Answers on the following page.

Solutions match the problem in level of difficulty. You don't need much prior knowledge to understand solutions to easy problems; more scientific background is assumed for solutions to harder problems.

**1**. B – Sabine's Law is a rule that tells you the reverberation time for a room. The more absorption, the less reverberation time, so Sabine's equation tells you the rate (in other words, "quickness") of sound absorption. Sabine's equation is not terribly useful for highways, which is why I included the statement about reflection in rooms.

**2**. B – the frequency of the $n$th harmonic of a pipe closed at one end is $f_n = \frac{nv}{4L}$. So, $L = \frac{(5)(343 \text{ m/s})}{4(1280 \text{ Hz})} = 0.335$ m.

**3**. C – closed pipes can only have odd harmonics. The first overtone is therefore the first partial *greater than* the fundamental, so this occurs at $f_3 = 3f$.

**4**. B – when sound waves interfere, the pressure variations at any point on the resulting wave is equal to the sum of the pressure variations of the individual waves. Because no two pressure nodes occur at the same point in the standing waves of harmonics $n = 1$, 3, and 7, with the exception of a node at the open end of the pipe, there is only one point that remains a node when the standing waves in the pipe interfere.

**5**. E – (A) is wrong on two counts: intensity does not fluctuate, and quantities that fluctuate are not necessarily sinusoidal waveforms. (B) may seem tempting, but it talks about sound *decay*. A low intensity could either mean that a sound decays really rapidly, or that the sound never had much intensity in the first place. (C) is outright wrong—greater intensities always lead to more loudness. Intensity is not about duration either, so (D) cannot be correct.

**6**. D – because air is 80% nitrogen gas and 20% oxygen gas, both of which are diatomic, the adiabatic constant $\gamma$ of air is approximately 1.4. Helium, being a noble gas, does not react easily, not even with itself, so it is monatomic with $\gamma = \frac{5}{3}$. The problem tells us that the molar mass of air is 28.98 g/mol (although you could have gotten this approximately by $0.8m_{\text{nitrogen}} + 0.2m_{\text{oxygen}}$), and I hope you already know that helium has a molar mass of 4 g/mol-! Because $v = \sqrt{\frac{\gamma RT}{m}}$ with $R$ and $T$ constant, the speed of sound in helium is $v_{\text{He}} = v_{\text{air}}\sqrt{\frac{\gamma_{\text{He}}/\gamma_{\text{air}}}{m_{\text{He}}/m_{\text{air}}}} = v_{\text{air}}\sqrt{\frac{\frac{5}{3}/\frac{7}{5}}{4.003/28.98}} = 2.936v_{\text{air}}$. Fundamental frequency is proportional to the speed of sound, so the fundamental frequency in helium has the same multiple of $f$ as the multiple of the speed of sound in helium.

**7**. B – these are not the *air column* frequencies, but the frequencies of the glass. In this case, the glass-and-water system resonates, not the air inside the glass. Because longer vibrating columns can support longer wavelengths, and the "length" of the water in glass $A$ is greater than the length of water in glass $B$, glass $B$ must have shorter wavelengths, and therefore higher frequencies.

**8**. B – because whacking is a very rapid motion, the palm of the hand will close off one end of the pipe at the same time that it excites the air inside the pipe. If you have a pipe, open up a tuning app and see what happens for yourself sometime!

**9**. B – pitch is the human perception of frequency, and we perceive pitch in ratios. That is, you have to multiply frequency by $\sqrt[12]{2}$ to add a half step increase in pitch. A good binder should have a reference of all pitches (although from the cover of this test, you could derive the nearest notes from $A_4 = 440$ Hz). The closest notes are $B_6$ (1975.53 Hz) and $C_7$ (2093.00 Hz). The ratio $\frac{2093}{2019}$

is greater than the ratio $\frac{2019}{1975}$, so the pitch of 2019 Hz is closer to the pitch of 1975 Hz than it is to 2093 Hz. There's no need to calculate how many cents each note is away from 2019 Hz, but if you're curious, the interval to $B_6$ is 37.7 cents and $C_7$ is 62.3 cents.

**10**. A

**11**. A

**12**. D

**13**. A – The lowest note on a piano is an A, so you can eliminate choices (D) and (E). Interestingly, scientists do use negative subscripts for very low frequencies, as in (C), but it is quick to reason (or to guess) that $A_{-1}$ would be outside the range of human hearing most of the time. Therefore, it can't be a note on a piano.

**14**. E – by convention, we treat twisting and turning of a pipe as having no effect on the fundamental frequency. The effects are negligible but they indeed do exist.

**15**. D – by definition, this is called a soliton, or a solitary wave.

**16**. D – an overtone is harmonic if it is an integer multiple of the fundamental. If the lowest frequency of a circular drum is $f$, then its overtones are $1.59f, 2.14f, 2.30f, 2.65f, 2.92f\ldots$ and so forth, so drums do not have harmonic overtones, but rather, inharmonic overtones. It should be mentioned that there are techniques specific to timpani that make the overtones sound slightly more harmonic, but even with these the overtones approximates integer multiples of the fundamental only somewhat.

**17**. A – the waves from both sources interfere at the midpoint, creating a standing wave. Because the tones are sinusoidal, you can eliminate (B). Only infinitely many sinusoidal waves can add up to a triangle wave. Because sound emitted by the sources are identical, including wavelength, phase, and amplitude, the resulting pattern must be a sinusoidal standing wave. The pressure then must vary sinusoidally at the midpoint of $A$ and $B$. (C) and (D) are not true because the power of each source is not increasing and decreasing periodically. If (E) were true, then the compressions of sound coming from $A$ must always be at the same position as the rarefactions of sound coming from $B$, and vice versa. However, at the midpoint, the waves from $A$ are traveling in the opposite direction as the waves from $B$, so this is a contradiction, so (E) cannot be true.

**18**. E – human detection of frequency is logarithmic. A unit increase in pitch (such as a semitone) requires frequency to be multiplied by a constant (which is $\sqrt[12]{2}$ for a semitone). Noticing that frequency increases here as a polynomial and not exponentially, we realize that eventually, the incremental rise in pitch gets smaller as time goes on. Alternatively, you could have calculated the interval of pitch between $f(98)$ and $f(99)$, then compared it to the interval of pitch between $f(99)$ and $f(100)$.

**19**. C – because 130 Hz and 140 Hz are so close, the person will hear a note approximately around those frequencies, so you can eliminate (A) and (E). Answer (A) is outside the range of human hearing anyways, so it can't be correct. The perceived frequency of two notes capable of forming beats is always the average of the two, so (C) is the correct answer.

Why do we take the average? (Please note that the following derivation is so advanced that it will rarely be tested on any sounds of music tests, so there is no need to memorize the proof below. But you should be familiar with the results.) Using the sum-to-product formula, for two sine waves in phase with equal amplitudes,

$$\sin(2\pi f_1 t) + \sin(2\pi f_2 t) = 2\sin\left(2\pi \frac{f_1 + f_2}{2} t\right)\cos\left(2\pi \frac{f_1 - f_2}{2} t\right)$$
$$= 2\sin\Big((135\text{ Hz})2\pi t\Big)\cos\left(2\pi \frac{10\text{ Hz}}{2} t\right).$$

You'll note that the factor of $\sin\Big((135\text{ Hz})2\pi t\Big)$ is essentially a sine wave of frequency 135 Hz—the average of both frequencies. The factor on the right in the cosine has a frequency so low that humans can't even hear it. But because these two factors are being multiplied by each other, the cosine factor is essentially the "amplitude" of the sine factor—the amplitude of the 135-Hz note fluctuates 10 times per second, resulting in *beats* of 10 Hz. So the person must hear a note of $\frac{f_1+f_2}{2}$, but she hears beats equal to $|f_1 - f_2|$. The beats themselves are not a note, but rather, they are a fluctuation in the loudness (amplitude) of another note. Again, this proof is extremely complicated so you probably do NOT have to memorize it for competition,[Note 2] but you definitely should be able to calculate both the average frequency and the beat frequency.

See also, Roederer, J. G. (2012). *Introduction to the Physics and Psychophysics of Music*. Springer Science & Business Media.

**20**. B – the plane must be moving faster than the speed of sound because the dark lines are the pattern of a supersonic shock wave. If (A) were true, then shock waves could not form: there would be wave fronts ahead of the plane propagating in all directions, but here, all wave fronts visible are trailing behind the plane at an angle. This angle, measured from the direction perpendicular to the direction of the plane, is known as the mach angle $\theta$, and may be found by $\sin\theta = \frac{v_{\text{plane}}}{v_{\text{sound}}}$. Because $\sin 30^\circ = \frac{1}{2}$ but the angle in the picture is clearly much steeper than 30°, the plane must be going slower than twice the speed of sound, so (B) is correct. The plane is not visibly accelerating or else the mach angle would be different at different points on the shock wave; that is, the shock waves would not appear linear, but curved (having nonzero curvature). So, although the plane *might* be accelerating a tiny amount, you can't tell from the image given, so (E) is not correct.

**21**. D – the bell on a brass instrument makes it louder directly in front of the instrument while also increasing the pitch of each overtone of the pipe. Clipping the horn of its bell will reverse these increases.

**22**. E – pronounce these sounds and feel your neck for vibrations. Only for [k] would you feel no vibrations. (More info for the curious, but which probably will never show up on any sounds of music tests you take: consonants [l, v, m] are called *voiced consonants*, and by definition are pronounced with vibrating vocal folds, while [k] is voiceless. Vowels are almost always voiced by default.)

**23**. D – enharmonic notes are those that are the same note in 12-tone equal temperament, but they may or may not be spelled with the same letter name. Aside from seven octaves and twelve perfect fifths, another example of enharmonic notes are A♭ and G♯. While Pythagorean temperament also divides the octave into twelve half steps, it builds note frequencies by defining the perfect fifth (seven half steps) as the ratio of $\frac{3}{2}$, an interval the Pythagoreans found pleasing to listen to. But if you multiply a frequency by the ratio of $\frac{3}{2}$, you'll never get a power of 2 times your original note

[2] I say "probably" because when I was in high school, I took a sounds of music test where I was asked to derive these equations (sad reaccs only) but this should be rare among all tests, and probably will never appear on most tests you take

(except for the trivial case of $\left(\frac{3}{2}\right)^0 = 2^0$). So, twelve perfect fifths and seven octaves are slightly different pitches in Pythagorean tuning, but they would be the same in 12-TET.

**24**. A – in Pythagorean tuning, a perfect fifth is a ratio of $\frac{3}{2}$. So, twelve perfect fifths have a ratio of $\left(\frac{3}{2}\right)^{12}$.

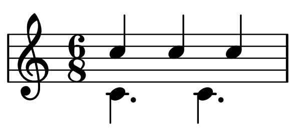
**25**. E – as the names suggest, sensorineural hearing loss results from worsened function of neural pathways, while conductive hearing loss results from worsened conduction (i.e. "touching" of waves) in the ear. The inner ear is where the auditory nerve and hair cells are; the outer and middle ear are the media for mechanical waves (i.e. waves actually touch part of the ear, in contrast with the inner ear, where the only waves are electrical waves sent to the brain).

**26**. E

**27**. B – note that you didn't actually need to know much about the other instruments other than a clarinet to answer the question. By noticing that the clarinet looks kind of like a long cylindrical pipe, you know that it isn't be conical. Furthermore, since you could probably guess that the Wagner tuba is a variation on the tuba without actually knowing what a Wagner tuba is, you can automatically eliminate both (C) and (D) because they would probably both have the same type of bore, even if you didn't know what type of bore it is (or even if you didn't know what a bore meant).

**28**. D – of these choices, only *ritardando* means a *decrease* in tempo. The markings *langsam*, *adagio*, and *lent* are not a decrease if they follow an even slower tempo, like *molto adagio*. *Rinunciarono* is a random Italian word that is literally so random that I got from a random item chooser (if you're curious the word means *they renounced*)

**29**. A – here's an example of a hemiola below:



**30**. A – an arpeggio is a chord where each note is separated temporally from the previously, and the notes proceed in either completely ascending or completely descending pitch.

**31**. B – Lower pitches attenuate less. Higher pitches attenuate more. Although Briana and Chloe both *hear* the same *pitch* because they move at the same velocity as Annie, in the point of view of the ground (the non-moving reference frame, which we'll call the "ground frame"), the lower pitch attenuates slightly less. Because the air from a train with *no walls and no ceiling* moves at a constant speed with respect to the Earth, the ground will think that Chloe is encountering a sound of lower pitch (even if Chloe doesn't hear a pitch any lower than what Briana hears). Therefore, in the ground frame, Chloe encounters a greater intensity than Briana. Because intensity doesn't depend on whether you're in the ground frame or the train frame, it follows that in the train frame, Chloe also encounters a greater intensity. lol obviously this problem was more nuanced than it first appeared especially as there was no choice for "they weren't different"

We may ask, why is answer choice (E) incorrect? When the train moves, Briana moves slightly further away from the place where Annie was just standing, while Chloe moves slightly towards the place where Annie was just standing relative to the ground frame. This is always happening as the train moves. In effect, Briana is moving away from the sound she is hearing—at least, according to the perspective of the ground frame—and when you move away from a sound source, the intensity diminishes. Likewise, Chloe approaches the apparent source of the sound, so the intensity she measures is greater. For an entirely different reason, we can conclude the same outcome. As long as the train is moving, this occurs; it doesn't matter how fast. In the extreme case, if the train is moving almost at the speed of sound, then Briana recesses with such great speed from the place Annie was standing a moment earlier, that Briana is always ahead of the sound: she will in fact hear close to nothing! Any time the train moves slower than the speed of sound, the same effect holds, because it approximates what would happen if the train moved at the speed of sound.

**32**. B – Chloe's device will measure the higher wavelength, because wave fronts emitted in Briana's direction are squeezed together because that's the direction the train is moving in. Meanwhile, wave fronts emitted towards Chloe's direction become spread out, as the train is moving away from that direction.

**33**. A – by the first postulate of special relativity, we see that Annie, Briana, Chloe, *and the air* are all non-moving in the train frame. Therefore, Briana and Chloe measure equal intensities and equal wavelengths.

Okay, but sounds of music can't seriously expect that we know of special relativity, right? How would we approach the answer without knowing relativity? From personal experience, you may have flown on an airplane before (if not, consider the bus/car you took to get to this invitational; the argument is the same). Airplanes for commercial carriers fly at speeds around 700 to 900 km/h. However, it would be very unpleasant if a gust of wind rushed towards your seat at 700 km/h, and as a result, you'd probably notice if this were occurring. By Newton's First Law, the air doesn't know that it's trapped in an airplane, so it moves at the same speed as the plane, and it will continue to do so unless some force acts upon it (which usually means the airplane accelerates or decelerates, but we only care about the case where the plane moves at a constant velocity). Therefore, from your point of view inside the plane, the air doesn't move, and so no shifting of wavelengths occurs either. And without shifts in wavelength, the intensity detected by both Briana and Chloe is identical. Why doesn't this happen when the plane, train, or bus has no walls? When we normally use the Doppler Effect in physics problems, the sound is emitted in air in the ground frame (e.g. outside of the train, outside of the ambulance, outside of the helicopter, outside of whatever). In a train sealed with walls and a ceiling, the sound is emitted *inside* a moving frame. And you can tell the air inside and the air outside are in different frames because if you open a window on a moving bus, you'll hear a strong roar of wind (and you can imagine how loud it would be on an plane or train). This is because the air in the bus is moving relative to the air outside the bus.

**34**. A – absolute pressure can never be negative, which eliminates (B), (C), and (E). Only (A) is a sinusoidal waveform.

**35**. D – because of diffraction, sound will reach regions behind the tree that are not directly within the line of sight of the loudspeaker at $P$, thereby eliminating (A). However, sound cannot diffract in circular patterns, eliminating (B) and (C). The correct answer, then, is (D). It is certainly possible for a shadow to occur, eliminating (E), but admittedly, the shadow may not be big enough to be visible in a somewhat to-scale illustration. If it weren't for the attached message that "a shadow is impossible in this situation," (E) may have seemed reasonable enough.

**36**. Diminished fourth

**37**. D, E, F♯, A, B, D

**38**. By the pigeonhole principle, there are twelve notes in an octave, so there are 12 minor scales.

**39**. The notes are F, A, C, E, G, B♭. A major 11th chord is a chord with a note an 11th, 9th, 7th, 5th, and 3rd above the lowest note. In general, a major $(2n-1)$th chord has notes every odd interval up to $2n-1$ above the lowest note. Of course, we never say "5th chord" or "3rd chord"—those are the triad and third respectively.

**40**. Both of these definitions are acceptable:

- A normal mode is a way/pattern/state in which an object vibrates such that the object forms a standing wave
- A normal mode is a motion where all particles of the object oscillate with equal frequency in a sinusoidal motion

Do not give credit if the student provides the chemical definition of a normal mode.

**41**. The speed of sound in a thin bar is $v = \sqrt{\frac{Y}{\rho}}$ where $Y$ is Young's modulus. By using $Y = 7.8 \times 10^{10}$ Pa and $\rho = 1.93 \times 10^4$ kg/m$^3$ as stated in the problem, we obtain $2.0(10) \times 10^3$ m/s, where figures in the parentheses are not significant. Alternatively, if you ignored the value of Young's modulus in the problem and calculated $Y$ from the bulk and shear moduli, you would have gotten $Y = 7.71 \times 10^{10}$ Pa, but you would still end up with an answer of $2.0(0) \times 10^3$ m/s.

**42**. By analogy with a string, the frequencies of a pipe closed at *both* ends is $f_n = \frac{nv}{2L}$ for all positive integer $n$. After all, a string and a closed-closed pipe are both symmetrical; both involve standing waves that are *forced* to reflect at the end of the string/pipe. From this equation, the first four harmonics are

$$\begin{aligned} f_1 &= 541 \quad \text{Hz} \\ f_2 &= 1080 \text{ Hz} \\ f_3 &= 1620 \text{ Hz} \\ f_4 &= 2160 \text{ Hz} \end{aligned}$$

correct to three significant figures. I graded very leniently on significant figures, and I also accepted a wide range of answers depending on your value of $v$. The cover page of the test stated that you should assume 20°C air which has $v = 343$ m/s, although I let teams go as far down as $v = 330$ m/s (the speed of sound at 0°C) for their calculations. I did not give credit for any lower values of $v$, nor any value of $v$ higher than 350 m/s (although no team used such a value in their calculation).

**43**. A zither is like a lute, but with no neck.

**44**. Infrasound is sound/frequency below the human range of hearing. Accept also references to sounds lower than 20 Hz in frequency.

**45**. By $v = \sqrt{\frac{B}{\rho}}$ where $B$ is the bulk modulus of the gas, we have it that

$$2.67 \times 10^2 \text{ m/s} = \sqrt{\frac{B}{1.98 \text{ kg/m}^3}}$$

so $B = 1.41 \times 10^5$ Pa. Because $B = \gamma p$ where $\gamma$ is the specific heat ratio, $p = 1.09 \times 10^5$ Pa.

**46**. 1 point awarded per correct note name

**47**. This seems to be based on several factors, any of which you can mention for full credit. Partial credit was awarded.

- There are eight notes for C across the piano, so the pitch notation accounts for $C_1$ to $C_8$. $C_4$ is middle C
- Thanks to the little subscript number, it is easy to tell how many octaves apart two notes are. In contrast, simply glancing at frequency values poses a challenge for readers to mentally figure the relative distance between notes in familiar terms like octaves and semitones
- When this system was first developed, the threshold of human hearing was believed to be 16.35 Hz. Funnily enough, that happened to be $C_0$. This was rather convenient, because the lowest note with a zero in its subscript was also the lowest note open to human hearing.[Note 3] The notation seems to stem largely in part from Robert W. Young in 1939 (DOI: 10.1121/1.1916017), which is sadly behind a paywall, but the reasons above I have summarized from the full article. This seems to be a relatively recent development; in 1914, a letter to the editor of Scientific American about pitch standards still used Helmholtz notation. Before Young, there was a variant of this notation where subscripts were used, but middle C was $C_3$ in the other notation, but this alternate notation hasn't seemed to stick around. This notation is called scientific pitch notation.[Note 4]

**48**. I didn't expect anybody to actually do this seriously so I don't have a rubric for this question... but if you make your own please be sure to tell me about it :)

[3] The current lower limit of hearing is by convention 20 Hz, but it is only convention. Frequencies that descend lower and lower become gradually harder and harder to hear, but tones do not suddenly vanish the moment they drop beneath 20 Hz, and humans can hear tones as low as 16 Hz (Moller & Pederson 2004, *Noise and Health* 6(23)).

[4] Contrary to what Wikipedia may lead you to believe, this system is not also called "American standard pitch notation." The reason is, if this is a standard notation, who did the standardizing? The name "American standard pitch notation" has never been used in any book until 2016, at least not in anything listed in the Google Books database for the past few centuries. It is possible that people only started calling scientific pitch notation as "American standard pitch notation" because somebody called it that on the Wikipedia article. You may also be interested in reading the Wikipedia article, "Wikipedia:List of hoaxes on Wikipedia" (just copy-and-paste it into the Wikipedia search box, without the quotes). As the IEEE speaker said at the 2019 national tournament, always check your sources!

The weight of each FRQ was multiplied by two in the final calculation of scores.

**49**. **4 points**

(a) 1 point

For a correct answer — 1 point

$$f_1 = \frac{1}{2L}\sqrt{\frac{mg}{\mu}}$$

(b) 1 point

For a correct answer

$$f_1 = \frac{1}{2L}\sqrt{\frac{2mg}{\mu}}$$

(c) 2 points

For checking "Yes" — 1 point

For a scientifically reasonable justification (anything that makes sense scientifically should be awarded credit because this problem is really hard) — 1 point

Example: the speed of waves on the string is much greater than the speed of the string (especially considering the mass on both sides are very close). Therefore, any waves induced on the string will reflect at each end quickly enough that resonance can occur.

**50**. **9 points**

(a) 5 points

For checking "Wavelength" — 1 point

For checking "Pressure amplitude" — 1 point

For checking "Intensity at a distance of one meter" — 1 point

1.5 points were subtracted if either "Frequency" or "RMS pressure divided by pressure amplitude" were checked. If both were checked, 3 points were subtracted.

For one of the following correct justifications in the table below (spans onto next page) — 2 points

| **Quantity** | **Justification** |
|---|---|
| Frequency | Frequency does not change from one medium to another *OR*<br>the pulses/oscillations/frequency of the membrane/diaphragm/surface in the loudspeaker does not change, so the frequency of the sound does not change *OR*<br>the pulses/oscillation/frequency of the electrical/voltage/current waves does not change in the loudspeaker, so the frequency of sound does not change |

*Table continues on the next page*

| Quantity | Justification |
|---|---|
| Wavelength | frequency is constant while wave speed decreases due to lower temperature/bulk modulus, so wavelength decreases too |
| Pressure amplitude | at higher altitudes, pressure/density/temperature/speed of sound change, so pressure amplitude changes as well |
| RMS pressure ÷ pressure amplitude | The root-mean-square pressure is always an exact multiple of the pressure amplitude, so this ratio does not change *OR*<br>The root-mean-square only depends on the waveform, which is a triangle tone, so this ratio does not change<br>Students will receive credit for writing the correct value of this ratio, which equals $\frac{1}{\sqrt{3}}$. They will also receive credit for writing the incorrect value of $\frac{1}{\sqrt{2}}$ (from mistaking the tone as a sinusoidal tone). |
| Intensity at fixed distance | Sound has zero intensity in a vacuum. The higher the altitude, the greater the similarity to a vacuum, so intensity must be lower than sea level at higher altitudes. |

Note: if student states that speed of sound changes in a justification, they had to state that speed of sound *decreased* for full credit. If not, only one point of credit was awarded. This was to prevent trivial justifications for "Frequency" and "Wavelength," as there would be a 50% chance of guessing the correct justification by saying "speed of sound changes."

(b) 2 points

For checking "Higher" 1 point

For a correct justification 1 point

Example: because the loudspeaker approaches the observer on the ground, the frequency is shifted to lower wavelengths.

For those who are interested, it is highly unlikely that an object will have a terminal velocity greater than the speed of sound, even though that wasn't an answer choice to this question. The sound waves would create air drag that would slow a falling object, since the object must push away air faster than it falls, and eventually the air around the object would be moving so fast that it would slow down the object.

(c) 2 points

For explaining that frequency is an emergent property, or that the Fourier transform is faulty for small samples, or that a poor choice of window function was selected, and then explaining how this led to blurs 2 points

If the point total of this problem was negative, the final score for this problem will be rounded upwards to zero. For instance, if a team received $-3$ points on (a) and zero points on (b) and (c), then their final score for this problem will be zero rather than negative three.

## How was your instrument scored?

The pitch score test was scored according to the rules manual. I used the same tuning app as the app used at the 2019 Science Olympiad National Tournament. The tuner is available at `www.pascioly.org/sounds`. I ran Audacity simultaneously as a backup app.

The procedure for the song score test was adapted from www.soinc.org/sites/default/files/uploaded_files/2020_Event_Logistics_Manual_100819.pdf. Here, a "point" refers to a point of your overall score, such that the written test is worth exactly 45 points and the pitch test score is exactly 36 points. I am not using "point" to refer to a unit of score on the written test.

| **Criterion** | 3 points | 2 points | 0 points |
|---|---|---|---|
| Time | For playing "Twinkle Twinkle Little Star" in 15 seconds or less | N/A | For duration longer than 15 seconds |
| Rhythm | For playing "Twinkle Twinkle Little Star" with a rhythm mostly matching the arrangement in the rules manual.<br>Most teams received 3 points for rhythm. | For rhythm that didn't match that of the rules manual, but was recognizable as "Twinkle Twinkle Little Star" | For not playing "Twinkle Twinkle Little Star" |
| Pitch | For having a pitch within $F_2$ and $F_3$ inclusive<br>For pitch that produces a recognizable version of "Twinkle Twinkle Little Star" | For a melody that was a believable but unconvincing rendition of "Twinkle Twinkle Little Star" and student did not correct mistakes | Wait... what song did you just play? |

If your team had a complete instrument consistent with the official rules manual, you probably got 8 or 9 points. There was pretty much no fair way for me to give you anything less. If your instrument was out of range, I probably gave you 6 points—zero on the pitch score, but a perfect for time and rhythm. Again, there was no fair way for me to give you anything less.

I didn't award only 1 point for any category.

# Share your thoughts!

I'd appreciate any remarks on what you thought of the test. If you'd like to discuss questions, don't hesitate to shoot me an email! My address is on the cover of this test.

You can also anonymously give your feedback at the link below.

https://scioly.web.unc.edu/rate-my-tests-gz839918

## Errata

The original version of this test and key included several errors. Question 5 had a typo where choice (B) read "more" in place of "greater." For question 25, all answer choices that included "and" should have had "or" instead. This version of the answer key has corrected these errors, as well as various minor grammatical errors.