HARMONICS

Name _____

Wavelengths of a Harmonic

One wavelength:

In each harmonic, there are *two questions to answer:*

1. How many wavelengths are there in this harmonic?

2. How long is a single wavelength in this harmonic?

For harmonics on a string, these are related by the intuitive formula**:

$$(\text{Number of Wavelengths})(\text{Wavelength}) = \text{Total Length of String}$$

** By *intuitive formula*, I mean that this is not one of the official physics formulas that appears in textbooks and on tests, but is a formula that you can make up yourself logically.

If a wave is 300 centimeters long and it contains 3.5 wavelengths, how long is a single wavelength?

If a wave is 200 centimeters long, and it contains 1.5 wavelengths, how long is a single wavelength?

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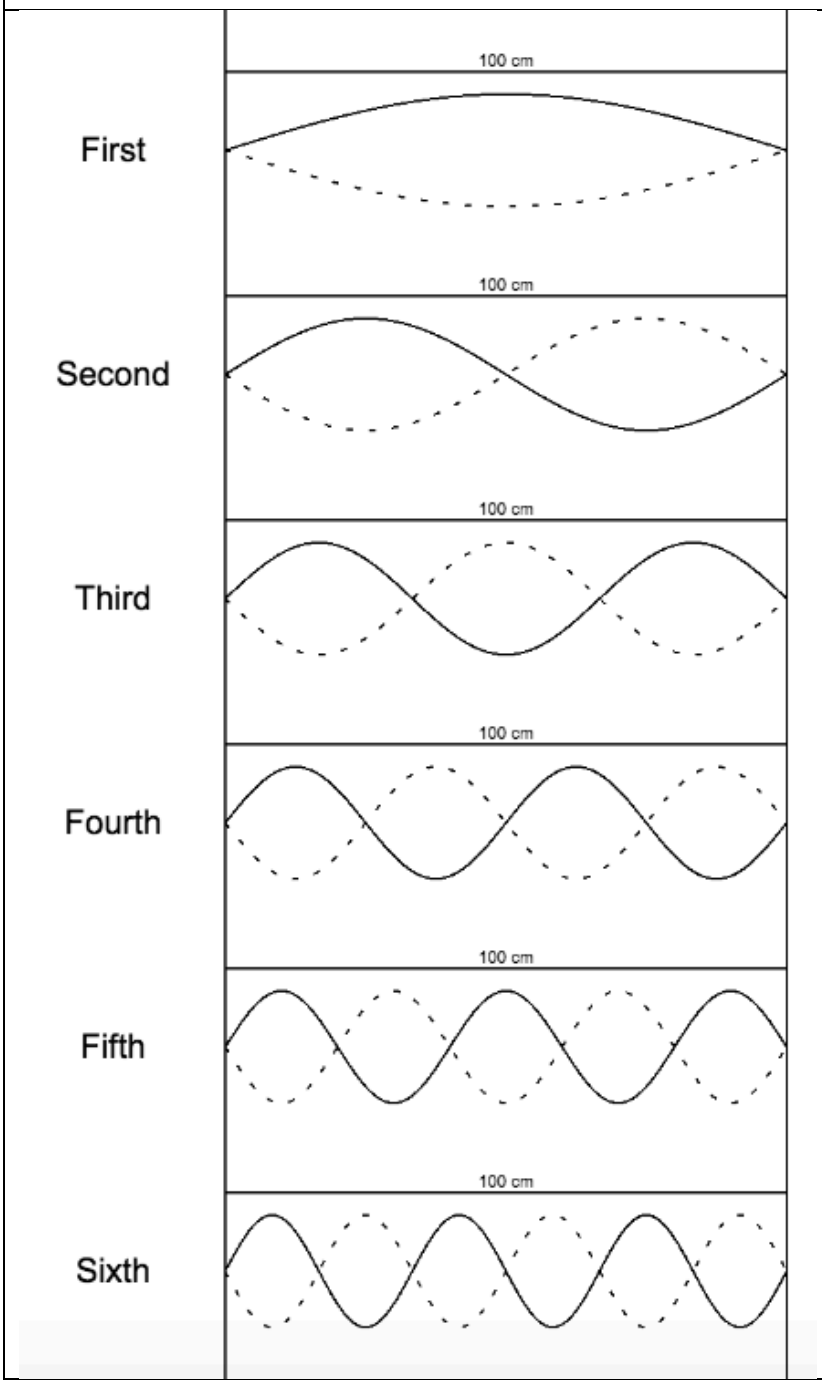
In the following picture, each harmonic has a *total length* of 100 centimeters.
Determine *how many wavelengths* are within each harmonic.
Determine *a single wavelength* for each harmonic:

	How many *wavelengths*?	What is a single *wavelength*?
		

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By following a pattern from the formulas above, can you figure out the wavelengths of more harmonics?

Total Length = 100 centimeters

Harmonic	How many wavelengths are in the harmonic?	What is one wavelength of this harmonic?
Seventh		
Eighth		
Ninth		
Tenth		

Speed and Frequency of Harmonics

Speed of a Harmonic

The *speed* of each harmonic in a series should be constant.
That is, all harmonics should have the same *wave speed*.

The SI unit is meters / second.
But, it could also be cm/s in some cases)

Frequency of a Harmonic

The *frequency* of a harmonic is how many times the standing wave oscillates in a single second.

The wave formula

All harmonics must satisfy the wave equation from page 1 of this packet:

$$v = \lambda f$$

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A series of harmonics are made on a string that is 100 centimeters long.
You can determine the *wavelength* from the previous page.
Assume that the *speed* of every one of these waves is 1800 cm/s. [This is a reasonable assumption.]
Find the *frequency* of each of the harmonics on this page.

Harmonic	**Wavelength (cm)**	**Frequency (Hz)**	**Speed (cm/s)**
First			
Second			
Third			
Fourth			
Fifth			
Sixth			
Seventh			
Eighth			

Fundamental Frequency The frequency of the first harmonic.
Natural Frequencies The frequencies of all the harmonics

What is the *fundamental frequency* of this wave pattern?

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You make harmonics on a string that is 150 centimeters long.
The speed of waves on this string is 2200 centimeters/second
Draw the first five harmonics. Find the wavelength of each:

Total Length = 150 cm

Harmonic	Drawing	How many wavelengths are in the harmonic	What is a wavelength?
First			
Second			
Third			
Fourth			
Fifth			

Fill out this table and find the frequency of each harmonic in the pattern.

Harmonic	**Wavelength (cm)**	**Frequency (Hz)**	**Speed (cm/s)**
First			
Second			
Third			
Fourth			
Fifth			
Sixth*			
Seventh			
Eighth			

* figure out the pattern to learn the wavelength of the sixth, seventh, and eighth harmonics?
What is the fundamental frequency of this wave pattern?

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You make harmonics on a string that is 80 centimeters long.
The speed of waves on this string is 900 centimeters/second
Draw the first five harmonics. Find the wavelength of each:

Total Length = 80 cm

Harmonic	Drawing	How many wavelengths are in the harmonic	What is a wavelength?
First			
Second			
Third			
Fourth			
Fifth			

Fill out this table and find the frequency of each harmonic in the pattern.

Harmonic	**Wavelength (cm)**	**Frequency (Hz)**	**Speed (cm/s)**
First			
Second			
Third			
Fourth			
Fifth			
Sixth			
Seventh			
Eighth			

What is the fundamental frequency of this harmonic?

Harmonics Math Name _____

10.
You make harmonics on a string that is 200 centimeters long.
The speed of waves on this string is 800 centimeters/second
Draw the first five harmonics. Find the wavelength of each:

Harmonic	Drawing [for full credit drawings must be the same length!]	What is a wavelength? (cm)
First		
Second		
Third		
Fourth		
Fifth		

Fill out this table and find the frequency of each harmonic in the pattern.

Harmonic	**Wavelength (cm)**	**Frequency (Hz)**	**Speed (cm/s)**
First			
Second			
Third			
Fourth			
Fifth			
Sixth			
Seventh			
Eighth			

What is the fundamental frequency of this wave pattern?

11.
You make harmonics on a string that is 50 centimeters long.
The speed of waves on this string is 2400 centimeters/second
Draw the first five harmonics. Find the wavelength of each:

Harmonic	Drawing	What is a wavelength? (cm)
First		
Second		
Third		
Fourth		
Fifth		

Fill out this table and find the frequency of each harmonic in the pattern.

Harmonic	**Wavelength (cm)**	**Frequency (Hz)**	**Speed (cm/s)**
First			
Second			
Third			
Fourth			
Fifth			
Sixth			
Seventh			
Eighth			

What is the fundamental frequency of this harmonic?

12. Explain in a few sentences how to determine the wavelength of each harmonic.

13. There is a pattern to the frequencies of each harmonic! Explain the pattern of frequencies in problem **10**.

14. Explain the pattern of frequencies in problem **11**.

Answers:

10.

Harmonic	Wavelength (cm)	Frequency (Hz)	Speed (cm/s)
First	400	2	800
Second	200	4	800
Third	133.33	6	800
Fourth	100	8	800
Fifth	80	10	800
Sixth	66.67	12	800
Seventh	57.14	14	800
Eighth	50	16	800

The fundamental frequency is 2 Hertz

11.

Harmonic	Wavelength (cm)	Frequency (Hz)	Speed (cm/s)
First	100	24	2400
Second	50	48	2400
Third	33.33	72	2400
Fourth	25	96	2400
Fifth	20	120	2400
Sixth	16.67	144	2400
Seventh	14.29	168	2400
Eighth	12.5	192	2400

The fundamental frequency is 24 Hertz