Instructions:

Instrument Testing: Please bring all your devices to the Device Collection Area. You will be called up during the test and your device tested; when called up, please also bring your practice log for inspection. Written Test **You have fifty (50) minutes to complete this exam. Do not begin until instructed to do so.** You are allowed: ONE three-ring binder of any size, which must be attached to the binder rings. Each team is allowed TWO stand-alone calculators of any kind Tiebreakers take the following order of priority: Best Pitch Score Best Song Score Best Test Score Tie-Breaker Questions on the Written Test (Questions 5d in the Short Answer Section and 4c in the Math Section) Highest Final Score wins, with Final Score being calculated as per the Scioly 2019 Rules Manual

Multiple Choice (1 pt each, 25 Points Total)

Time Signature

1.) What time signature is most commonly used in marches and gallops?

a.) 4/4

b.) 3/4

c.) 3/8

d.) 2/4

2.) If the time elapsed by 5 half notes at a tempo of 100 is equal to the time elapsed by 4 half notes at a new tempo, what is that new tempo?

a.) 80

b.) 60

c.) 120

d.) 100

3.) Which of the following is an example of a non-dyadic time signature?

a.) 10/4

b.) 5/32

c.) 5/6

d.) 7/8

Chords and Scales

4.) In a movable Do Solfege, how many half steps is “Sol” from “Do”?

a.) 3

b.) 5

c.) 7

d.) 9

5.) In a hexachord, which 2 pitches are separated by a semitone?

a.) ut/mi

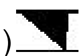
b.) mi/fa

c.) sol/la

d.) fa/sol

6.) In shape note notation, which of the following shapes is usually attributed to “fa” in the solfege?

a.) 

b.) 

c.) 

d.) 

Instrument Properties

7.) When playing the clarinet, how many “pipe lengths” does a sound wave travel with each cycle?

a.) 2

b.) 1

c.) 4

d.) 3

8.) When tuning a western violin using standard tuning, one starts at _____ and ends at ____, tuning the strings in _______

a.) C3/A4//Major Thirds

b.) E1/G2//Perfect Fourth

c.) G3/A5//Perfect Fifths

d.) B0/G2//Major Sixth

9.) This instrument originally had strings that could only play a single note at a time, meaning its strings had to be manually returned to play in another key.

a.) Violin

b.) Cello

c.) Erhu

d.) Harp

10.) What variable is most important with regards to acoustics when constructing a flute?

a.) Head joint geometry

b.) Material for the flute

c.) Embouchure hole impedance

d.) Fundamental resonant frequency

Humans and Sounds

11.) Which part of the middle ear allows for displacement of cochlear fluid?

a.) Oval Window

b.) Round Window

c.) Hair Cells

d.) Tympanic Membrane

12.) According to contemporary thought, which theory of hearing is responsible for frequencies above 5000 HZ?

a.) Place Theory

b.) Frequency Theory

c.) Volley Theory

d.) All of the above

13.) Within the octave of 1000-2000 Hz, what is the frequency resolution of the human ear?

a.) 3.0 Hz

b.) 3.6 Hz

c.) 4.2 Hz

d.) 4.8 Hz

14.) What set of curves contains equal loudness contours such as the "absolute threshold of hearing" and the "threshold of pain"?

a.) Threshold Tuning Curves

b.) Cochlear Resonance Curves

c.) Fletcher Munson Curves

d.) Robinson Dadson Curves

Math Time

15.) What is the speed of sound if the air temperature is 30 degrees Celsius?

a.)313.3 m/s

b.)339.3 m/s

c.)349.3 m/s

d.)359.3 m/s

16.) Given a radio wavelength of 10^5m, what is its frequency in Hz?

a.) 10^-1

b.) 10^1

c.) 10^2

d.) 10^3

Question 17 to 20 refer to the following scenario:

Consider a 25.0 cm long string with a mass of 5.3 g, and a resulting tension of 12.3 kN. A 3rd harmonic standing wave is created on the string.

17.) What is the speed of the waves on the string?

a.) 761.7 m/s

b.) 753.3 m/s

c.) 354.3 m/s

d.) 360.9 m/s

18.) How many antinodes are on this standing wave?

a.) 0

b.) 1

c.) 3

d.) 4

19.) How many wavelengths are on this string?

a.) 1

b.) 1.5

c.) 2

d.) 2.5

20.) What is the frequency of the standing wave?

a.) 3.25*10^3 Hz

b.) 6.56*10^3 Hz

c.) 4.56*10^3 Hz

d.) 5.58*10^3 Hz

21.) If the resonant frequency of a resonator is 100 Hz and its resonance width (FWHM) is 200 Hz, what is its Q-Factor?

a.) 100

b.) 300

c.) 2000

d.) 0.5

Miscellaneous Music/Sound Properties

22.) This term is one type of musical texture that is associated with the late Middle Ages and Renaissance:

a.) Monophony

b.) Homophony

c.) Heterophony

d.) Polyphony

23.) Which type of waveform is commonly found in time base generators?

a.) Sine Wave

b.) Square Wave

c.) Triangle Wave

d.) Sawtooth Wave

24.) Which of the following is not true of Helmholtz Resonators?

a.) It is a phenomenon of air resonance in a cavity such as in an empty bottle

b.) A gastropod seashell is an example of a Helmholtz Resonator

c.) Helmholtz resonance amplifies skin friction drag on objects

d.) Helmholtz resonators are used in some two-stroke engines

25.) These set of equations calculate the diffraction pattern for waves in the near field.

a.) Fresnel Diffraction Equation

b.) Fraunhofer Diffraction Equation

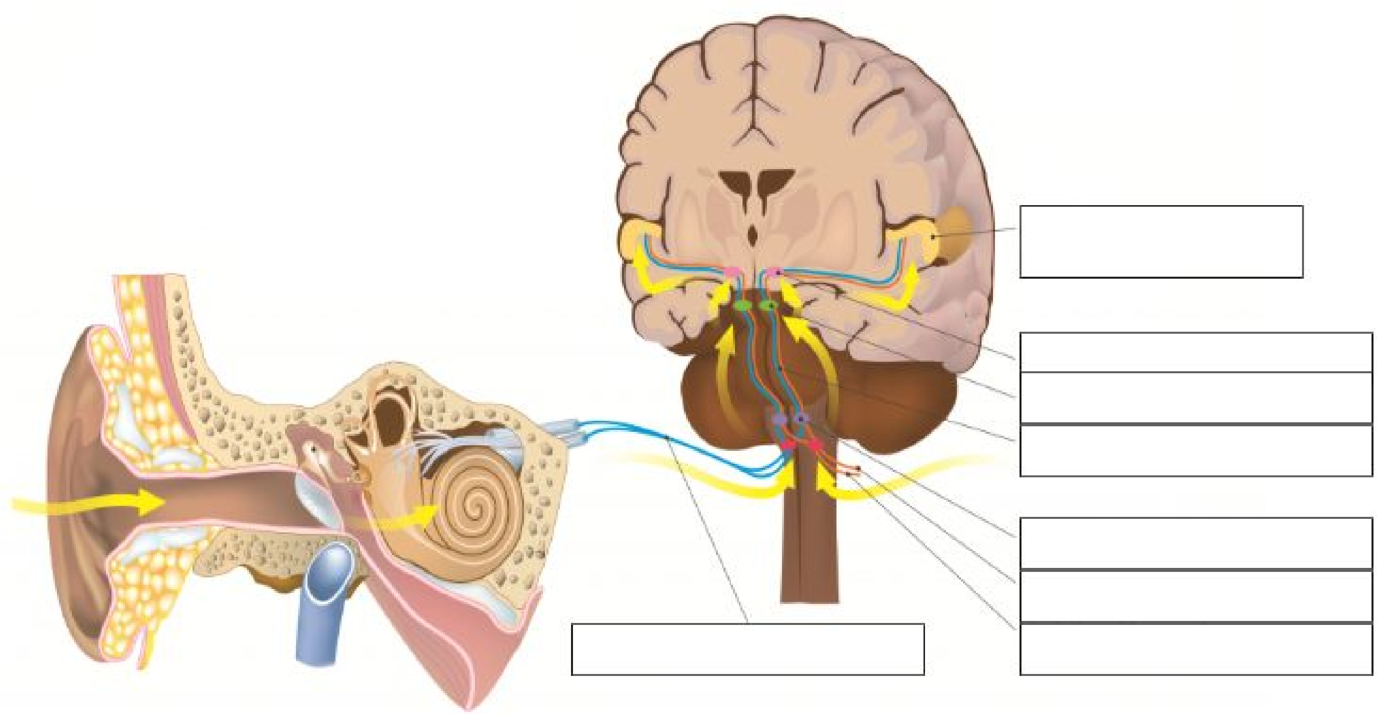
c.) Huygen Diffraction Equation

d.) Arago Diffraction Equation

Short Answer (88 Points Total)

Human Anatomy

1.) Label the parts of the pathway from the cochlear nucleus to the brain. *(8 pts)*



2.) Identify the three general components of the human voice and briefly explain how each component contributes to making sound. *(4 pts)*

More Chords

3.) Identify the following intervals/chords *(1 pt ea, 8 pts total)*

a.) Chord with C, E, G, B ____

b.) Chord with B, D♯, F♯, A ____

c.) Chord with C♯, E♯, G♯♯ ____

d.) Chord with C, E, G, B, F♯ ____

e.) Interval from C to G♭ ____

f.) Interval from B to F♯ ____

g.) Interval from D to C♯ ____

h.) Interval from C to B♭♭ ____

How Well Do You Know Pianos?

4a.) How does the soft pedal function differently in grand pianos and upright pianos? What is the result of these differences? *(3 pts)*

4b.) Identify the 3 factors that affect the pitch of a vibrating string in a piano and how varying each factor individually affects the pitch. *(5 pts)*

4c.) What material are most piano soundboards made of and what is the advantage of using this specific material? *(4 pts)*

4d.) Why is a piano never in tune? Include in your answer the type of tuning commonly used on pianos and any associated frequency ratios. *(6 pts)*

How About French Horns?

5a.) Discuss the general mechanism of sound production in the french horn, with regards to the type of standing waves produced, the effective shape of the air column produced, and the wave impedance/resonant frequencies in the pipe. *(6 pts)*

5b.) Explain how the bell of the french horn affects its harmonic sequences and identify the additional "tone" that is produced as a result of the bell effect. *(4 pts)*

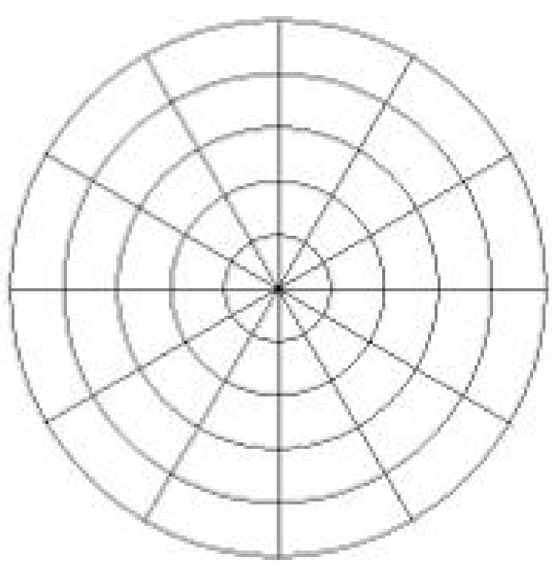
5c.) Draw diagrams of the air columns for the first 4 harmonics of a cylinder closed at one end and a cone closed at one end. *(5 pts)*

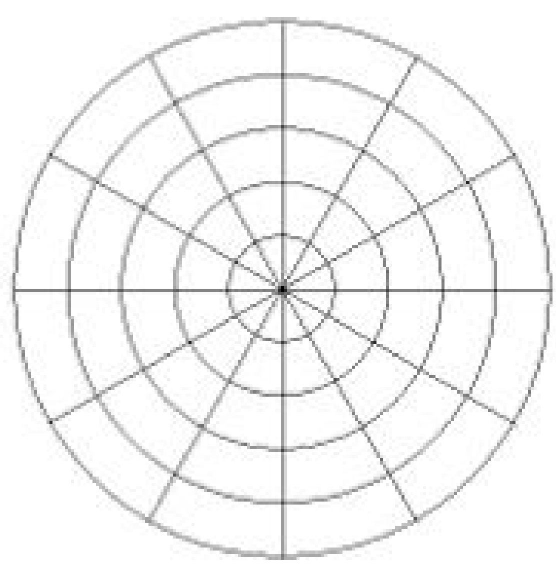
5d.) It is generally advised that french horns should not be situated in front of the percussion section of an orchestra. Why is this and what could happen to the french horn players themselves? *(7 pts, Tiebreaker #1)*

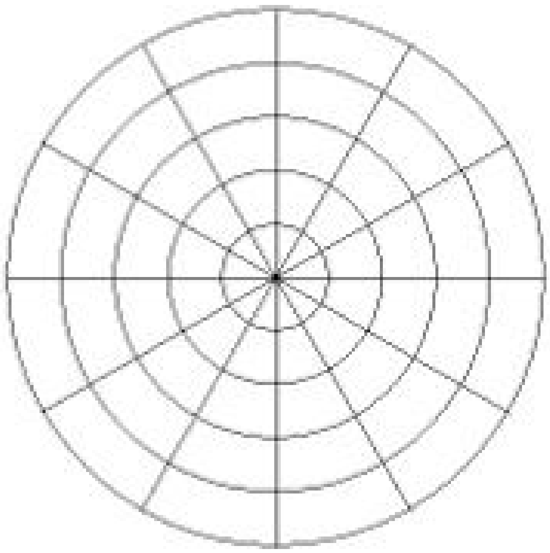
Graph Time

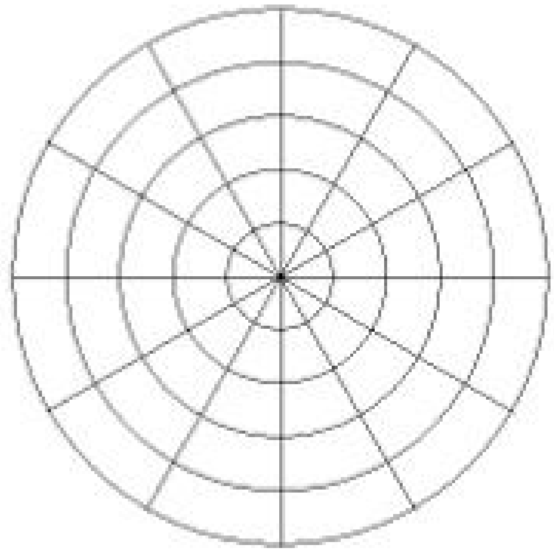
6a.) Define the following terms with regards to sound: Monopole Source, Dipole Source, Lateral Quadrupole Source, Linear (Longitudinal) Quadrupole Source *(4 pts)*

6b.)Please draw a diagram of the directivity pattern for each of the above sources on the graphs below (don't forget to demarcate your decibel levels and label each graph) *(6 pts)*









6c.) A tuning fork is an example of which of the above terms? *(1 pt)*

6d.) What is special about the linear (longitudinal) quadrupole source in particular? You may also make a note of this on your above graph. *(5 pts)*

Echoooooooooooo

7.)What are the main differences between an echo and reverberation? Be sure to include limiting conditions in your discussion. *(5 pts)*

8.)Explain how acoustic anechoic chambers absorb with regards to minimizing sound reflections. Please draw a 2d representation of a portion of the walls and explain the schematic. *(7 pts)*

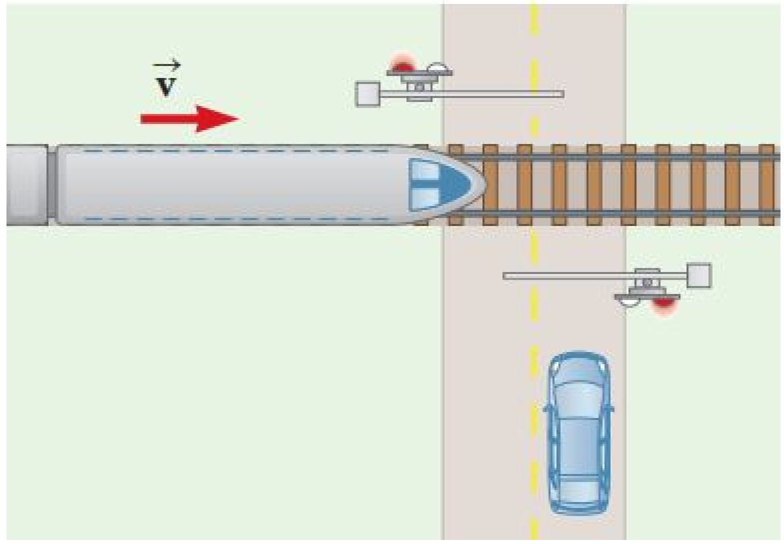
OK, Now It's Really Math Time

(Please show work!) (Also round all final numeric answers to the nearest tenth)

(57 Points Total)

1a.) Given that the equation for the doppler effect is $f' = (\frac{v+v_o}{v-v_s})f$ with v_o = velocity of observer, v_s = velocity of wave source, v = speed of sound, f ' = observed frequency, f = source frequency, write the more general form of the Doppler equation when the sources and the observers are not moving in a straight line with respect to each other. *(3 pts)*

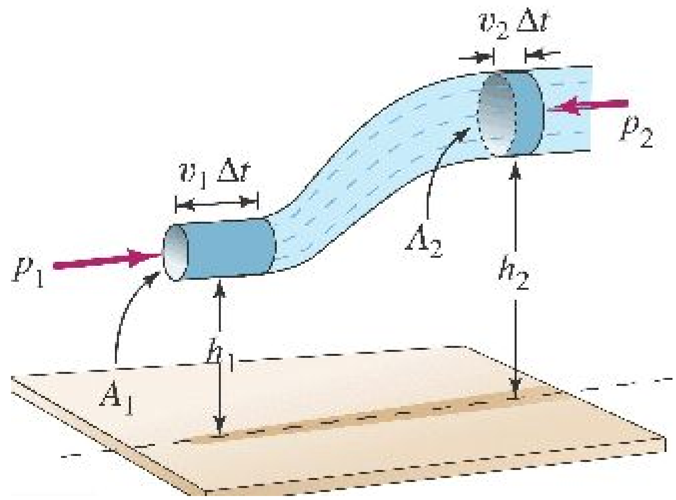
1b.) Consider figure 1.1. The train is moving at a constant speed of 27.0 m/s toward the intersection and a car is stopped 20.0 m from the tracks. The train's horn emits a frequency of 320 Hz when the train is 21.0 m from the intersection. Using the equation derived in part 1a, what is the frequency observed by the passengers in the car? (Use 343 m/s for the speed of sound) *(4 pts)*



(Figure 1.1)

1c.) Referring to figure 1.1 again, if the car is stopped at the intersection for a long time before the train arrives and for a long time after it leaves the intersection, and supposing the train emits the same frequency continuously, what is the range of frequencies that could be observed by passengers in the car (suppose they can hear the frequency even extremely far away). *(5 pts)*

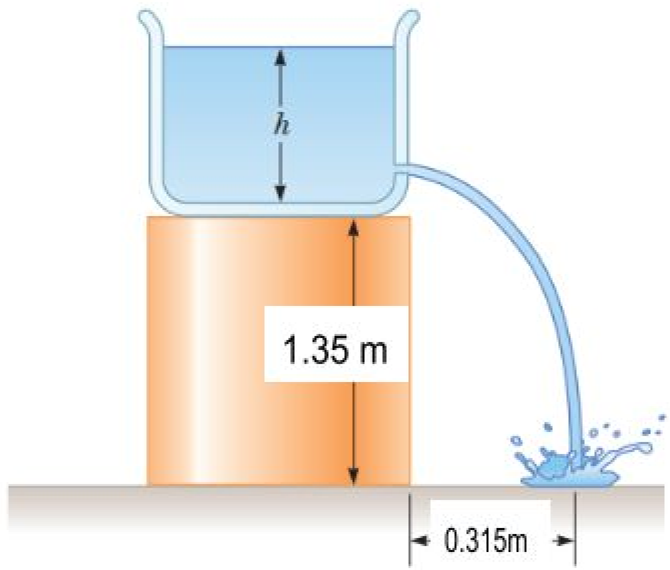
2a.) Given the Figure 2.1 (using the associated variables) and assuming our ideal fluid undergoes laminar flow and is incompressible (i.e the product of the area and fluid speed at all points along the pipe is constant), derive Bernoulli's equation: $p + \frac{1}{2}\rho v^2 + \rho g h = c$ where ρ = mass density = m/V for mass m of the segment of fluid and volume V, v=velocity of the dark blue portion of the fluid in the diagram, p=pressure and c is an arbitrary constant.



(Figure 2.1)

(Hint: Try to relate the work done on a portion of the fluid as it travels along the pipe over some time interval Δt.) *(6 pts)*

2b.) Consider the above diagram (Figure 1.2). Consider a jet of water squirting out horizontally from a hole near the bottom of the tank as in Figure 1.2. If the hole has a diameter of 1.0 cm, what is the height h in cm of the water level in the tank? (Use $g=9.8\ m/s^2$) *(5 pts)*



(Figure 2.2)

2c.) Bernoulli's Equation in Part 1a applied only for incompressible fluids. Let us now briefly explore how the equation would look when applied to compressible fluids in the case of an isentropic process, where $p/(\rho^{k}) = c$ for some constants, c and k, p=pressure and ρ = mass density. Using the above relation, rederive Bernoulli's equation: $\frac{1}{2}v^{2} + gh + \frac{k}{k-1}(\frac{p}{\rho}) = \alpha$ for some arbitrary constant α, and all other constants as discussed in parts 1a and 1c. (Hint: Work with the differential form of Bernoulli's Equation. Also note that c from our given relation never appears in the final equation). *(6 pts)*

3a) Given that the equation for the amplitude X_0 of a driven harmonic oscillator is

$X_0 = \frac{F_0}{m}\left(\frac{1}{((\omega_0^2-\omega^2)^2+(\omega\gamma)^2)^{1/2}}\right)$ for a driving force F_0, a mass m, $\omega_0 = \sqrt{\frac{k}{m}}$ with spring constant k, $\gamma = \frac{b}{m}$ for damping constant b and ω = frequency of driving force. If $\frac{\gamma}{\omega_0} \ll 1$, identify what the resonant frequency of the system is and explain why it is the resonant frequency. *(3 pts)*

3b.) Now derive what the resonant frequency of the system should be when damping is large. *(4 pts)*

3c.) Make a sketch of an Amplitude vs ω graph for the cases where damping is sufficiently small and for where damping is large, be sure to note where ω_0 is on the x axis. *(4 pts)*

4a.) The one-dimensional wave equation of a vibrating string is:

$\frac{\partial^2\psi}{\partial x^2} - \frac{1}{v^2}\left(\frac{\partial^2\psi}{\partial t^2}\right) = 0$ for ψ = the wave function, ρ = linear mass density, $v = \sqrt{\frac{\tau}{\rho}}$ for τ = tension in the string. It can be shown that $\psi(x,t) = f(x+vt) + g(x-vt)$ is a solution to the wave equation. What is the physical interpretation of this wave function (describe each component)? What law is described by this solution? *(4 pts)*

4b.) Let us now consider what happens when a wave approaches a rigid support. If we consider the point x=0 to be the rigid support point, and consider a wave function of the form $f(x+vt)$, what “imaginary disturbance” should be considered to fulfill the rigid support condition? Give your answer as a mathematical expression and also describe what phenomenon this expression describes by providing a sketch of what is going on at the boundary. (Hint: $f(vt) = 0$ at x=0). *(5 pts)*

4c.) If we need a general solution to the wave equation that is harmonic, we run into more complications as our solution ends up being a combination of several exponential terms that must be summed up over arbitrarily many components of the wave function. For simplicity though, we can discuss the functional form of each wave function individually as they are essentially the same. The simplified wave function we arrive at is $\psi(x,t) = Ae^{-ikx}(e^{i\omega t} + e^{-i\omega t})$ where ω is the frequency of the wave function and "k" is the wave number, which in this case, can be treated as an arbitrary constant just like "A". Compared to our solution in 4a, what is different in nature about this wave function? What is the physical interpretation when $\psi(x,t) = 0$ and for what values of x is $\psi(x,t) = 0$ satisfied? (Hint: Euler's formula will also be necessary for writing our wave function in terms of functions that are easier to evaluate. Use $cos(x) = \frac{e^{ix}+e^{-ix}}{2}$ and note that we only care about the real parts of our solutions for wave functions.) *(8 points, Tiebreaker #2)*