Sounds of Music C - Sounds of Music - Yale University Invitational 2021 - 02-06-2021

Instructions (shown before students start the test)

You will be given 50 minutes to complete this exam.

This test has 2 portions: Multiple Choice and Calculations

No work on the exam will be graded.

There are 20 multiple choice worth 3 points each. Choose the best single answer for each.

There are 12 calculations worth 10 points each.

All calculation answers MUST be input in the EXACT following format:

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- Order of magnitude will go in the second blank (DO NOT type the E)
- Units will go in the third blank
- Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

All calculation answers will be in scientific notation, graded according to the following criteria:

- 7 points for correct digits (5% rounding error allowed)
- 2 points for correct order of magnitude
- 0.75 points for correct significant figures
- 0.25 points for correct units

Example grading of student calculations, with a correct answer of 2.51 E1 J:

- 25.1 E0 J; 1 point (+0 digits, +0 mag, +0.75 sig figs, +0.25 units)
- 2.39 E1 J; 10 points (+7 digits, +2 mag, +0.75 sig figs, +0.25 units)
- 2.385 E1 J; 9.25 points (+7 digits, +2 mag, +0 sig figs, +0.25 units)
- 2.384 E1 kJ; 2 points (+0 digits, +2 mag, +0 sig figs, +0 units)

Tiebreaker questions will be counted in reverse chronological order (32>31>...>2>1)

For all questions, use 343 m/s for the speed of sound in air unless other information is given.

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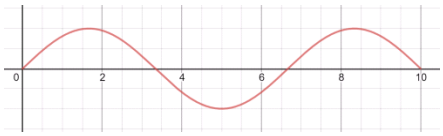
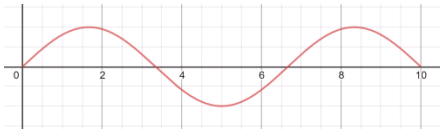
1. (3.00 pts) For questions 1-5, refer to the following graph of a vibrating string's transverse wave. The x-axis is in meters.



What is the overtone number of this string?

- A) 1
- B) 1.5
- C) 2
- D) 2.5
- E) 3

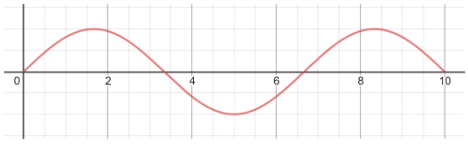
2. (3.00 pts) For questions 1-5, refer to the following graph of a vibrating string's transverse wave. The x-axis is in meters.



When the vibrating string is at maximum amplitude, which of the following is at a minimum?

- A) Kinetic Energy
- B) Potential Energy
- C) Linear Acceleration
- D) Angular Acceleration
- E) Moment of Intertia

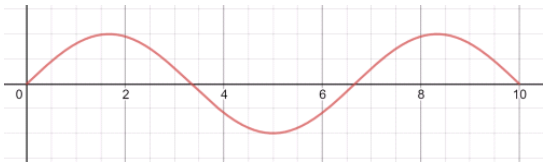
3. (3.00 pts) For questions 1-5, refer to the following graph of a vibrating string's transverse wave. The x-axis is in meters.



If you increase the string's density while playing it at the same power and pitch, what will happen to its amplitude?

- A) Increase
- B) Increase momentarily
- C) Stay the same
- D) Decrease momentarily
- E) Decrease

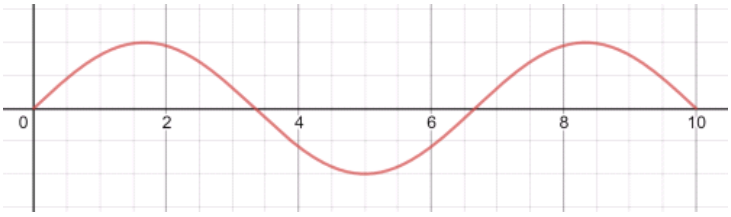
4. (3.00 pts) For questions 1-5, refer to the following graph of a vibrating string's transverse wave. The x-axis is in meters.



Rather than at the center, the string is plucked at x = 2.5. This will change the initial transverse wave to which of the following shapes?

- A) Square
- B) Sine
- C) Cosine
- D) Triangle
- E) No change in shape

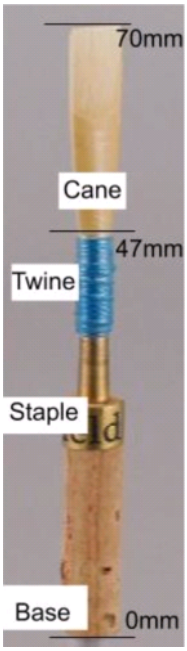
5. (3.00 pts)
For questions 1-5, refer to the following graph of a vibrating string's transverse wave. The x-axis is in meters.



According to the concept of resonance, if you applied a downward force at the 5m mark when the fundamental wave reaches its highest point on the y-axis, what would happen to the volume?

- A) Increase
- B) Increase momentarily
- C) Stay the same
- D) Decrease momentarily
- E) Decrease

6. (3.00 pts)
The image below depicts an oboe reed. It consists of two pieces of cane tied with twine to a hollow metal tube called a staple, which is partially surrounded by cork. The player puts their mouth around the cane and blows to vibrate air. Use this info in questions 6-10.

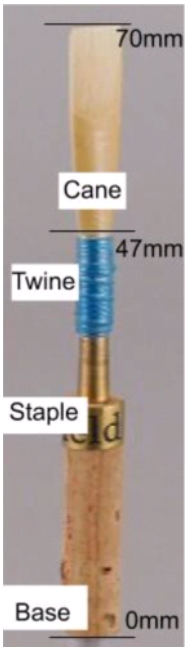


Based on the fundamentals of air columns, how might an oboist adjust their reed if it is playing flat?

- A) Tighten the twine
- B) Trim the cane shorter
- C) Restart and make the cane longer
- D) Retie the cane higher up the staple
- E) Trim the cane thinner

7. (3.00 pts)

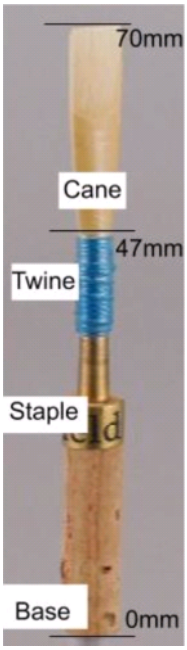
The image below depicts an oboe reed. It consists of two pieces of cane tied with twine to a hollow metal tube called a staple, which is partially surrounded by cork. The player puts their mouth around the cane and blows to vibrate air. Use this info in questions 6-10.



If the cane pieces do not form an airtight seal, an oboist may put parafilm around the cane to stop the leaks. Compared to an unwrapped reed, how might tightly wrapping adhesive sheets around the vibrating cane pieces alter the reed's sound?

A) Decrease the volume
B) Increase the volume
C) Sharpen the pitch
D) Flatten the pitch
E) Destabilize the timbre

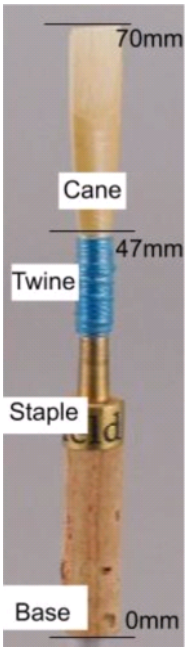
8. (3.00 pts)
The image below depicts an oboe reed. It consists of two pieces of cane tied with twine to a hollow metal tube called a staple, which is partially surrounded by cork. The player puts their mouth around the cane and blows to vibrate air. Use this info in questions 6-10.



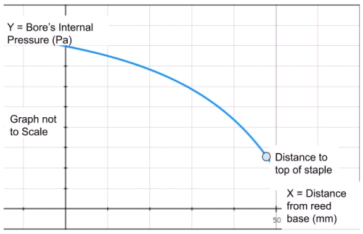
An oboe reed can be vibrated alone without the instrument body. What Hornbostel-Sachs classification would an oboe reed be?

A) Wind
B) Double Reed
C) Lamellophone
D) Aerophone
E) Woodwind

9. (3.00 pts)
The image below depicts an oboe reed. It consists of two pieces of cane tied with twine to a hollow metal tube called a staple, which is partially surrounded by cork. The player puts their mouth around the cane and blows to vibrate air. Use this info in questions 6-10.



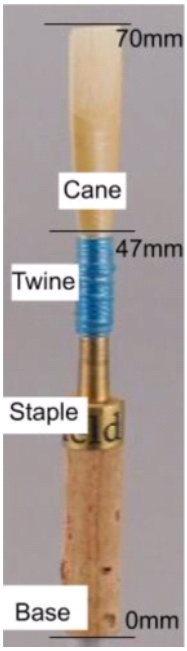
The graph below shows the internal pressure of the reed as a function of height. The x-axis starts from the base of the staple (at 0mm on the diagram) and ends at its tip (at 47mm on the diagram). Assume uniform power. Based on the qualitative info displayed by the graph, what is the shape of the staple's bore?



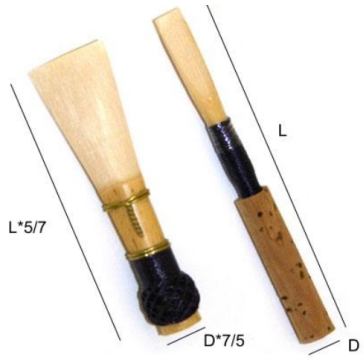
- A) Cylindrical
- B) Conical
- C) Rectangular
- D) Square
- E) Straight

10. (3.00 pts)

The image below depicts an oboe reed. It consists of two pieces of cane tied with twine to a hollow metal tube called a staple, which is partially surrounded by cork. The player puts their mouth around the cane and blows to vibrate air. Use this info in questions 6-10.



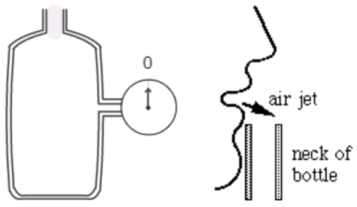
A bassoon reed is similar to an oboe reed, but it is notably 5/7 as long and 7/5 as wide at its base. Assuming a player blows with identical pressure and pressure amplitude, what will be the ratio of the average sound intensity/mm^2 be for the bassoon reed/oboe reed?



- A) 2401/625
- B) 343/125
- C) 49/25
- D) 7/5
- E) 1

11. (3.00 pts)

The images below depicts a Helmholtz Resonator. It is played by blowing across the open neck hole of an otherwise closed chamber. The “springiness” of air causes the resonator to produce a uniform pitch. The dial attached to the resonator in the image is a pressure gauge. Use this info in questions 11-15.



If the gauge’s arrow turns right when pressure increases and left when pressure decreases, what movement pattern would you expect while the resonator is being played?

- A) Turn left

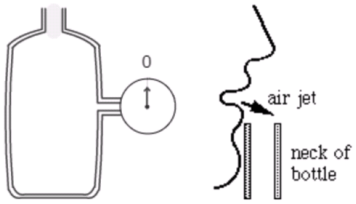
B) Turn left momentarily, then return to 0

C) Oscillate left and right

D) Turn right momentarily, then return to 0

E) Turn right

12. (3.00 pts)
The images below depicts a Helmholtz Resonator. It is played by blowing across the open neck hole of an otherwise closed chamber. The “springiness” of air causes the resonator to produce a uniform pitch. The dial attached to the resonator in the image is a pressure gauge. Use this info in questions 11-15.



If the neck opening widens, what would happen to the resonator’s sound?

A) Decrease the volume

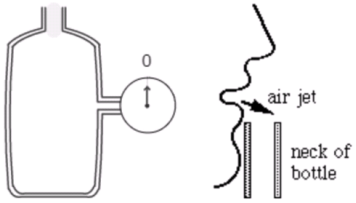
B) Flatten the pitch

C) Sharpen the pitch

D) A & B

E) A & C

13. (3.00 pts)
The images below depicts a Helmholtz Resonator. It is played by blowing across the open neck hole of an otherwise closed chamber. The “springiness” of air causes the resonator to produce a uniform pitch. The dial attached to the resonator in the image is a pressure gauge. Use this info in questions 11-15.



A person takes the Helmholtz Resonator into a room filled with extra-dense air. Assume this extra-dense air is an ideal gas with the same adiabatic constant as normal air.
If the person blew into the resonator in the room, compared to playing outside the room, what would happen to the resonator’s sound?

A) Decrease the volume

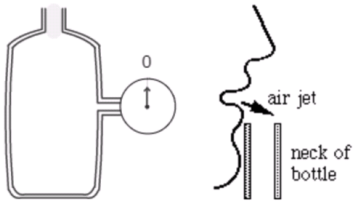
B) Flatten the pitch

C) Sharpen the pitch

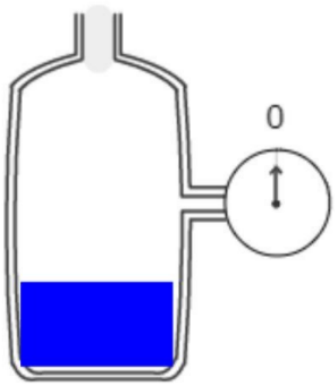
D) A & B

E) A & C

14. (3.00 pts)
The images below depicts a Helmholtz Resonator. It is played by blowing across the open neck hole of an otherwise closed chamber. The “springiness” of air causes the resonator to produce a uniform pitch. The dial attached to the resonator in the image is a pressure gauge. Use this info in questions 11-15.

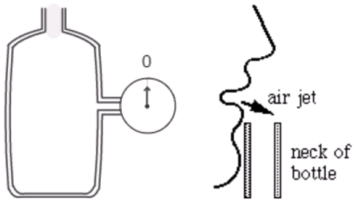


Water is poured into a vertically-standing Helmholtz Resonator bottle as shown below. How will this affect the pitch compared to a waterless resonator?

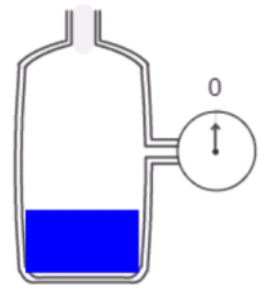


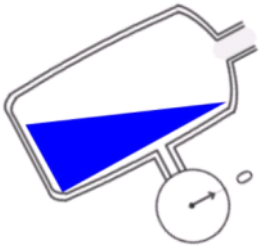
- A) Sharpen
- B) Sharpen momentarily
- C) Stay the same
- D) Flatten momentarily
- E) Flatten

15. (3.00 pts)
The images below depicts a Helmholtz Resonator. It is played by blowing across the open neck hole of an otherwise closed chamber. The “springiness” of air causes the resonator to produce a uniform pitch. The dial attached to the resonator in the image is a pressure gauge. Use this info in questions 11-15.



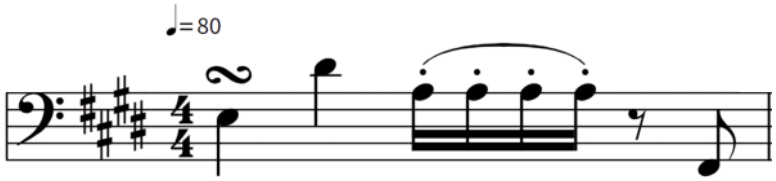
The resonator in question 14 is now tilted to its side so air reaches the bottom, as shown below. How will this affect the pitch compared to the un-tilted resonator from question 14? Assume the gauge remains unsubmerged.





- A) Sharpen
- B) Sharpen momentarily
- C) Stay the same
- D) Flatten momentarily
- E) Flatten

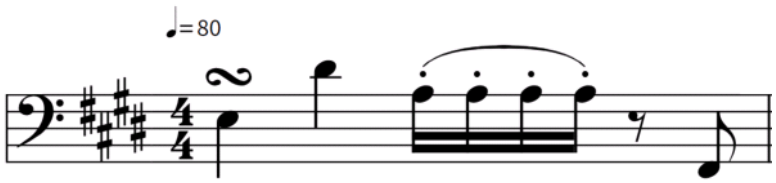
16. (3.00 pts) For questions 16-20, refer to the following measure of notes.



Which of the following is the closest equivalent to the articulation on the second sixteenth note?

- A) No articulation marking
- B) Marcato
- C) Tenuto
- D) Marcato above staccato
- E) Tenuto above staccato

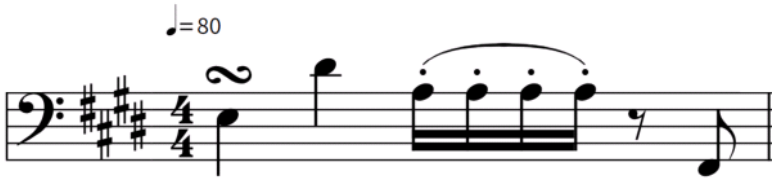
17. (3.00 pts) For questions 16-20, refer to the following measure of notes.



If the composer wanted the following measure to change to about 88 bpm, which of the following could be written?

- A) Adagietto
- B) Allegretto
- C) Calando
- D) Piu mosso
- E) Accelerando

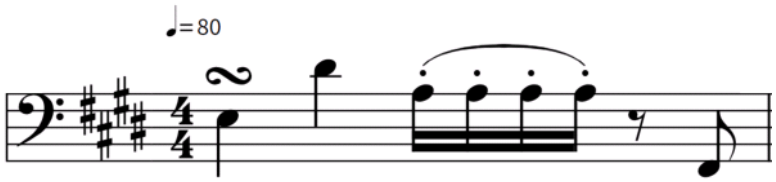
18. (3.00 pts) For questions 16-20, refer to the following measure of notes.



What is the name of the last eighth note?

- A) F#2
- B) F#3
- C) D#2
- D) D#3
- E) D#4

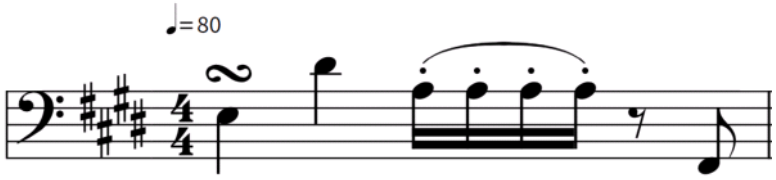
19. (3.00 pts) For questions 16-20, refer to the following measure of notes.



What is the interval between the two quarter notes?

- A) m6
- B) M6
- C) m7
- D) M7
- E) m8

20. (3.00 pts) For questions 16-20, refer to the following measure of notes.



What type of marking is on the first quarter note?

- A) Accent
- B) Ornament
- C) Grace
- D) Signature

○ E) Articulation

21. (10.00 pts)
Jerry wants to play an F3 on his violish, a messed-up violin with a single string measuring 50.00cm from bridge to peg. Assuming he plays with an average power of 100.0 W, and the string has a mass density of 0.3250 kg/m and max amplitude of 4.50 mm, how far from the violish's string peg should Jerry place his finger?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

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Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

22. (10.00 pts)
Antonio decides to play in a trio with Brian and Chris for David. David is 10.21 meters away from Antonio, 17.13 meters away from Brian, and 22.32 meters away from Chris. The concert hall is 290.K. If all three play the same note, what is the minimum frequency they can play so David observes complete constructive interference, given the waves start exactly in phase?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

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Units will go in the third blank

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23. (10.00 pts)
Ana performs a solo 12.0m away from Joanne. However, Joanne is partially deaf and can only hear volumes 20. dB or higher. Assuming the air has a density of 1.3kg/m^3, what is the minimum pressure amplitude Ana must create for Joanne to hear her?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

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Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

24. (10.00 pts) James restrings his harp with a string displaced according to the equation:

$$y=(2.00\text{mm})\sqrt{[(5.0\text{m}^{-1})x-2\pi(40.0\text{s}^{-1})t]}$$

Where x = 0 at one end of the string, x is in meters, and t is in seconds. If he tightens it to 135N of tension, how heavy must the string be?

Repeated for convenience

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[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

25. (10.00 pts)
Mark decides to test the sonic properties of jello. He places a buoy at the bottom of a jello pool, known to rise at 3.20 m/s. He sends sound waves of 120.Hz from the top of the pool to the buoy, recording a maximum beat frequency of 5.00Hz. How fast does sound move through jello?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

26. (10.00 pts)
Grace is flying a plane 5000.m at Mach 1.5. Wyatt looks up and sees Grace flying directly overhead. The temperature is 273.15K. How long will it be until Wyatt hears the sonic boom?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

27. (10.00 pts)
David plucks his violin twice, creating two sinusoidal waves of the same period, with amplitudes of 5.0 and 7.0 mm. The waves travel in the same direction along the stretched string, producing a resultant wave with an amplitude of 9.0 mm. Assuming the phase constant of the 5.0 mm wave is 0, what is the phase constant of the 7.0 mm wave?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

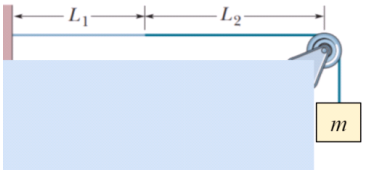
Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

28. (10.00 pts)
Joe is bored in physics class and decides to mess around with some wires. He ties wire 1, which is 30.0 cm long, to wire 2. Wire 2 is draped over a pulley, 43.3 cm away. The wires have linear densities of 0.00160 kg/m and 0.00480 kg/m respectively, and they have the same cross-sectional area. Joe then ties a block of mass m = 10.0 kg to the end of the second wire as shown. There are nodes at the pulley and wire knot. Find the lowest frequency that generates a standing wave along wires 1 and 2.



Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

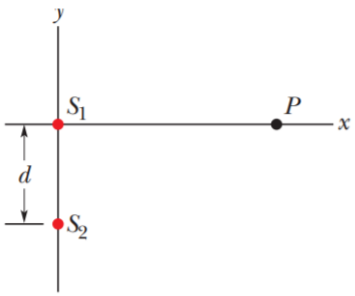
Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

29. (10.00 pts)
Alex and Jasper play a clarinet duet, emitting a wavelength of 2.00 m. The emissions are isotropic and in phase, and the two of them (depicted by S_1 and S_2 respectively) are d = 16.0 m apart. An observer (depicted by P) is testing how out of phase their waves are depending on where he stands on the x-axis. Where should the observer stand to observe a 1.50 wavelength phase difference?



Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

30. (10.00 pts)
Charlotte is getting creative with her Sounds of Music build. She takes a tube 1.20 m long is closed at one end and places a stretched wire near the open end. The wire is 0.330 m long, fixed at its ends, and has a mass of 9.60 g. When strummed, the wire sets the air column in the tube into oscillation at the tube's fundamental frequency. What is the tension in the wire?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

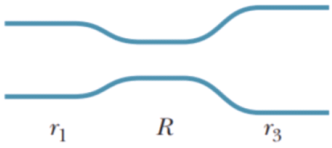
Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

31. (10.00 pts)
Richie dropped and dented his tuba, and now he has trouble emptying his water valve. The dented valve has the depicted shape, with r_1 = 1.00 cm, R = 0.50 cm, and r_3 = 1.50 cm. Richie has an old tuba with an Amado water valve, so he needs to blow into his instrument to empty it. Water flows through the middle section at 0.500 m/s. If Richie empties a ridiculously large 0.500 m^3 of water out of his tuba, how much work must he do? Assume the water's change in height is negligible.



Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

32. (10.00 pts)
Bella manufactures long rectangular metal rod with a mass of 2.00 x 10^4 kg and an elastic modulus of 3.15 x 10^{10} Pa. The ends are square with side length 0.100 m. Amy right walks by the rod, and when her ear is next to one end, Bella whacks the other side. Amy hears the first sound after 0.114 s. How much longer after the first sound will she hear the second sound?

Repeated for convenience

All calculation answers MUST be input in the EXACT following format:

[Digits] E[Order of Magnitude] [Units]

Digits will go in the first blank

Order of magnitude will go in the second blank (DO NOT type the E)

Units will go in the third blank

Input one of these units EXACTLY: m, Hz, Pa, kg, sec, deg, N, J

Your test is now complete.