Name: _____

Class: _____

Due Date: _____

Physics Topic 37 – Standing Waves

Answer the following questions. The solutions to this worksheet can be found on the YouTube channel Go Physics Go.

1. C: List some observations which can be made from standing waves but not traveling waves.

C: Define the following terms:

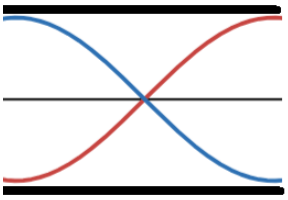
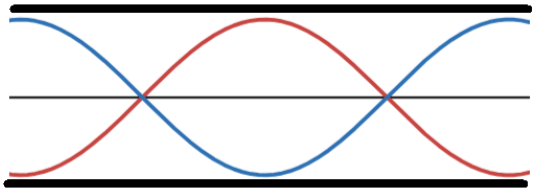
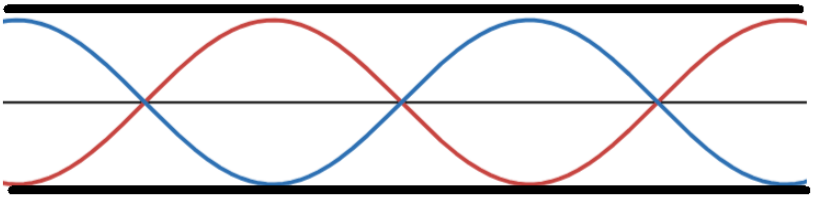
a. Node

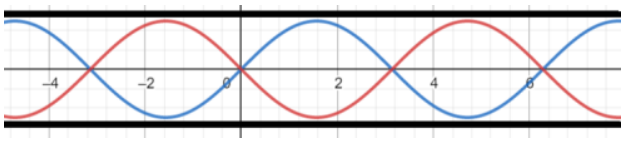
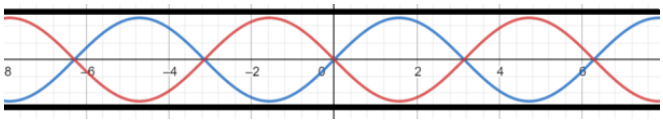
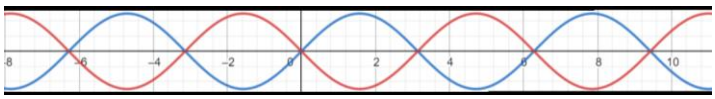
b. Anti-node

c. First harmonic

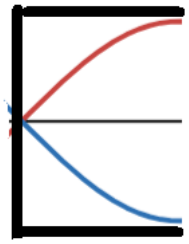
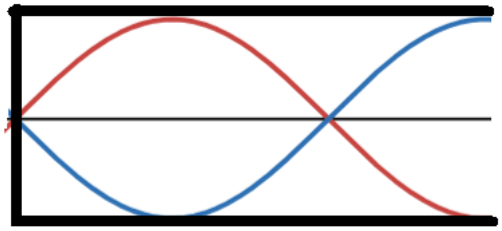
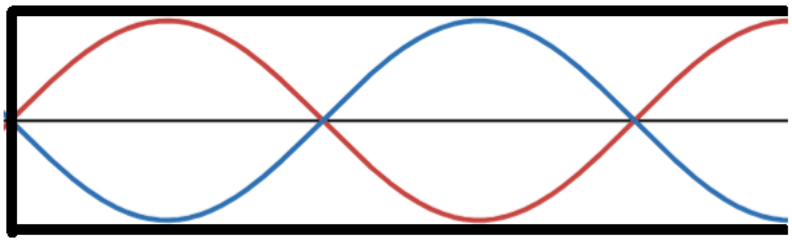
d. Fundamental frequency

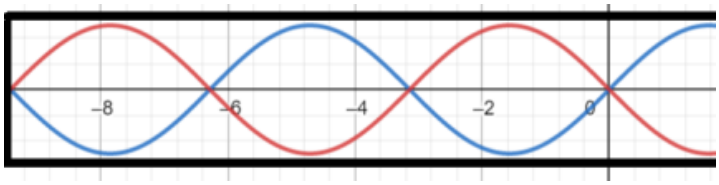
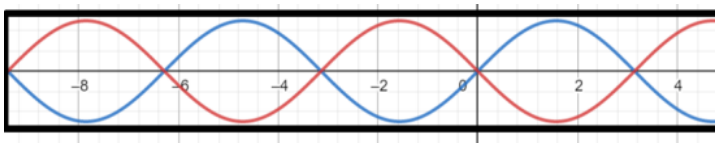
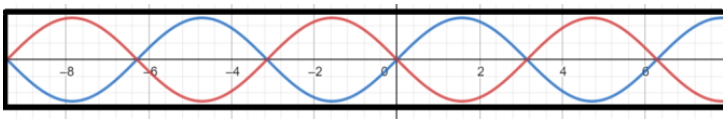
3. C: **Use a pencil and ruler!** Below are the first three harmonics of a tube with both ends open. The frequencies of the first three harmonics are derived for you. Draw and solve for the next three frequencies on the next page.

 First harmonic	$L = \frac{\lambda}{2}$ $\lambda = 2L$ $v = \lambda f$ $v = 2Lf$ $f = \frac{v}{2L}$
 Second harmonic	$L = \lambda$ $\lambda = L$ $v = \lambda f$ $v = Lf$ $f = \frac{v}{L}$
 Third harmonic	$L = \frac{3\lambda}{2}$ $\lambda = \frac{2L}{3}$ $v = \lambda f$ $v = \frac{2Lf}{3}$ $f = \frac{3v}{2L}$

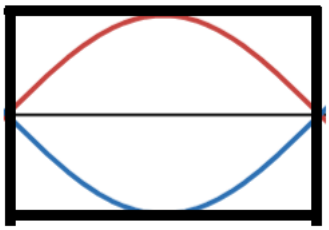
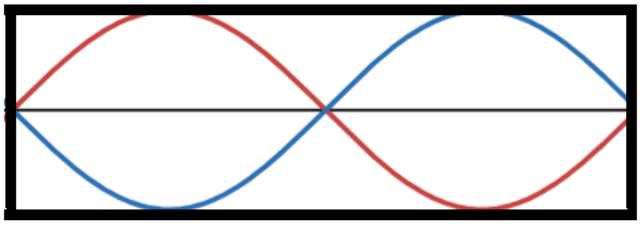
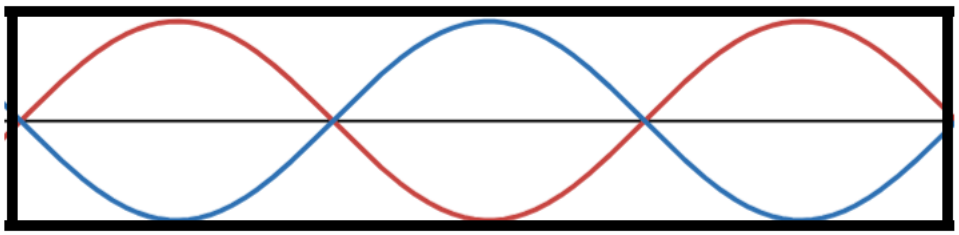
 Fourth harmonic	
 Fifth harmonic	
 Sixth harmonic	

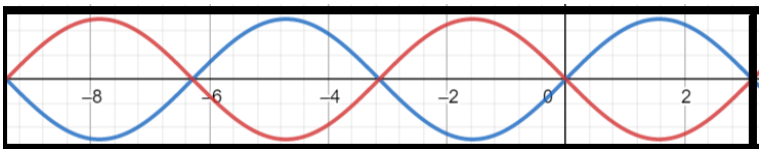
4. C: **Use a pencil and ruler!** Below are the first three harmonics of a tube with one end open and one end closed. The frequencies of the first three harmonics are derived for you. Draw and solve for the next three frequencies on the next page.

 First harmonic	$L = \frac{\lambda}{4}$ $\lambda = 4L$ $v = \lambda f$ $v = 4Lf$ $f = \frac{v}{4L}$
 Third harmonic	$L = \frac{3\lambda}{4}$ $\lambda = \frac{4L}{3}$ $v = \lambda f$ $v = \frac{4Lf}{3}$ $f = \frac{3v}{4L}$
 Fifth harmonic	$L = \frac{5\lambda}{4}$ $\lambda = \frac{4L}{5}$ $v = \lambda f$ $v = \frac{4Lf}{5}$ $f = \frac{5v}{4L}$

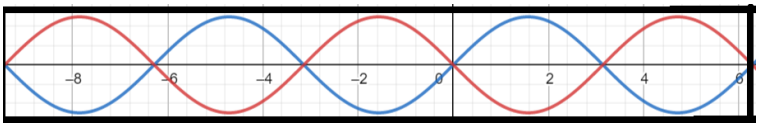
 Seventh harmonic	
 Ninth harmonic	
 Eleventh harmonic	

5. C: **Use a pencil and ruler!** Below are the first three harmonics of a tube with both ends closed. The frequencies of the first three harmonics are derived for you. Draw and solve for the next three frequencies on the next page.

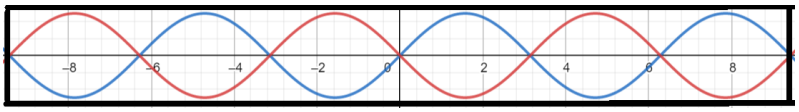
 First harmonic	$L = \frac{\lambda}{2}$ $\lambda = 2L$ $v = \lambda f$ $v = 2Lf$ $f = \frac{v}{2L}$
 Second harmonic	$L = \lambda$ $\lambda = L$ $v = \lambda f$ $v = Lf$ $f = \frac{v}{L}$
 Third harmonic	$L = \frac{3\lambda}{2}$ $\lambda = \frac{2L}{3}$ $v = \lambda f$ $v = \frac{2Lf}{3}$ $f = \frac{3v}{2L}$



Fourth harmonic



Fifth harmonic



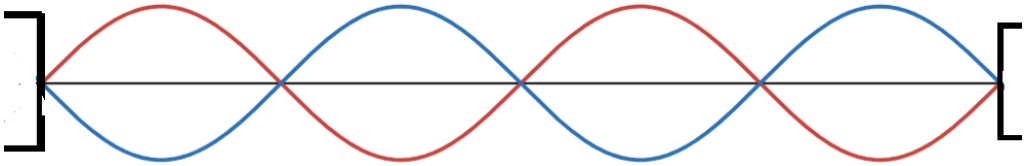
Sixth harmonic

6. C: Give an example of a standing wave formed in an open-open pipe.

7. C: Give an example of a standing wave formed in a open-closed pipe.

8. C: Give an example of a standing wave formed in a closed-closed pipe.

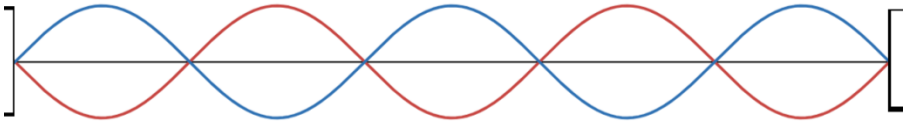
9. E: A string is stretched between two rigid supports which are 1.20 m apart. The string is plucked and it is noted that a standing wave is formed on the string which consists of five nodes, including the endpoints, and four antinodes.



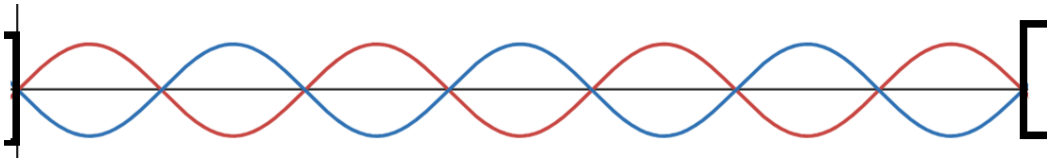
   a. What is the wavelength of this standing wave?

   b. If the frequency of this vibration is 220. Hz then what is the frequency of the fundamental frequency which will vibrate in this string?

c. What will be the frequency of the fifth harmonic which will vibrate in this string?



10. E: Transverse waves are being generated in a string between two fixed points which are 3.50 m apart by a wave oscillator which is generating a frequency of 28.0 Hz.



a. What is the wavelength of the wave?

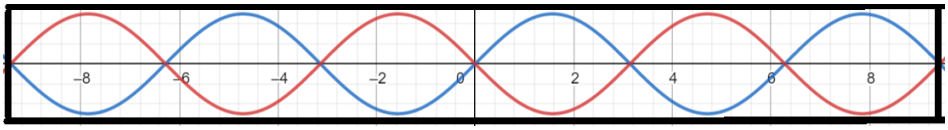
b. What is the speed of the wave?

c. What is the lowest frequency which could be used to generate a standing wave in this string?

d. What is the wavelength of the lowest frequency wave which could form a standing wave in the string?

e. What other frequencies could form standing waves in the string?

11.E: Consider the string vibrating below and forming a standing wave with a frequency of 180. Hz. The length of this string is 1.50 m.

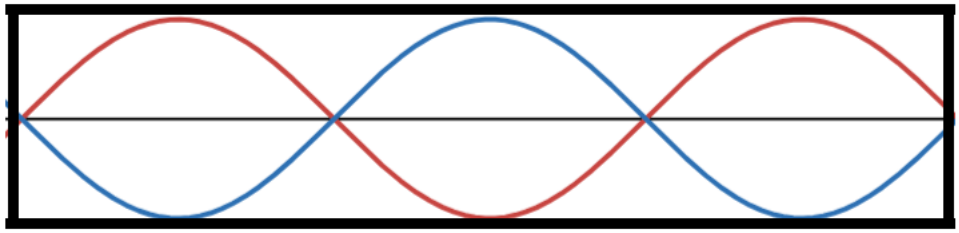


a. What is the wavelength of the wave?

b. What is the speed of the wave?

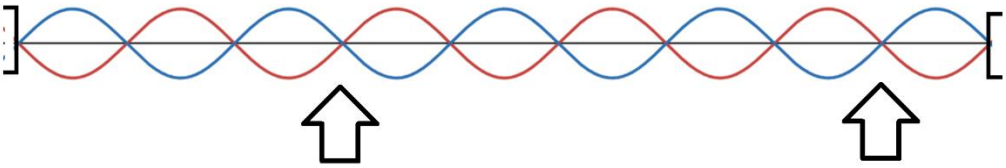
c. What is the fundamental frequency which will resonate in the string?

d. What will be the frequency of the third harmonic which will resonate in the string?

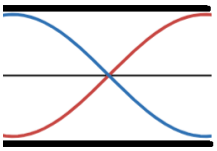


What will be the frequency of the ninth harmonic which will resonate in the string?

12. A closed-closed guitar string has a standing wave on it. The distance between the fourth node and ninth node is 50.0 mm. What is the wavelength of the standing wave?



13. An open-open pipe has a length L. State an equation for the frequency of vibration of the first harmonic (fundamental frequency) standing wave which can be set up in the pipe if the speed of sound is v.



14. An open-closed pipe has a fundamental frequency f. What will be the first harmonic (fundamental frequency) of another pipe of the same length which is open at both ends?

15.E: Pipe A has a length of 2.00 m and is open at both ends. Pipe A produces a frequency of 36.0 Hz when the air inside it vibrates in its first harmonic (fundamental frequency). Pipe B is closed at one end and also produces a frequency of 36.0 Hz when the air inside it vibrates in its first harmonic (fundamental frequency). Calculate the length of pipe B.

16. Water is in a vertical cylinder. A smaller vertical cylinder is inside the larger vertical cylinder. A tuning fork which produces a vibration with frequency *f* is placed above the smaller cylinder. When the length of the smaller cylinder above the water is L_1 a maximum sound is heard at the first harmonic (fundamental frequency). Water is then drained from the larger vertical cylinder. When the length of the smaller cylinder above the water is L_2 another maximum sound is heard at the third harmonic. Determine an expression for the speed of sound in the smaller cylinder in terms of *f*, L_1, and L_2.

17. Consider two pipes. Pipe A is an open-open pipe with a length L. Pipe B is an open-closed pipe with a length L'. The frequency of the first harmonic of both pipes is the same. Calculate $\frac{L'}{L}$.

18. Consider two pipes. Pipe A is an open-open pipe with a length L with a first harmonic of 300 Hz. Pipe B is an open-closed pipe with a length L. Calculate the frequency of the first harmonic of pipe B.