, $u(L,t) = 0$, and that t is nonnegative. We also set the initial conditions $u(x,0) = f(x)$ and $u\_t\,(x, 0) = 0$, where f is an arbitrary function of x. In this problem, we examine the solutions to this equation.

16. (2.00 pts) Interpret the boundary and initial conditions; what do they say about the displacement of the string?

Expected Answer: boundary conditions ⇔ string is fixed at ends (as displacement is zero); initial conditions: some initial displacement f(x) [ie. the string is pulled] and it is released with zero velocity

17. (3.00 pts)
We proceed with separation of variables. Let $u(x,t) = X(x)\,T(t)$. Substitute u into the wave equation. Both sides must be equal to some constant. We'll call that constant -A. We should have two ordinary differential equations now: X'' + Ax = 0, and T'' + c^2AT = 0. Using the boundary conditions earlier and the relationship between *u*, X, and T, justify the following new boundary & initial conditions on X and T: Boundary Conditions: X(0) = 0, X(L) = 0; Initial Condition: T'(0) = 0.

Expected Answer: this is basically plugging in the initial values then noting that only one variable matters in each function (ie. x=0, L gives X(0) = X(L) = 0, etc.)

18. (4.00 pts)
The solutions to the ODE's earlier are well known, and I won't make you derive them. Essentially, it boils down to an eigenvalue problem, and we will have A = *n*^2 pi^2 /L^2 for each nonnegative integer *n*. From this, we can derive that X is proportional to sin (n pi x/L). We also can plug in A to get T = *a* cos (*n* pi c *t*/L) + *b* sin (*n* pi c *t*/L) for some constants *a* and *b*. Deduce, based on the boundary/initial conditions, that *b* = 0.

Expected Answer: this follows directly from T'(0) = 0; differentiate T and then set both sides equal.

19. (3.00 pts)
Using the solutions for X and T, we can determine solutions for *u*.
Specifically, we have *u_n* = sin (n pi x/L) cos (*n* pi c *t*/L) for the *n*th function (ie. n=1, 2, etc) that works. Why is it that we can thus sum a linear combination (that is, c1 u1 + c2 u2 + …) and still have a valid solution? (2)

Expected Answer: Superposition.

This isn't a question; I'm just finishing the solution. We then can examine the boundary conditions and get that the coefficients of the series (the c1, c2 above) are precisely the coefficients of the Fourier series of *f*. We're done! Notice that you can find the period, frequency, etc. which are the formulas you're already familiar with.

Section 2: Acoustics
"What sound does a bird make?"

"shut up skythee" - 404ic 哥哥
"go the [expletive] to sleep skythee" 🥰 *- skythee* 妹妹
"washed" - andruwuwu 哥哥
"kachow" - chewy 哥哥
"[expletive] you" - ayu
"[EXPLETIVE]" - sea
"bird go "give me admin"" - br8nd0n

20. (2.00 pts) Which of the following statement(s) are correct?

(Mark **ALL** correct answers)
☐ A) A sound can have *fullness* when its reverb time at low frequencies is extremely high.

- [ ] B) A sound can have *warmth* when the audience hears much more direct sound compared to reflected sound.
- [ ] C) A sound has *clarity* when the low frequencies of the sound have a much longer reverb time than high frequencies.
- [x] D) A sound is *brilliant* when its reverberation time at low frequencies does not decrease significantly.

21. (3.00 pts)
Skythee is playing her flute in band, and while tuning to an A4, she finds that her instrument is 20 Hz sharp. Should she make the instrument shorter or longer? By how much? Express your answer as a decimal to the nearest tenth followed by "mm" and either "shorter" or "longer," such as "100.0 cm longer".

16.9 mm longer

22. (2.00 pts)
The "A" string on Allen's violin is 33cm long. Given that the tension in the string is 120N, then the mass of the string can be expressed as *x* milligrams, where *x* is the integer closest t the actual value. What is *x*? Do not include any units.

470

23. (2.00 pts)
Ma, standing in a room at STP, blows on a round bottom flask, which is an ideal Helmholtz resonator. The neck, which has a circular cross section, has an inner radius of the opening of the neck is 2cm. The neck is 8cm long, and the flask is a perfect sphere with radius 6cm. The frequency of the note that Ma plays can be expressed as *x* Hz, where *x* is the closest integer to the exact frequency. Do not account for end correction. What is *x*?

227

For questions 24-26, use the following information.
Yang, standing next to Ma, blows on a round bottom flask with a rectangular neck, 8cm long, with cross-sectional dimensions of 2cm x 5cm. The flask is also an ideal Helmholtz resonator.

24. (3.00 pts) Compute the effective length of the neck after accounting for end correction to the nearest 0.01cm. Do not include units in your answer.

8.86

25. (3.00 pts)
The flask resonates with a frequency of exactly 1000Hz. If the flask is a perfect sphere, what is the radius of the sphere to the nearest 0.01cm? Do not include units in your answer.

3.23

For questions 26-27, use the following information.

Wang stands in a 8m x 12m rectangular room with height 3m. The walls are fully covered with thin acoustic tiles with sound absorption coefficient $\alpha=0.60$. The carpeted floor has a sound absorption coefficient $\alpha=0.25$, and the ceiling has a sound absorption coefficient $\alpha=0.05$.

26. (2.00 pts) What is the absorption of the room in metric sabins, to the nearest tenth? Do not include units.

100.8

27. (4.00 pts)

Nyda screams into a microphone at an intensity of 100 dB (original volume), amplifying the intensity of his voice by another factor of 100 to an even louder sound greater than 100dB Let *t* be the number of seconds after the scream that it takes for the sound intensity level to get to 30dB. Express *t* to the nearest 0.01 second, and do not include any units.

0.69

28. (3.00 pts) What is the lowest resonant frequency of this room to the nearest integer? Do not include units.

57

29. (2.00 pts)
Using the linear approximation for the speed of sound in air as a function of temperature, compute the speed of sound in 2220°C hot air in m/s. Do not include units, and use 3 significant figures.

1660

30. (4.00 pts)
What is the speed of sound in chlorine gas with an adiabatic index of 1.33 and a molecular mass of 35.45amu at 20°C? The answer can be expressed to the nearest integer in the form *x* m/s. Compute *x*.

302

Section 3: Instruments & Musical Sound

"Eric is a nerd"

-Chinese Proverb

31. (3.00 pts) Classify each instrument using the Hornbostel-Sachs system of instrument classification:

Flute [1]

Harpsichord [2]

Chimes [3]

Aerophone | Chordophone | Idiophone

32. (2.00 pts) Which of the following is an incorrect classification of an Idiophone?

- (●) A) Blown Idiophone - Standing Bell
- ( ) B) Friction Idiophone - Nail Violin
- ( ) C) Struck Idiophone - Alimba
- ( ) D) Plucked Idiophone - Mbira

33. (2.00 pts) Which of the following instruments is least often found in a concert band?

- ( ) A) String bass
- ( ) B) Euphonium

- [x] C) Recorder
- [ ] D) Contrabassoon

34. (2.00 pts) Which of the following instruments is least often found in a symphony orchestra?

- [ ] A) String bass
- [x] B) Euphonium
- [ ] C) Piccolo
- [ ] D) Piano

35. (2.00 pts) Which of the following statements are true about just intonation?

- [ ] A) Just intonation provides the exact frequency between intervals as a ratio of integers.
- [ ] B) Just intonation is always used in modern instruments.
- [ ] C) The ratios most commonly used in just intonation are the same ratios used in Pythagorean tuning.
- [x] D) Just intonation is often used in a cappella ensembles.

36. (2.00 pts) Of which of the following expressions is equal to the frequency ratio of the syntonic comma?

- [ ] A) $2^{1/55}$
- [ ] B) $2^{1/81}$
- [x] C) 81/80
- [ ] D) 55/54

37. (2.00 pts) The frequency of Midi tone 157 can be expressed as *x* Hz, where *x* is the closest integer to the actual frequency. What is *x*?

70959

38. (3.00 pts)
What is the absolute difference between the number of cents in a minor third, the first calculated using Pythagorean tuning and the second using equal temperament? Express your answer to the nearest integer, and do not include units.

6

39. (3.00 pts)
There exists several rational numbers, *m/n*, which approximate the ratios of the frequencies of the notes in a tritone, where the absolute difference between *m/n* and the true ratio is less than 0.001 and both *m* and *n* are relatively prime positive integers less than 100. What is *m*+*n*? There are multiple correct answers.

Expected Answer: 70, 99, 128, or 169

40. (2.00 pts) A thereminist's hands control which two aspects of the sound of a theremin?

- A) Timbre and Loudness
- B) Pitch and Timbre
- C) Pitch and Vibrato
- D) Pitch and Loudness

41. (2.00 pts) In an erhu, how does the player produce a variety of pitches?

- A) The player pinches the strings together to produce pitches.
- B) The player presses down on the strings to produce pitches.
- C) The player pulls the string to vary the tension in the string.
- D) The player plays more forcefully with the bow to produce higher pitches.

42. (4.00 pts) What wood are violin fingerboards typically made out of, and why is this wood chosen to make the fingerboard?

Expected Answer: Violin fingerboards are typically made out of ebony wood (2). Ebony wood is extremely dense and very durable (2), so it is often used to make fingerboards.

43. (2.00 pts) Which of the following colors of noise has a power spectrum of $P \propto f^2$ in a two-dimensional signal?

- A) White noise
- B) Pink noise
- C) Brownian noise
- D) Blue noise
- E) Gray noise
- F) Black noise

44. (4.00 pts) Define quantization, then briefly explain how dithering is used in audio signal processing to minimize the effects of quantization.

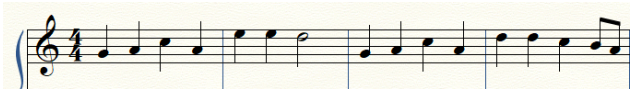
Expected Answer: 2 points for defining quantization correctly: 1) Mentions some sort of data loss 2) Mentions data loss when mapping a large range of values to a smaller finite set of values. 2 points for explaining dithering: 1) Mentioning that dithering is a form of noise or a mask 2) Mentions that dithering can decrease quantization error, make the audio more clear, or mask jarring frequencies. Sample: Quantization is the loss in data when mapping a large range of values to a smaller finite set of values. This often results in quantization error, which creates noise. Dithering is noise or a mask that is added to the signal that can mask more jarring frequencies, such as higher harmonics.

Section 4: Music Theory

"Why does a bird go [expletive] so much?"

"😋🌹🐌🦢🍴" - *404ic*

45. (2.00 pts) Sick Ratley plays the following version of Never Gonna Give You Up, where all the rhythms are stretched out.

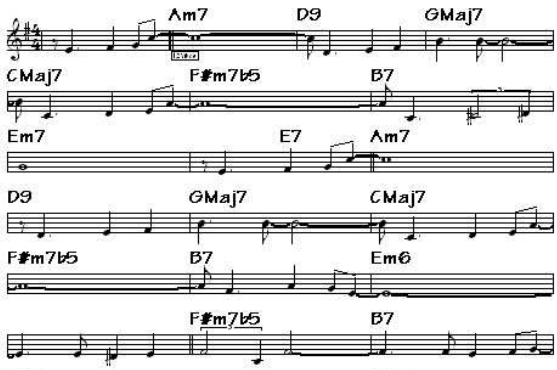


Which of the following terms best describes this musical technique?

- A) Diminution
- B) Ritardando
- C) Rallentando
- D) Augmentation

For questions 46-50, use the following information.

Below is the first half of a very famous jazz piece.



46. (2.00 pts) Caleb plays this tune on an Eb alto saxophone. What key does he have to transpose it to?

- A) A minor
- B) E Major
- C) C# minor
- D) Bb Major

47. (4.00 pts)
Consider measures 6-9 (F#m7b5 B7 Em7). Specifically, which typical Western scale (don't write a mode) would best fit over those measures? Yes, there are many possible answers, but which scale fits the notes in the chords the best? Briefly explain why.

Expected Answer: Full points for E harmonic minor; 2 points for "E minor" (not specific enough), "E natural minor", "G Major"(doesn't account for the D# on the B7), and "E melodic minor" (doesn't account for the C natural on the F#m7b5) If the reasoning is incorrect, the score will be halved.

48. (3.00 pts) Which of the following notes is in the D9 Chord? Select all that apply.

(Mark **ALL** correct answers)

- [x] A) A
- [x] B) C
- [x] C) E
- [ ] D) Eb
- [ ] E) F
- [x] F) F#

49. (4.00 pts)
Do a Roman Numeral analysis on the first phrase, from the Am7 to the Em7. Only write the Roman Numerals; no extensions, inversions, etc. are necessary. If you think the answer is I-II-III-IV-V-VI-VII, write “I II III IV V VI VII”, with spaces and no commas between each Roman Numeral. Write any secondary chords with a slash and no space (such as V/V).

Expected Answer: Correct answer: "ii V I IV vii III vi", OR "ii V I IV vii V/vi vi" 0.5 points for each chord, +1 points if all are correct. Partial credit awarded if the key was wrong but chord relationships were correct.

50. (1.00 pts) Name that tune!

Autumn Leaves

Section 5: Anatomy
“We have two ears and one mouth so that we can study two different body parts for Sounds.”

- Epictetus, probably

51. (1.00 pts) One of these letters/sounds is produced differently than the others by the voice. Which one is it?

- ( ) A) "K" (car)
- ( ) B) "G" (get)
- ( ) C) "Gh" (ghost)
- (•) D) "H" (hello)

52. (2.00 pts)
In the previous question, three of the sounds are similar because of the manner of the pulmonic consonant - how the consonant is articulated and pronounced. What is this manner called?

- ( ) A) Affricate
- ( ) B) Fricative
- ( ) C) Nasal
- (•) D) Plosive

For questions 53-56, match the purpose to a part of the ear.

53. (1.00 pts) This term describes the three small bones in the middle ear (one word).

Ossicles

54. (1.00 pts) This part of the ear separates the outer ear canal from the middle ear (two words).

Tympanic membrane

55. (1.00 pts) Vibrations move through this part of the ear into the cochlea (two words).

Oval Window

56. (1.00 pts) This part of the ear contains hair cells and is shaped like a spiral (one word).

Cochlea

57. (2.00 pts) Which cochlear fluid contains a high concentration of sodium [1]? Which cochlear fluid contains a high concentration of potassium [2]?

Perilymph | Endolymph

58. (2.00 pts) Which of the following are true of the larynx?

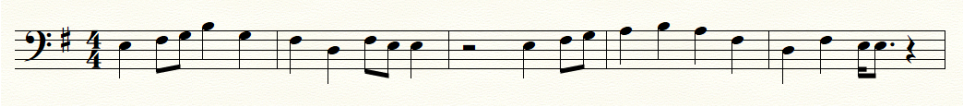
(Mark **ALL** correct answers)

- [x] A) The larynx is also known as the voice box.
- [x] B) The larynx includes the vocal cords.
- [ ] C) The vocal cords contain 3 bones.
- [x] D) The vocal cords contain 6 cartilages.

Section 6: Aural Music Theory

"Courage is courageous courage."
- JC

59. (6.00 pts)
Caleb was cramming for AP Music Theory's listening section. He transcribes a melody as shown below, with some either pitch or rhythmic (or both) errors:

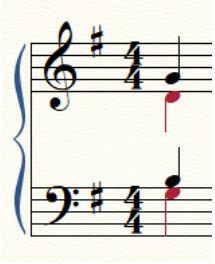


Listen to the following recording. Then, identify the errors in Caleb's work. Please indicate which measure(s) and beat(s) you are talking about.

0:00 / 0:11

Expected Answer: 2 pt for each of the following: the B in measure 1 beat 3 should be an A, the rhythm in meas. 2 beat 3 - meas. 3 beat 2 is incorrect, the rhythm in meas. 5 beat 2-3 is incorrect

60. (4.00 pts)
Continuing his studying, Caleb moves on to harmonic dictation. Help him write the Roman Numerals for the chords in “SoM_Aural_2”. If you think the answer is I-II-III-IV-V-VI-VII, writ “I II III IV V VI VII”, with spaces and no commas between each Roman Numeral. Do not notate nonharmonic tones, but do write any secondary chords with a slash and no space (such as V/V). The first chord is I (G Major), voiced as shown below; please include it in your answer. (4)



0:00 / 0:09

Expected Answer: 0.5 points for each numeral: I V I V vii/V V V/V V

After sufficiently cramming, Caleb decides to practice a bit before he collapses from exhaustion. He records the attached recording, written by Mozart. Answer questions 61 to 63 using this recording.

0:00 / 0:29

61. (2.00 pts) The trill (5-7 sec in) is stylistically incorrect. Why?

(Mark **ALL** correct answers)

- [ ] A) It is too fast; there should be fewer notes in the trill.
- [ ] B) It is too slow; there should be more notes in the trill.
- [x] C) It starts on the wrong note.
- [x] D) It ends on the wrong note.
- [ ] E) There is no error.

62. (2.00 pts)
Caleb doesn’t own an A clarinet, but when Mozart wrote originally for Anton Stadler, he didn’t write for the modern A or Bb clarinets. Instead, he wrote for a special variation of a clarinet that has a slightly larger range. What is it called (two words)?

Basset Clarinet

63. (1.00 pts) Which of the following terms best describes the technique in the excerpt beginning at around 9 sec?

- (●) A) Chromaticism
- ( ) B) Hemiola
- ( ) C) Stepwise Modulation
- ( ) D) Glissando

Finally, Caleb is done studying. He decides to play his favorite video game, Celeste. Listen to the following 8-measure transcription from the piece “Awake” by Lena Raine. Then, answer questions 64 to 67.

0:00 / 0:32

64. (1.00 pts) Consider the first note of the piece; it belongs in an incomplete measure before the first “true” measure of the piece. What is the technical name for this kind of note?

Anacrusis

65. (2.00 pts) The left-hand notes in this piece are best described with which term(s)?

(Mark **ALL** correct answers)

- [ ] A) Block Chords
- [x] B) Arpeggios
- [ ] C) Melody
- [x] D) Harmony

66. (2.00 pts) Which musical term best describes the minor change in tempo during the upbeats of most measures in the piece?

- ( ) A) Piu mosso
- ( ) B) Grave
- ( ) C) Bewegt
- (●) D) Rubato

67. (5.00 pts) Transcribe the notes of the melody of the piece using solfege from measures 5-8, including the upbeat. The upbeat of measure 5 is a “La”.

Expected Answer: 0.5 points for each note, not counting the first "La". La Mi Re Do Ti La Ti Do Mi Si Ti

Thank you for taking our Sounds of Music exam!

If possible, please complete the feedback form here: https://forms.gle/tB1AQvjNGvzzrYnX8 (https://forms.gle/tB1AQvjNGvzzrYnX8). As this is the first time a build portion of the Sounds of Music exam has been run in a virtual competition, your feedback is extremely valuable at determining the feasibility of running a device portion of the event virtually.

We wish you the best on your future events! :)

-Allen and Klebb