

Welcome to Sounds of Music!!!

Assume the velocity of sound is 343 m/s at 20°C if not specified.

Please refrain from leaving the test. Thank you.

If you come across a problem with the test, you may email the event supervisors at:

utsounds2020@gmail.com

We will try to reply to your emails as fast as possible.

This test is worth 262 points and consists of 25 True or False, each worth **2 points**, followed by 61 multiple choice each worth **3-5 points** (the higher value questions typically take longer to solve). The breakdown of the multiple choice is as follows:

35 3-point questions

23 4-point questions

3 5-point questions

These questions are mixed with each other. If you wish to tackle certain point value questions first we recommend ctrl/cmd F'ing for the certain values. We also highly recommend splitting up the test with your partner. This test is not meant to be finish-able so just try to answer as much as you can! There is no penalty for guessing.

Tiebreakers:

First tiebreaker: Sum of score from **3 point Multiple Choice Questions**

Second tiebreaker: Sum of score from **True False Section**

Third tiebreaker: Sum of score from **4 point Multiple Choice Questions**

Fourth tiebreaker: First missed question in test order

You have 50 minutes to complete the exam. Good Luck!

1. (2.00 pts) A standard major scale follows the pattern: WWHWWWH

☒ True ☐ False

2. (2.00 pts) Lower air pressure exists under an airplane wing.

☐ True ☒ False

3. (2.00 pts) Adding rosin to a cello bow increases the velocity of the wave traveling along the string.

☐ True ☒ False

4. (2.00 pts) Adding rosin to a violin bow increases the amplitude of the wave traveling along the string.

☒ True ☐ False

5. (2.00 pts) A note on the top bar line for alto clef is seven semitones above a note on the top bar line for treble clef.

☐ True ☒ False

6. (2.00 pts) Increasing the air velocity into a clarinet will increase the pitch.

☒ True ☐ False

7. (2.00 pts) Pianos are usually tuned in equal temperament.

☒ True ☐ False

8. (2.00 pts) Increasing the airflow rate into a clarinet will increase the pitch.

☐ True ☒ False

9. (2.00 pts) A caesura is a symbol for a rest with definite length.

☐ True ☒ False

10. (2.00 pts) The Helmholtz resonator is analogous to a block oscillating on a spring.

☒ True ☐ False

11. (2.00 pts) The inner ear is responsible for transferring the mechanical waves between bone structures.

☐ True ☒ False

12. (2.00 pts) Major 3rd and Major 7th are both intervals that are considered to be consonant.

☐ True ☒ False

13. (2.00 pts) Close-ended pipes can only play odd harmonics.

☒ True ☐ False

14. (2.00 pts) Open-ended pipes can only play even harmonics.

☐ True ☒ False

15. (2.00 pts) Close-ended pipes can play both even and odd overtones.

☒ True ☐ False

16. (2.00 pts) There are 1200 cents in an octave.

☒ True ☐ False

17. (2.00 pts) The key signature with the most flats is the Cb major scale.

☒ True ☐ False

18. (2.00 pts) As two frequencies get closer, their beat frequencies get larger.

☐ True ☒ False

19. (2.00 pts) As wavelength increases, the frequency also increases (with everything else kept constant).

☐ True ☒ False

20. (2.00 pts) Amplitude is the maximum displacement of a wave from the rest position.

☒ True ☐ False

21. (2.00 pts) The product of velocity and period gives you the units of wavelength.

☒ True ☐ False

22. (2.00 pts) The strings of a harp vibrate with a wave velocity of 343 m/s.

☐ True ☒ False

23. (2.00 pts) Sounds under 0 dB cannot be heard by young people.

☒ True ☐ False

24. (2.00 pts) When a sound wave propagates from air to water, the wavelength increases and the frequency decreases.

☐ True ☒ False

25. (2.00 pts) Harmonics are resonant frequencies above the fundamental, while overtones are integer multiples of the fundamental.

☐ True ☒ False

26. (3.00 pts) If the popular song "Happy Birthday" is to be sung in a major key, what scale degree would it begin on?

- ☐ A) Tonic
☐ B) Supertonic
☐ C) Median
☐ D) Subdominant
☒ E) Dominant
☐ F) Submediant

27. (3.00 pts) What is the interval between F7 and B7?

- ☐ A) Major 7th
☐ B) Perfect 5th
☐ C) Diminished 5th
☒ D) Augmented 4th
☐ E) Augmented 5th
☐ F) Diminished 4th

28. (3.00 pts) What is the interval between B3 and D5?

- ☐ A) Minor 9th
- ☐ B) Major 9th
- ☒ C) Minor 10th
- ☐ D) Major 10th
- ☐ E) Perfect 11th
- ☐ F) Diminished 4th

29. (3.00 pts) What is the interval between G5 and F♭6?

- ☐ A) Major 6th
- ☐ B) Major 7th
- ☒ C) Diminished 7th
- ☐ D) Minor 7th
- ☐ E) Minor 6th
- ☐ F) Augmented 5th

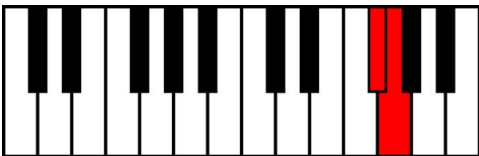
30. (3.00 pts) What is the interval between Mi and Si?

- ☐ A) Augmented 2nd
- ☐ B) Major 2nd
- ☐ C) Diminished 4th
- ☐ D) Perfect 4th
- ☒ E) Major 3rd
- ☐ F) Minor 3rd

31. (3.00 pts) What is the difference between Mi and Le?

- ☐ A) Major 3rd
- ☐ B) Perfect 5th
- ☐ C) Augmented 4th
- ☒ D) Diminished 4th
- ☐ E) Augmented 3rd
- ☐ F) Minor 3rd

32. (3.00 pts) What is the interval between the 2 red keys on the piano?



- ☐ A) Diminished 2nd
- ☒ B) Minor 2nd
- ☐ C) Major 2nd
- ☐ D) Diminished 3rd
- ☐ E) Minor 3rd
- ☐ F) Major 7th

33. (3.00 pts)

A dominant seventh chord consists of a major triad and an added minor 7th interval from the root. For example, C E G B \flat would spell out a dominant seventh chord and consists of a C major triad and the minor 7th interval between the C and B \flat . How would you spell out a dominant seventh chord with D as the root?

- ☐ A) D F A \flat C
- ☐ B) D F A C
- ☐ C) D F A C \sharp
- ☒ D) D F \sharp A C
- ☐ E) D F \sharp A C \sharp
- ☐ F) D F \sharp A \sharp C \sharp

34. (3.00 pts) Which of the following is not true between a tie and slur?

- ☒ A) A slur can link more than 2 notes together while a tie can't.
- ☐ B) A tie must link 2 identical notes while a slur can link different notes together.
- ☐ C) When indicated on sheet music a tie touches two notes while a slur does not touch the 2 notes.
- ☐ D) The total amount of beats to play a tie is the sum of the length of each note in the tie.

35. (4.00 pts)

Two musicians, Andrew and Jenny, begin a piece at the same time. Andrew is playing a piece with the time signature 7/8 at $\text{♩} = 60$ and Jenny is playing a piece with the time signature 3/4 at $\text{♩} = 90$. How many seconds after they begin will they start a measure at the same time.

- ☒ A) 14 seconds
- ☐ B) 21 seconds
- ☐ C) 63 seconds
- ☐ D) 70 seconds
- ☐ E) 3543.75 seconds
- ☐ F) 5400 seconds

36. (3.00 pts) What is the interval between the 1st and 2nd overtone of a tube open at one end?

- ☐ A) Perfect 5th
- ☐ B) Perfect Octave
- ☐ C) Perfect 4th
- ☐ D) Major 3rd
- ☒ E) Major 6th
- ☐ F) Minor 6th

37. (4.00 pts) If you take an A \flat Major Scale and flat the 3rd, 6th, and 7th scale degrees, then which of the following modes would be enharmonic to the resultant scale?

- ☐ A) A Mixolydian
- ☒ B) E \flat Phrygian
- ☐ C) B \flat Aeolian
- ☐ D) G \flat Ionian
- ☐ E) A \flat Lydian
- ☐ F) C \flat Dorian

38. (3.00 pts) Which of the following comparisons apply to 3/4 time and 3/8 time? (select all that apply)

(Mark **ALL** correct answers)

- ☒ A) There are 3 beats per measure in both signatures
- ☒ B) 3/8 time has half as many dotted quarter notes as 3/4 time

- ☒ C) If 3/4 is played at $\text{♩} = 120$ and 3/8 is played at $\text{♩} = 60$, a measure of both signatures takes the same amount of time
- ☐ D) One of these is referred to as the "waltz time signature" while the other is "cut time"
- ☒ E) Both time signatures are considered simple meters as opposed to compound meters.
- ☐ F) If 3/4 is played at $\text{♩}=60$ and 3/8 is played at $\text{♩}=120$, a measure of both signatures takes the same amount of time

39. (4.00 pts)

A music passage has 53 measures and is played in 6/8 time. If the whole passage takes around 207 seconds to be fully played through, what is the tempo likely to be?

- ☐ A) Largo
- ☐ B) Grave
- ☒ C) Andante
- ☐ D) Allegro
- ☐ E) Presto
- ☐ F) Vivace

40. (3.00 pts) An open pipe has a length of 0.75 m. What is the frequency of its first overtone?

- ☐ A) 229 Hz
- ☐ B) 343 Hz
- ☒ C) 457 Hz
- ☐ D) 572 Hz
- ☐ E) 686 Hz
- ☐ F) 734 Hz

41. (3.00 pts) A closed pipe has a length of 1.50 m. What is the frequency of its third overtone?

- ☐ A) 172 Hz
- ☐ B) 286 Hz
- ☐ C) 343 Hz
- ☒ D) 400 Hz
- ☐ E) 800 Hz
- ☐ F) 834 Hz

42. (3.00 pts)

The lowest string on an acoustic guitar has a linear mass density of $6 \times 10^{-3} \text{ kg/m}$ and a length of 650 mm. If the string vibrates at a frequency of E2, then what is the tension on the string?

- ☐ A) 40.7 N
- ☐ B) 64.3 N
- ☒ C) 68.8 N
- ☐ D) 126 N
- ☐ E) 265 N
- ☐ F) 325 N

43. (3.00 pts) At what speed would a sound wave travel in a liquid with bulk modulus $2 \times 10^9 \text{ N/m}^2$ and density 1300 kg/m^3 ?

- ☐ A) $4.470 \times 10^4 \text{ m/s}$
- ☐ B) $3.440 \times 10^1 \text{ m/s}$

- ☒ C) $1.240 * 10^3 m/s$
- ☐ D) $1.538 * 10^6 m/s$
- ☐ E) $3.420 * 10^3 m/s$
- ☐ F) $4.552 * 10^6 m/s$

44. (3.00 pts)

Terence and Justin are playing a violin and viola respectively. Terence is playing at a perfect frequency of 300 Hz while Justin is a little off at 297 Hz. How many beats per minute are heard?

- ☐ A) 3
- ☐ B) 6
- ☐ C) 0
- ☒ D) 180
- ☐ E) 5
- ☐ F) 16

45. (3.00 pts) How many cents are in a whole step?

- ☐ A) 50
- ☐ B) 100
- ☐ C) 150
- ☒ D) 200
- ☐ E) 1000
- ☐ F) 1200

46. (3.00 pts) Sound waves are _____ waves and water surface ripples are _____ waves:

- ☒ A) Longitudinal/Transverse
- ☐ B) Longitudinal/Longitudinal
- ☐ C) Transverse/Longitudinal
- ☐ D) Transverse/Transverse
- ☐ E) None of the above

47. (3.00 pts) Infrasonic sounds are sounds that are _____:

- ☐ A) Above the threshold of hearing
- ☒ B) Below the threshold of hearing
- ☐ C) Within the threshold of hearing

48. (3.00 pts) If the energy of a wave doubles and all other factors remain constant, how much did the amplitude change by?

- ☐ A) $\frac{1}{\sqrt{2}}$

- ☐ B) $\frac{1}{2}$
- ☐ C) 1
- ☒ D) $\sqrt{2}$
- ☐ E) 2
- ☐ F) 4

49. (3.00 pts) Which of the following impact the speed of sound? (Select all that apply)

(Mark **ALL** correct answers)

- ☒ A) Temperature
- ☒ B) Medium of Travel
- ☒ C) Density
- ☐ D) Pressure

50. (3.00 pts) Ultrasonic sounds are those that are:

- ☐ A) Below 20 Hz
- ☐ B) Between 20 and 20,000 Hz
- ☒ C) Above 20,000 Hz
- ☐ D) Sounds that travel faster than the speed of sound
- ☐ E) Sounds that travel at least 7 times the speed of sound

51. (3.00 pts)

Terry and Sarah are playing their flutes. Sarah checks with a tuner and knows she is playing a Gb exactly correct at 369.99 Hz. Terry is off by -17 cents. What frequency is he playing at?

- ☐ A) 352.99 Hz
- ☐ B) 358.12 Hz
- ☒ C) 366.38 Hz
- ☐ D) 373.64 Hz
- ☐ E) 382.26 Hz
- ☐ F) 398.23 Hz

52. (4.00 pts)

John is playing the 4th overtone on an instrument that is open ended with a length of 0.75 meters. Let a be the wavelength in meters and b be the number of displacement antinodes. What is a*b?

- ☐ A) 1.875
- ☒ B) 1.8
- ☐ C) 1.5
- ☐ D) 1.636
- ☐ E) 1.2
- ☐ F) 2.1

53. (4.00 pts) If there are 4 displacement nodes on an instrument's air column when playing the 3rd overtone, is the instrument closed or open?

- ☐ A) Closed
- ☐ B) Open
- ☒ C) Could be either; need more information
- ☐ D) Neither; this is not possible

54. (4.00 pts) If there are 4 displacement antinodes on an instrument's column when playing the 3rd overtone, is the instrument closed or open?

- ☒ A) Closed
- ☐ B) Open
- ☐ C) Could be either; need more information
- ☐ D) Neither; this is not possible

55. (3.00 pts) What harmonic is being played on a violin if the resonant frequency is 440 Hz and the length of the string is 0.5 meters? (assume velocity to be 220 m/s)

- ☐ A) 1st
- ☒ B) 2nd
- ☐ C) 3rd
- ☐ D) 4th
- ☐ E) 5th
- ☐ F) 6th

56. (4.00 pts)

Consider a closed instrument and an open instrument. On the two ends of each instrument, there is either a pressure node or pressure antinode. Between the closed and open instrument, how many total pressure nodes are there at the ends? (add up the number of pressure nodes at the ends of an open and the ends of the closed)

- ☐ A) 0
- ☐ B) 1
- ☐ C) 2
- ☒ D) 3
- ☐ E) 4
- ☐ F) 5

57. (4.00 pts)

Two speakers are set up such that they emit identical sounds in unison. The sounds they emit have a wavelength of 6 m. There is a point that is 12 m away from one speaker and 15 m away from the other speaker. Do the sounds interfere constructively or destructively at this point?

- ☐ A) Neither
- ☒ B) Destructively
- ☐ C) Constructively

58. (3.00 pts)

There is a singer rehearsing on stage for a show. The intensity of the singing at a distance of 15 meters away is measured to be 40 dB. Later that night, there are thirty singers performing on stage. Assuming that each of them sing at the same intensity as the first singer, what is the intensity measured at a distance of 30 meters away?

- ☐ A) 33.98 dB
- ☐ B) 43.99 dB
- ☒ C) 48.75 dB
- ☐ D) 54.77 dB
- ☐ E) 60.79 dB
- ☐ F) 71.38 dB

59. (4.00 pts)

A police car is emitting a sound through its siren at 330 Hz. An observer hears the sound from a small distance away. It is unknown if the observer and source are stationary or moving away/towards each other. The police car's maximum possible speed is 35 m/s and the observers is 2.5 m/s. Which of the following is possible if the observer hears a pitch that is 36 Hz off from the source (observed pitch could be higher or lower than source)? (Select all that apply)

(Mark **ALL** correct answers)

- ☐ A) Observer stationary, Source towards
- ☒ B) Observer towards, Source stationary

- ☒ C) Observer towards, Source towards
- ☐ D) Observer away, Source stationary
- ☐ E) Observer away, Source away
- ☐ F) Observer stationary, Source stationary

60. (3.00 pts) A speaker emits spherically with a power of 20 W. What is the absolute difference in decibels heard from 4 meters and 9 meters away?

- ☐ A) 0.0798
- ☐ B) 0.1975
- ☐ C) 3.52
- ☐ D) 6.61
- ☒ E) 7.04
- ☐ F) 6290

61. (4.00 pts)

Two vertical tubes(A and B) that are open at the top also have a hole on the bottom where water leaks out. The length of the air column in tube A with respect to time is represented by the function $L(t) = 2t^{1/2}$ for $0 < t < 100$. The water in Tube B starts to leak 1 second after the water in Tube A starts to leak. What is the instantaneous beat frequency between the 2 vibrating air columns at $t = 6$ seconds?

- ☐ A) 2.217 Hz
- ☐ B) 1.298 Hz
- ☐ C) 3.341 Hz
- ☐ D) 1.095 Hz
- ☒ E) 1.671 Hz
- ☐ F) 1.429 Hz

62. (3.00 pts) If you hold two parallel sheets of paper in front of you and blow air between them, what will happen to the two sheets of paper and why?

- ☐ A) The two sheets of paper will move away from each other because the movement of fluid between the sheets of paper causes a pressure drop.
- ☐ B) The two sheets of paper will come together because the movement of fluid between the sheets of paper causes a pressure increase.
- ☐ C) The two sheets of paper will move away from each other because the movement of fluid between the sheets of paper causes a pressure increase.
- ☒ D) The two sheets of paper will come together because the movement of fluid between the sheets of paper causes a pressure drop.
- ☐ E) The two sheets of paper will stay still because the air exerts a force parallel to the paper so zero torque is exerted.

63. (4.00 pts)

Emily is trying to practice playing harmonics on her violin. This is done by taking an open string and lightly placing a finger on various points along the string, essentially creating a node. If Emily wants to play the A string (A4) but produce a pitch an octave and fifth above (E6), where along the string should she place her finger?

- ☐ A) Halfway between nut and bridge
- ☒ B) A third of the way from either the nut and bridge
- ☐ C) A fourth of the way from either the nut and bridge
- ☐ D) A fifth of the way from either the nut and bridge
- ☐ E) Any position on the string will be able to create a E6
- ☐ F) No position on the string will be able to create a E6.

64. (4.00 pts)

Tasha wants to fill up an empty cylindrical pitcher in her kitchen sink. The pitcher has a height of 25 centimeters and a base area of 180 square centimeters. As the water fills up the container, the air column in the pitcher is continuously vibrating. If the flow rate of the sink water is 250 milliliters per second, what is the instantaneous pitch Tasha can hear after 8 seconds?

- ☐ A) 891.4 Hz
- ☒ B) 1235 Hz
- ☐ C) 1544 Hz

- ☐ D) 2841 Hz
- ☐ E) 2977 Hz
- ☐ F) 6860 Hz

65. (5.00 pts)

A jet travels at $0.992187v_{\text{air}}$ (where v_{air} is the speed of sound in air) towards Monica who is standing still. If there is a speaker on the jet that creates a constant pitch of A_2 according to the jet pilot, how many octaves above A_2 is the sound that Monica perceives?

- ☐ A) 2
- ☐ B) 3
- ☐ C) 4
- ☐ D) 5
- ☐ E) 6
- ☒ F) 7

66. (4.00 pts)

Jessica cuts 2 copper pipes to create a D_3 when they are struck by a mallet. When calculating the lengths for both pipes Jessica considers end correction for tube A but does not consider end correction for Tube B. If both pipes have a diameter of 20mm what is the beat frequency between the 2 tubes? Useful formula: $\Delta L = 0.6(\text{diameter})$

- ☐ A) 0.7504 Hz
- ☐ B) 1.524 Hz
- ☐ C) 1.235 Hz
- ☒ D) 1.493 Hz
- ☐ E) 2.956 Hz
- ☐ F) 3.272 Hz

67. (3.00 pts)

Transverse waves can be mathematically modeled by wave functions: $y(x,t) = A \sin(kx - \omega t)$. Given the wave function: $y(x,t) = 10.30 \sin(0.1784x - 20.55t) + 12.14$, what is the velocity of this wave?

- ☐ A) 3.27 m/s
- ☐ B) 3.67 m/s
- ☒ C) 115 m/s
- ☐ D) 0.306 m/s
- ☐ E) 35.2 m/s
- ☐ F) 287 m/s

68. (4.00 pts)

Reverberation time is the amount of time that passes for a sound wave's intensity to decrease by 60 dB. A room with dimension 15 meters long by 25 meters wide by 10 meters high has wood floor and uniform bricks for its walls and ceiling. The absorption coefficient for the wood floor is 0.1 and 0.3 for the uniform bricks. How long does it take for a sound with intensity $1 \times 10^{-3} \text{ W}$ to drop to $1 \times 10^{-6} \text{ W}$?

- ☐ A) 3.87 seconds
- ☐ B) 0.116 seconds
- ☐ C) 1.63 seconds
- ☒ D) 0.769 seconds
- ☐ E) 1.29 seconds
- ☐ F) 0.250 seconds

69. (4.00 pts)

You are standing in front of a speaker d meters away from it. Soon after, a second identical speaker is placed directly next to the first one. Both speakers triple their power output and you move back until you are $5d$ meters away from the speakers. By what factor did the perceived loudness change by?

- ☐ A) 114

- ☐ B) 0.240
- ☐ C) 1.06
- ☒ D) 0.651
- ☐ E) 0.0191
- ☐ F) 83.6

70. (4.00 pts)

Gases X, Y, and Z are held in separate rigid containers under specific conditions. The temperatures of gases X, Y, and Z are 240K, 811K, and 492K respectively. The molar masses of gases X, Y, and Z are 21 g/mol, 69 g/mol, and 44 g/mol. Lastly, X and Z are monatomic gases, while Y is a diatomic gas. Rank the speed of sound in each gas sample from least to greatest. (Hint: The adiabatic constant is $5/3$ for monatomic gases and $7/5$ for diatomic).

- ☐ A) XYZ
- ☐ B) XZY
- ☐ C) ZXY
- ☒ D) YZX
- ☐ E) YXZ
- ☐ F) Can not be determined without the volume of each container.

71. (4.00 pts)

Sally looks down into a deep empty well. She screams into the well and drops a rock into it at the same time. If some time after, she hears her own echo and the sound of the rock hitting the bottom of the well at the same time, how deep is the well? Ignore the effects of air resistance and assume that the acceleration due to gravity is constant at all altitudes.

- ☒ A) 23,520 meters
- ☐ B) 5,882.5 meters
- ☐ C) 11,764 meters
- ☐ D) 710.225 meters
- ☐ E) 1,004.4 meters
- ☐ F) 262.27 meters

72. (4.00 pts)

Claude creates a DIY clarinet out of scrap pieces of metal he found in his garage. When visiting Montreal during the winter it was -9 degrees Celsius and his clarinet is in tune at 130cm in length. However, when he takes the clarinet outside during a 43 degree Celsius hot summer day in Texas, he realizes that it's out of tune and the length of the clarinet has slightly changed. How many cents sharp is Claude's clarinet when it is in Texas. Useful Formulas: $\Delta L = L_0(\Delta T)\alpha$, $\alpha = 8.9 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$, $v_{\text{air}} = 331 + 0.6T$.

- ☐ A) 161.32 cents
- ☒ B) 80.095 cents
- ☐ C) 72.792 cents
- ☐ D) 11.517 cents
- ☐ E) 288.28 cents
- ☐ F) 411.86 cents

73. (4.00 pts)

Kieron stands in the middle of an infinitely large room where there is a speaker 13.6 meters in front of him and another speaker 11.1 meters behind him that is 180 degrees out of phase from the other one. If Kieron hears maximum constructive interference, which of the following choices could be the frequency of the 2 speakers?

- ☒ A) 480.2 Hz
- ☐ B) 274.4 Hz
- ☐ C) 137.2 Hz
- ☐ D) 279.9 Hz
- ☐ E) 34.30 Hz
- ☐ F) 2.817 Hz

74. (4.00 pts) There are 3 strings of equal lengths L and linear density μ . What is the ratio of tensions for each string if the strings make up a minor triad chord?

- ☐ A) 1.000 : 1.250 : 1.500
- ☐ B) 1.000 : 1.118 : 1.225
- ☐ C) 1.000 : 1.200 : 1.500
- ☒ D) 1.000 : 1.440 : 2.250
- ☐ E) 1.000 : 1.095 : 1.225
- ☐ F) 1:000 : 1.333 : 1:500

The four following questions refer to this scenario.

Alice and Bob are driving towards each other. Alice is traveling at a speed of 31 m/s and playing a sound of unknown frequency. While Alice and Bob are driving towards each other, Bob hears a frequency of 352.131 Hz. After they pass each other and are now driving away from each other, Bob hears a frequency of 258.345 Hz.

75. (3.00 pts) What is the original frequency Alice was playing to the nearest integer?

- ☐ A) 298 Hz
- ☒ B) 301 Hz
- ☐ C) 305 Hz
- ☐ D) 308 Hz
- ☐ E) 310 Hz
- ☐ F) 323 Hz

76. (3.00 pts) What is Bob's velocity to the nearest integer?

- ☐ A) 11 m/s
- ☐ B) 14 m/s
- ☐ C) 17 m/s
- ☒ D) 22 m/s
- ☐ E) 26 m/s
- ☐ F) 45 m/s

Assume Alice's speaker is emitting spherically in an isotropic medium at a power of 50 Watts. Bob was mad at how loud Alice was playing her speaker and flicked her off as he passed. Let t_0 represent the time right after Alice and Bob pass each other (such that their distance is 1 meter) and t_1 represent the time that Alice and Bob are now 15 meters away. Alice has high tech sound proof headphones such that the sound will not hurt her ears. In rebuttal to Bob, at t_1 , Alice plugs in another speaker playing at the same power in an effort to hurt Bob's ears.

77. (3.00 pts) What is the absolute difference of the intensity's heard by Bob at t_1 and t_0 in decibels?

- ☒ A) 20.5 dB
- ☐ B) 21.5 dB
- ☐ C) 22.5 dB
- ☐ D) 23.5 dB
- ☐ E) 24.5 dB
- ☐ F) 25.5 dB

78. (3.00 pts)

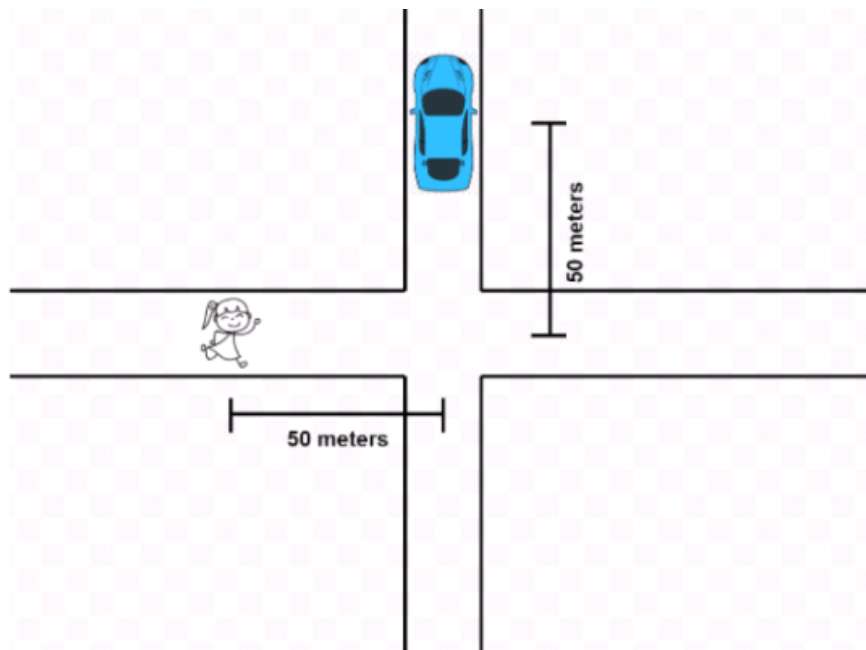
Unfortunately even with the addition of the second speaker, the sound was not nearly loud enough to hurt Bob's ears. Alice wants to reach an intensity level equal to when she passed Bob at t_0 . What power will she have to increase each individual speaker at t_1 to in order for Bob to hear the same intensity as t_0 ?

- ☐ A) 2000 Watts
- ☐ B) 2500 Watts
- ☐ C) 2625 Watts
- ☐ D) 5000 Watts

- ☐ E) 5250 Watts
- ☒ F) 5625 Watts

The three following questions refer to this scenario.

Angela stands 50 meters west of a two street intersection, which Albert drives on the street that goes south to north while playing a A5 on his trumpet. When Albert is exactly 50 meters north of the intersection, Angela claims that she hears a note 150 cents below an A5.



79. (3.00 pts) What is the frequency of the note that Angela perceives?

- ☒ A) 806.96 Hz
- ☐ B) 512.19 Hz
- ☐ C) 497.59 Hz
- ☐ D) 917.32 Hz
- ☐ E) 261.99 Hz
- ☐ F) 722.85 Hz

80. (3.00 pts) How fast is the direct distance between Angela and Albert changing when Albert is 50 meters north of the intersection?

- ☐ A) 25.51 m/s
- ☐ B) 12.79 m/s
- ☐ C) 48.45 m/s
- ☒ D) 31.04 m/s
- ☐ E) 52.70 m/s
- ☐ F) 24.17 m/s

81. (4.00 pts) What is the velocity of Albert's car when he is 50 meters north of the intersection relative to the intersection?

- ☐ A) 11.94 m/s
- ☐ B) 19.24 m/s
- ☐ C) 9.133 m/s
- ☐ D) 47.12 m/s
- ☐ E) 37.93 m/s
- ☒ F) 43.90 m/s

The two following questions refer to this scenario.

A taut string is x meters in length. The most left point on the string is indicated by $L=0$ meters and the most right point on the string is indicated by $L=x$ meters. Select all of the choices that apply.

82. (5.00 pts)

At which points on the string will there exist a displacement node for both the (n) th and $(n+2)$ th harmonics, $n \in 2\mathbb{Z}^+$. ($n \in 2\mathbb{Z}^+$ means that n is a value that exist in the set of positive even integers)

(Mark **ALL** correct answers)

- ☒ A) 0
- ☐ B) $x/3$
- ☒ C) $x/2$
- ☐ D) $2x/3$
- ☒ E) x
- ☐ F) No positions satisfy these conditions

83. (5.00 pts)

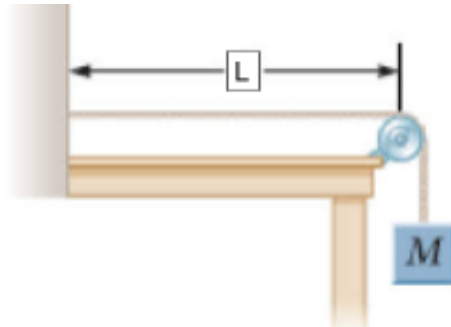
At which points on the string will there exist a displacement antinodes for both the (n) th and $(n+1)$ th harmonics, $n \in \mathbb{Z}^+$. ($n \in \mathbb{Z}^+$ means that n is a value that exist in the set of positive integers)

(Mark **ALL** correct answers)

- ☐ A) 0
- ☐ B) $x/3$
- ☐ C) $x/2$
- ☐ D) $2x/3$
- ☐ E) x
- ☒ F) No positions satisfy these conditions

The two following questions refer to this scenario.

A string with L length is attached to a wall on one end and to a brick of mass " m " on the other end.



84. (4.00 pts)

If the string has " d " mass density, " r " radius, and " n " harmonic, what is the frequency of the string when it vibrates at the n th harmonic. Write your answer in terms of the provided variables and constants.

- ☒ A) $\frac{n}{2L} \sqrt{\frac{mg}{d\pi r^2}}$
- ☐ B) $\frac{n}{4L} \sqrt{\frac{mg}{dr}}$
- ☐ C) $\frac{n^2}{2L} \sqrt{\frac{mg}{d\pi r^2}}$

☐ D) $\frac{2L}{n} \sqrt{\frac{mg}{2d\pi r^2}}$

☐ E) $\frac{n}{2L} \sqrt{\frac{mgd\pi^2}{r}}$

☐ F) $\frac{4n}{L} \sqrt{\frac{2d^2}{mgr}}$

85. (4.00 pts)

Another string is placed next to the first under the same setup. If you want to make the second string a semitone above the first what should be the new radius when a second brick is added to the string?

- ☐ A) 1.75r
- ☐ B) 0.65r
- ☐ C) 2.25r
- ☐ D) 1.25r
- ☐ E) 0.75r
- ☒ F) 1.33r

86. (3.00 pts) How are the p-series/harmonic series related to the harmonics of a standing wave?

$$\sum_{n=1}^{\infty} \left(\frac{1}{n} \right) = 1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6} + \dots \frac{1}{\infty}$$

- ☐ A) The summation is equal to double the length of the standing wave.
- ☒ B) The terms correspond to each harmonic's wavelength relative to the fundamental.
- ☐ C) The series diverges(summation goes to infinity or negative infinity), meaning that this standing wave creates an unstable harmonic series..
- ☐ D) The terms correspond to each harmonic's frequency relative to the fundamental.
- ☐ E) The summation is equal to double the wavelength of the standing wave.

Congrats! You are done :) Go eat some ice cream