Unit Plan – SPH3U
Waves and Sound

Rationale

Curriculum Expectations

The expectations from the latest curriculum document are listed below for quick reference

Overall Expectations

By the end of this course, students will:

E1. analyse how mechanical waves and sound affect technology, structures, society, and the environment, and assess ways of reducing their negative effects;

E2. investigate, in qualitative and quantitative terms, the properties of mechanical waves and sound, and solve related problems;

E3. demonstrate an understanding of the properties of mechanical waves and sound and of the principles underlying their production, transmission, interaction, and reception.

Specific Expectations

E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

E1.1 analyse how properties of mechanical waves and sound influence the design of structures and technological devices (e.g., the acoustical design of a concert hall; the design of headphones, hearing aids, musical instruments, wave pools) [AI, C]

E1.2 analyse the negative impact that mechanical waves and/or sound can have on society and the environment, and assess the effectiveness of a technology intended to reduce this impact [AI, C]

E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

E2.1 use appropriate terminology related to mechanical waves and sound, including, but not limited to: longitudinal wave, transverse wave, frequency, period, cycle, amplitude, phase, wavelength, velocity, superposition, constructive interference, destructive interference, standing waves, and resonance [C]

E2.2 conduct laboratory inquiries or computer simulations involving mechanical waves and their interference (e.g., using a mass oscillating on a spring, a mass oscillating on a pendulum, the oscillation in a string instrument) [PR]

E2.3 plan and conduct inquiries to determine the speed of waves in a medium (e.g., a vibrating air column, an oscillating string of a musical instrument), compare theoretical and empirical values, and account for discrepancies [IP, PR, AI, C]

E2.4 investigate the relationship between the wavelength, frequency, and speed of a wave, and solve related problems [PR, AI]

E2.5 analyse the relationship between a moving source of sound and the change in frequency perceived by a stationary observer (i.e., the Doppler effect) [AI]

E2.6 predict the conditions needed to produce resonance in vibrating objects or air columns (e.g., in a wind instrument, a string instrument, a tuning fork), and test their predictions through inquiry [IP, PR, AI]

E2.7 analyse the conditions required to produce resonance in vibrating objects and/or in air columns (e.g., in a string instrument, a tuning fork, a wind instrument), and explain how resonance is used in a variety of situations (e.g., to produce different notes in musical instruments; to limit undesirable vibrations in suspension bridges; to design buildings so that they do not resonate at the frequencies produced by earthquakes) [AI, C]

E3. Understanding Basic Concepts

By the end of this course, students will:

E3.1 distinguish between longitudinal and transverse waves in different media, and provide examples of both types of waves

E3.2 explain the components of resonance, and identify the conditions required for resonance to occur in vibrating objects and in various media (e.g., with reference to a musical instrument, a child on a swing, the Tacoma Narrows Bridge)

E3.3 explain and graphically illustrate the principle of superposition with respect to standing waves and beat frequencies

E3.4 identify the properties of standing waves, and, for both mechanical and sound waves, explain the conditions required for standing waves to occur

E3.5 explain the relationship between the speed of sound in various media and the particle nature of the media (e.g., the speed of sound in solids, liquids, and gases; the speed of sound in warm and cold air)

E3.6 explain selected natural phenomena (e.g., echo location, or organisms that produce or receive infrasonic, audible, or ultrasonic sound) with reference to the characteristics and properties of waves

Course Expectations

These course expectations will be developed across all strands and will not be completely covered in this particular unit. They are listed here for reference.

A. Scientific Investigation Skills and Career Exploration

Overall Expectations

Throughout this course, students will:

A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

A2. identify and describe careers related to the fields of science under study, and describe the contributions of scientists, including Canadians, to those fields.

Specific Expectations

A1. Scientific Investigation Skills

Throughout this course, students will:

*Initiating and Planning [IP]**

A1.1 formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research

A1.2 select appropriate instruments (e.g., probeware, calorimeters, pendulums, solenoids) and materials (e.g., drag sleds, electric bells, balls, ramps), and identify appropriate methods, techniques, and procedures, for each inquiry

A1.3 identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately

A1.4 apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection

*Performing and Recording [PR]**

A1.5 conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data

A1.6 compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams

A1.7 select, organize, and record relevant information on research topics from a variety of appropriate sources, including electronic, print, and/or human sources, using suitable formats and an accepted form of academic documentation

*Analysing and Interpreting [AI]**

A1.8 synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error

A1.9 analyse the information gathered from research sources for logic, accuracy, reliability, adequacy, and bias

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge

*Communicating [C]**

A1.11 communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

A1.12 use appropriate numeric (e.g., SI and imperial units), symbolic, and graphic modes of representation for qualitative and quantitative data (e.g., vector diagrams, free-body diagrams, algebraic equations)

A1.13 express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures

A2. Career Exploration

Throughout this course, students will:

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., theoretical physicist; communications, networks, and control systems professional; engineer; metallurgist) and the education and training necessary for these careers

A2.2 describe the contributions of scientists, including Canadians (e.g., Richard E. Taylor, Leonard T. Bruton, Willard S. Boyle, Martha Salcudean, Harriet Brooks, Louis Slotin), to the fields under study

(Ontario Ministry of Education, 2008)

Achievement Chart

For reference, the Achievement Chart Categories from the curriculum document are listed below with the abbreviation to be used throughout this document.

K Knowledge and Understanding

T Thinking and Investigation

C Communication

A Application

(Ontario Ministry of Education, 2008)

Learning Skills

For Reference, the Learning Skills and Work Habits from the Growing Success document are listed below with the abbreviation to be used throughout this document.

R Responsibility

O Organization

IW Independent Work

C Collaboration

IN Initiative

S Self-Regulation

(Ontario Ministry of Education, 2010)

Key Expectations

The key expectations must be covered and are the focus of this unit. The key expectations of this unit are as follows:

E2.1 – Students must be able to use and recognize the appropriate terminology in this unit to be successful. This expectation is covered directly or indirectly in all unit content. This knowledge will also be required in the Wave Nature of Light strand in grade 12.

E2.3 – This expectation covers important concepts like how waves travel in different mediums, which leads to key understandings throughout the unit. This material has many applications for solving various problems and must be understood when covering other expectations in this unit.

E2.6 and E2.7 – Students must understand resonance (E2.7) to be able to cover expectation E2.6

E1.1, E1.2, E3.6 – This expectation is important to cover to ensure the material is authentic and relevant to the students. It shows them how and where these concepts can be applied. This information is useful for students looking to take physics in the future and may also motivate students to continue to take physics in the future. These expectations can be combined or split up and covered in a small chunk of time each but they should be a priority to cover.

Minor Expectations

The minor expectations can be briefly covered or downplayed if time becomes an issue. The minor expectations for this unit are as follows:

E3.1 – This expectation can be covered relatively quickly as part of the introduction to the unit and assessed with some examples. Students simply need to understand and be able to understand the types of waves.

Other expectations can be described as having normal importance. They could be combined with other normal importance expectations if time is critical.

Assessment and Evaluation

The assessment strategy for this unit focuses on assessing the students often to ensure understanding of the concepts. Regular assessment will also help motivate the students to complete their homework. A Do Now question is an assessment for learning that will be completed at the start of each class to assess prior knowledge coming into the lesson. Occasionally, students will peer assess the Do Now question for an assessment as learning exercise. Any topics that need to be reinforced can be prior to the lesson. Technology tools like Plickers will be used to aid in assessment as described in the Daily Plan.

Every lesson will have homework assigned and class time will be given each day to work on the assigned questions. During this time, the teacher will circulate the classroom to assess for learning. If the teacher recognizes that students are struggling with a particular question, they can re-engage the class to discuss or clear up any misconceptions. Assessment for learning will also occur when discussing the activities and demonstrations with the class.

The two major assessments of learning will be a formal lab report and a unit test. The formal lab also includes questions to guide the student learning. As this unit occurs later in the semester, there is an expectation of a quality formal lab report as the students will have experience from previous units. The unit test will appropriately cover the expectations of the course. A copy of each of these assessments is included in this unit plan. The formal lab report will focus on assessing the students ability to apply the concepts in a hands-on manner. The lab will be executed after learning the theoretical concepts. This will allow students to think critically as they apply their knowledge in the lab. The goal is for students to use metacognitive skills to determine if the lab results are appropriate and correct during the lab if it is not going well or at least determine why it may not be working as expected. The unit test was selected as an opportunity for students to apply their learning in a more common setting. The test will be based on homework questions and application of knowledge through the unit.

General Notes

Although any grade 11 physics textbook could be used with this unit, the Nelson Grade 11 Physics, University Preparation text will be used as the reference text.

Demonstrations are utilized throughout the unit to solidify the concepts for the students. If physical apparatus are unavailable, video demonstrations are available as an alternative.

The class notes for the next day will be made available each day on the class website so students can prepare for the next day. This should help ease anxiety and assist ELL students. The use of demonstrations and kinesthetic representations will assist diverse learners in the classroom.

Daily Plan

The following table lays out the daily plan for the unit. Based on group discussions regarding time allocated to the unit. This plan is particularly optimistic and will be a challenge to complete in the time allotted. To remain true to the spirit of the assignment, the tight schedule will remain intact.

Day	Lesson Topics	Curriculum Expectations	Lesson Summary	Assessment/Evaluation
1	1. Introduction to Waves 2. Transverse Waves 3. Longitudinal Waves	E2.1 E2.2 E3.1	- Discuss "What is a wave" with students. - Have the students line up and do "the wave" as a kinesthetic representation of a wave. Use this to drive discussion using proper terminology. - Use a guitar string video (https://www.youtube.com/watch?v=CPAD49PKdYE) to demonstrate transverse wave demonstration. - Use slinky for longitudinal wave demonstration video of the demonstration can be found here (http://courses2.cit.cornell.edu/physicsdemos/secondary.php?pfID=42). - think-pair-share to discuss demos and communicate the difference between transverse and longitudinal waves. Content Text Reference: Nelson Chapters 8.1-8.2 Instructional Strategies: Lecture, Demonstration, Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class.	Assessment FOR Learning: - Circulation during homework time Assessment AS Learning - Think-pair-share during demonstration Achievement Chart: K/T/C Skills: C/IN/S
2	1. Wave Characteristics 2. Wave Speed 3. Universal Wave Equation	E2.4	- Do Now to assess prior knowledge from previous class. - Use Geogebra (https://www.geogebra.org/) to show and compare waveforms. Changing the characteristics of the wave and observing how the waveform changes. Content Text Reference: Nelson Chapters 8.3-8.4 Instructional Strategies: Lecture, Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support.	Assessment FOR Learning: - Do Now at the start of class - Questioning during Geogebra demo - Circulation during homework time

				Achievement Chart: K/T/C Skills: R/C/IN/S
3	1. Sound Waves 2. Speed of Sound in Different Mediums	E2.3 E3.5	- Plickers questioning to assess previous class knowledge - Perform bell jar experiment to demonstrate what happens to sound in a vacuum (example video: https://www.youtube.com/watch?v=hIOqX4uJtYY). - Discuss (think-pair-share) what happens at each stage of the demonstration. - Give students lab to review for next class. Content Text Reference: Nelson Chapter 8.5 Instructional Strategies: Lecture, Demonstration, Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support.	Assessment FOR Learning: - Plickers questions at the start of class - Circulation during homework time Assessment AS Learning - Think-Pair-Share Achievement Chart: K/T/C Skills: R/C/IN/S
4	1. The Doppler Effect	E2.5	- Do Now to assess previous class knowledge - Audio example from YouTube (https://www.youtube.com/watch?v=a3RfULw7aAY) - Discuss Gizmos Starter (http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=363) and Advanced (http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=584) - Use Plickers during questioning with Gizmos Content Text Reference: Nelson Chapter 9.5 Instructional Strategies: Lecture, Demonstration, Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support.	Assessment FOR Learning: - Do Now at the start of class - Circulation during homework time - Plickers questioning during demonstration Achievement Chart: K/T/C Skills: R/C/IN/S
5	1. Constructive and Destructive Interference 2. Beats	E3.3	- Do Now to assess previous class knowledge - Use Audacity sound demo to demonstrate beats. - think-pair-share questioning during demonstration, “What do you think will happen when…”	Assessment FOR Learning: - Do Now at the start of class

			Content Text Reference: Nelson Chapters 9.1, 9.3 Instructional Strategies: Lecture, Demonstration, Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support.	- Circulation during homework time Assessment AS Learning - think-pair-share during demonstration Achievement Chart: K/T/C Skills: R/C/IN/S
6	1. Waves at Media Boundaries 2. Standing Waves	E3.4	- Do Now to assess previous class knowledge - PhET demo (http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html and http://phet.colorado.edu/simulations/stringwave/stringWave.swf) Content Text Reference: Nelson Chapter 9.2 Instructional Strategies: Lecture, Demonstration, Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support.	Assessment FOR Learning: - Do Now at the start of class - Questioning during demo - Circulation during homework time Achievement Chart: K/T/C Skills: R/C/IN/S
7	1. Lab - Investigating Standing Waves in an Air Column	E2.6 A1.5 A1.6 A1.8 A1.10 A1.11 A1.12 A1.13	- Review lab and lab safety. - Lab sheet included later in Unit Plan for reference. Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support. Encourage cooperative work with partners. Materials Required for Lab (see attached lab): • resonance apparatus like the one found at (https://www.wardsci.com/store/catalog/product.jsp?catalog_number=160192) • metre stick • tuning forks of varying frequencies • rubber hammer	Assessment OF Learning - Formal lab report Achievement Chart: K/T/C/A Skills: R/O/IW/C/IN/S

			• tape (optional)	
8	2. Dampening and Resonance	E2.7 E3.2	- Do Now to assess previous class knowledge - Demonstration of resonance and beats using apparatus found on this YouTube video (http://video.mit.edu/watch/tuning-forks-resonance-a-beat-frequency-11447/) Content Text Reference: Nelson Chapter 9.4 Instructional Strategies: Lecture, Demonstration, Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support.	Assessment FOR Learning: - Do Now at the start of class - Questioning during demo - Circulation during homework time Achievement Chart: K/T/C Skills: R/C/IN/S
9	1. Wave Applications	E1.1 E1.2 E3.6	- Do Now to assess previous class knowledge - Bridge Resonance Hook Video (https://www.youtube.com/watch?v=j-zczJXSxnw) - Example problems reviewed as a class, students will work in pairs to solve real world application problems. - Review questions assigned for homework for next class. Content Text Reference: Selections from Nelson Chapter 10 Instructional Strategies: Multimedia, Question Posing Accommodations: Provide notes for ELL students prior to class. Also, provide extra time/support.	Assessment FOR Learning: - Do Now at the start of class - Questioning during demo - Circulation during homework time Achievement Chart: K/T/C/A Skills: R/C/IN/S
10	1. Unit Review		- Review questions assigned in previous lesson will be taken up in class - If a large number of students are having challenges with a particular question, students will work in pairs or groups to attempt to solve. Content Text Reference: Selections from Nelson Chapter and Unit Reviews Accommodations: Provide extra time/support for ELL students. Encourage cooperative work with partners. Ensure questions are clearly and simply worded.	Assessment FOR Learning - Review Questions done in class - Teacher circulating during work time Assessment AS Learning

				- Pair work for problem questions Achievement Chart: K/T/C/A Skills: R/IW/C/S
11	1. Unit Test		- Test included later in this document Accommodations: Provide extra time/support for ELL students. Ensure questions are clearly and simply worded.	Assessment OF Learning - Unit Test Achievement Chart: K/T/C/A Skills: R/O/IW

References

DiGiuseppe, M., Howes, C. T., Speijer, J., Stewart, C., van Bemmel, H. M., Vucic, R., & Wraight, V. (2011). *Nelson Physics 11.* Toronto: Nelson Education Ltd.

Ontario Ministry of Education. (2008). *The Ontario Curriculum Grades 11 and 12 Science.* Ministry of Education.

Ontario Ministry of Education. (2010). *Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools.* Toronto: Ontario Ministry of Education.

Investigating Standing Waves in an Air Column

Description

As we learned previously, waves reflect off both fixed and open ends of a medium, be it a rope or an air column. In this investigation, you will use what you have learned to predict the length of the resonance tube that will support the first harmonic for several tuning forks. In addition, you will determine points of resonance and the local speed of sound.

You will strike a tuning fork of known frequency and place it at the end of a resonance tube. The water reservoir can be manipulated to create various lengths. You will hear a louder sound when resonance has occurred.

You will calculate the wavelength of the fundamental frequency by measuring the tube length for the harmonics you detect. The tuning fork is at the open end of the tube. Thus, the situation is for one open and one closed end. When you have produced a standing wave, the standing wave's amplitude should be about twice that of the tuning fork. As you modify the length, you will hear a variation in loudness. Using your wavelength measurements and the frequencies of the tuning forks, you will calculate the local speed of sound.

Purpose

To measure the length of the resonance tube that will support the first harmonic for various tuning forks and to measure the local speed of sound.

Materials

- resonance apparatus (pictured) like the one found at (https://www.wardsci.com/store/catalog/product.jsp?catalog_number=160192)
- metre stick
- tuning forks of varying frequencies
- rubber hammer
- tape (optional)

Procedure

1. Set up the resonance apparatus and fill the water reservoir.

2. You may want to make some initial tape marks on the resonance tube to indicate approximate distances.

3. Practise striking a tuning fork with a rubber hammer so that you do not double-strike it and that the volume is sufficient. Do not strike it too hard. If you bend the tuning fork, its properties will change.

4. Strike a tuning fork and place it near the open end of the resonance tube and listen. Now move the water reservoir steadily. Listen for changing sound levels. Repeat this step two or three times until you are comfortable with the procedure.

5. Move the water reservoir as far as possible. Determine the distance expected for $\frac{\lambda}{4}$ of the fundamental frequency. Use the frequency stamped on the tuning fork and an estimate of the speed of sound in air in your classroom. Retract the water reservoir slightly, so that it is still inside the expected $\frac{\lambda}{4}$.

6. Strike the tuning fork and slowly retract the water reservoir. Mark the location of the resonance point.

7. Repeat Step 8 several times and calculate an average value.

8. Retract the water reservoir farther and determine the lengths of the harmonics. Calculate averages of these as well.

9. Repeat Steps 5 through 10 as necessary for the various frequencies of tuning forks available.

Analyze and Evaluate

Complete the following questions and submit them along with your observations in a formal lab report. Your lab report is worth 15 Marks. Marks for each question are as indicated. The total value of this lab is 37 Marks.

1. Was the prediction you made about the length of the resonance tube supported? Explain. [K 3 Marks]

2. Make a drawing of the standing waves in your resonance tube for each harmonic you detected. Using shading to indicate regions of high and low pressure, make at least one diagram of longitudinal waves in one of the harmonics you detected. [C 3 Marks]

3. How did you know that you found a point of resonance? Explain. [K 3 Marks]

4. Calculate the speed of sound for all of your resonance points and tuning forks. Do the answers agree? [I 5 marks]

5. Identify any sources of error in this investigation. Suggest how the procedure could be improved. [I 4 Marks]

Apply and Extend

1. Using what you have learned in this investigation, explain the purpose of the small holes along the tube of some wind instruments, such as the flute, that the musician covers up with his or her fingers. [M 4 Marks]

Adapted from Nelson Physics 11 Investigation 9.4.1

Name ____

MARK

/ 60

Unit Test
SPH3U- Waves and Sound

Part 1 – Multiple Choice (10 marks total)

Read each question carefully and circle the letter corresponding to the **most** correct answer. (1 mark each)[K]

1. The speed of a mechanical wave as it propagates through a medium is dependent on
   a. Wavelength
   b. Frequency
   c. Medium the wave is travelling through
   d. Period

2. A transverse wave has an amplitude of 2.5m. What is the distance between the top of a crest and the bottom of a trough?
   a. 2.5m
   b. 5.0m
   c. 1.25m
   d. 10.0m

3. Why does sound not travel in a vacuum?
   a. The sound travels but the human ear is not sensitive enough to hear it.
   b. A vacuum is too cold for sound to travel.
   c. Sound propagates through matter and there is no matter in a vacuum.
   d. Sound does travel in a vacuum.

4. Which property of a sound wave is responsible for loudness?
   a. Frequency
   b. Amplitude
   c. Speed
   d. Wavelength

5. If you are standing still and a police car approaches you with the siren blaring, the frequency you observe will be
    a. Higher than the actual frequency
    b. Lower than the actual frequency
    c. The same as the actual frequency
    d. There is not enough information to know for sure

6. A plucked guitar string is an example of which type of wave?
    a. Longitudinal
    b. Electromagnetic
    c. Acoustic
    d. Transverse

7. If you add two waves which are exactly out of phase and have the same amplitude, what will be the result?
    a. The resulting wave will have double the amplitude
    b. The resulting wave will have half the amplitude
    c. The waves will cancel each other completely
    d. The waves will speed up

8. What is the relationship between period and frequency?
    a. period = frequency * amplitude
    b. period = frequency
    c. period = frequency/amplitude
    d. period = 1/frequency

9. The speed of sound would most likely be fastest in which season?
    a. Spring
    b. Summer
    c. Fall
    d. Winter

10. Which statement about the nodes of a standing wave on a string with two fixed ends is **false**?
    a. The fixed ends are always nodes
    b. Adjacent nodes are separated by one wavelength
    c. Adjacent nodes are separated by a half wavelength
    d. The fundamental frequency occurs when the distance between adjacent nodes is from the standing wave pattern with the longest wavelength

Part 2 – Short Answer Questions (50 marks total)

Carefully read the following questions. Answer using complete sentences and showing all of your work.

1. Define each of the following terms and include a diagram [K/C]
    a. Frequency (2 marks)

    b. Amplitude (2 marks)

    c. Wavelength (2 marks)

2. You are listening to your favourite song on your iPod and you decide to double the volume. Describe what happens to the amplitude, frequency, and speed of the sound wave? (3 marks)[K]

3. A longitudinal wave travelling along a spring has a frequency of 80Hz. If the distance between successive compressions is 0.5m, what is the speed of the wave? (3 marks)[K]

4. A tour guide shouts across a canyon. At a temperature of 24 °C, her echo is heard 2.0s later. How wide is the canyon? (3 marks)[K/I]

5. In the movies, people will sometimes place their ear on train tracks to listen for trains. Would this work in reality? Explain your answer. (3 marks)[K/C/I]

6. Explain how the distance to a lightning bolt can be determined by counting the seconds between the flash and the sound of thunder. (3 marks)[K/I/C]

7. Referring to the image below, answer the following questions [K]

a. How many nodes are depicted? (1 mark)

b. What is the wavelength? (2 marks)

c. If the frequency is 60Hz, what is the speed of the wave? (2 marks)

8. A closed air column is 35.0cm long. Calculate the frequency of a tuning fork that will cause resonance at the third resonant length if it is 0.0°C. (4 marks)[K/I]

9. Hollow tube chimes are made of metal and are open at each end. These columns resonate best at their third resonant length. One chime is 2.5m long and the air temperature is 25.0°C.
   a. What is the speed of sound? (2 marks)[K]

   b. What is the wavelength of the sound produced? (3 marks)[K]

   c. What is the frequency of the sound produced? (2 marks)[K]

10. Based on what you have learned about open and closed air columns, explain the purpose of air holes on a flute. (3 marks)[K/C/M]

11. A source passing a stationary observer is emitting a frequency of 560 Hz. If the speed of sound is 345 m/s, what must the speed of the source be if the frequency source is 480 Hz? (4 marks)[K]

12. Two vibrating tuning forks make 12 beats in 4.0s. If one tuning fork is 1000Hz, what are the possible frequencies of the other tuning fork? (2 marks)[K]

13. How did the information you learned in this unit affect your thinking about the dangers and benefits of vibrations and waves? (4 marks)[K/C/M]