MOVIE GUIDE

MOVIE NUMBER **1017**

The Bose Speaker

The Movie:

“You can never do anything better unless it is different,” according to Dr. Amar Bose, who uses the rules of mathematics to achieve superior sound quality in his Bose radio and speakers. Featured: Amar Bose, president, Bose Corporation. *(Movie length: 1:59)*

Background:

To get a lot of sound, you need a lot of speaker. Everybody knew that—until the year that the first Bose “Acoustic Wave” speaker was put on the market.

The basic operation of a speaker is simple enough. An electromagnet is connected to a diaphragm. The magnet becomes stronger and weaker in response to a changing electric current, and pushes the diaphragm in and out, creating sound waves. The electric current itself is controlled by signals from a CD player, phonograph, or telephone wire—in all cases, those signals represent the shape of the original sound wave which the speaker should reproduce.

But, like all types of vibration, sound waves are affected by something called resonance. For any enclosed space, there are natural frequencies of vibration which depend on the size and shape of the space.

An example is a soda bottle half-filled with water. When you blow across the top of it, you create a complex collection of vibrations in the air. One of those vibrations has a frequency which matches the natural frequency of the space in the bottle, and so that vibration is reinforced. As a result, you hear a fairly pure tone of that frequency.

What if you could create a space with a special shape which reinforced vibrations of many different frequencies? Actually, this technique was mastered many hundreds of years ago, and is manifested in the bodies of fine violins and, later, guitars.

The problem is that low-frequency sound vibrations—the “bass” part of the range—consist of relatively long vibrations, which in turn means you need a larger resonance space to reinforce them. Hence, a big bass sound needed big speakers—that is, until Amar Bose came along.

Curriculum Connections:

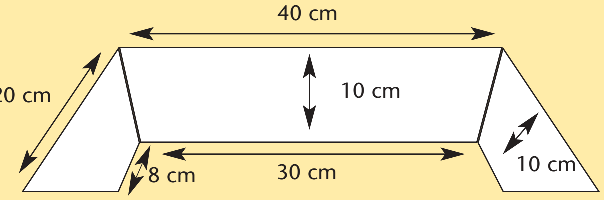
Fractions

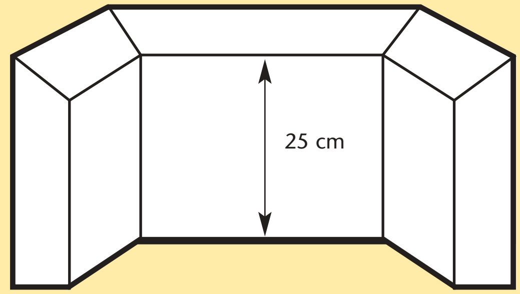
1

In a musical scale, an octave is two notes in which the second note has twice the frequency, and half the wavelength, of the first note. If an “A” on a piano has a wavelength of 80 centimeters, what would be the wavelength of the note that is 4 octaves higher?

Geometry (volume) 2

Find the volume of this symmetrical design for a speaker box. If a cylinder were 8 centimeters in diameter, how long would it be to have the same volume?





Ratios 3

The human ear can hear sounds from a wavelength of around .016 meters up to around 16 meters. Find the ratio of largest to smallest wavelength.

Scientific Notation 4

The signals that come from a CD player or phonograph must be increased in magnitude (amplified) before they are strong enough to drive a speaker. Suppose a certain device has three linked stages of amplifiers, each of which increases the magnitude of the signal coming into it by a factor of 1.32×10^2. What would the total amplification be?

Algebra (laws of equations), Decimals 5

The frequency and wavelength of a sound vibration are related to the speed with which it travels by this equation:

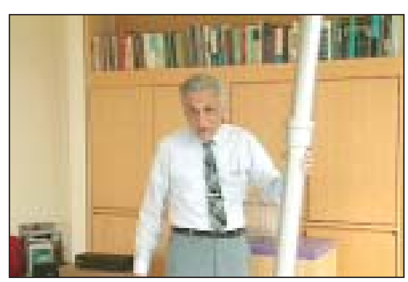
$$\lambda \nu = c^*$$

λ = wavelength, in meters
ν = frequency, in cycles per second
c = speed, in meters per second

Fill in the missing numbers in this table:

λ	ν	c
3 meters	?	340 meters/sec
.5 meters	700 cycles per second	?
?	10,000 cycles per second	345 meters/sec
.025 meters	?	350 meters/sec

*Traditionally in mathematics and science, the wavelength of a vibration is represented by the Greek letter lambda (λ), the frequency is represented by the Greek letter nu (ν), and its speed of travel is represented by the English letter c.

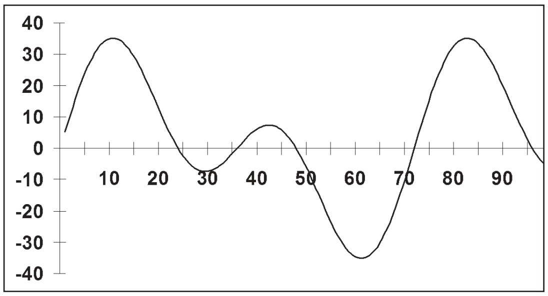


Waveforms

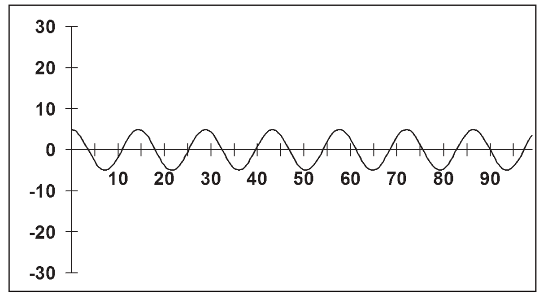
A sound engineer must do more than just listen; he should be able to look at the sounds being produced by his equipment and rapidly identify exactly what he's looking at.

An experienced professional could do the exercise below in two minutes. Can you do it in ten? Each waveform on the left is made by combining two of the waveforms on the right. Match them.

1.



A.



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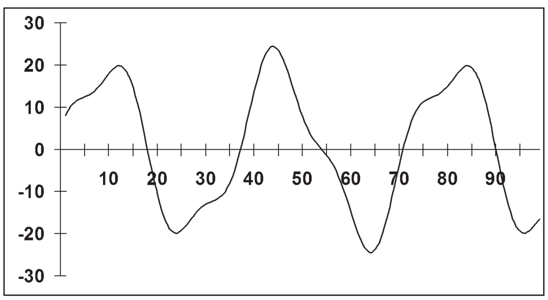

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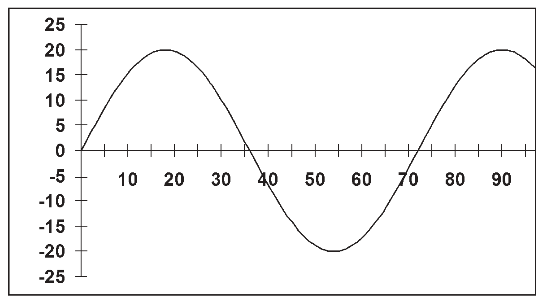

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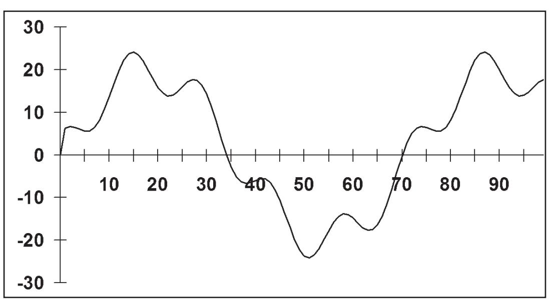

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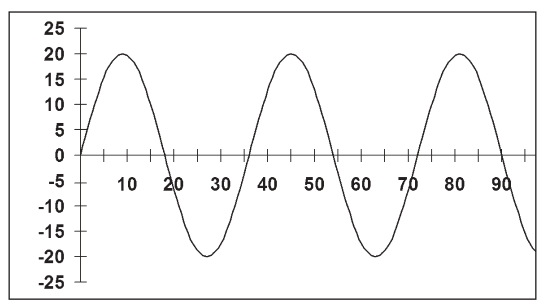

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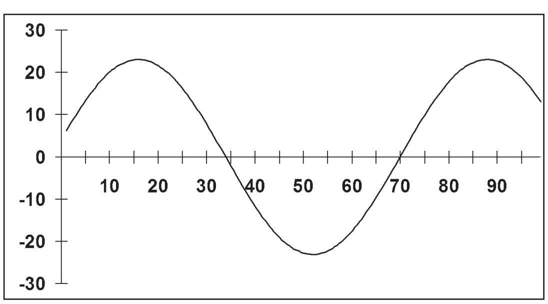

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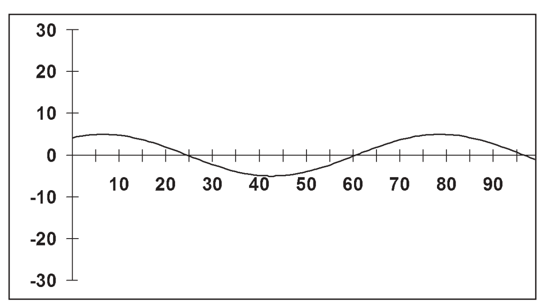


Teaching Guidelines: Waveforms
Math Topics: Algebra (patterns and functions), Trigonometry (functions)

Students should do this activity individually or in teams of two. You may wish to help students get started as follows:

Ask students if they think that waveform #1 could have waveform A as a component. Lead students to the realization that since waveform #1 doesn't have the shorter vibrations that are in waveform A, then waveform A could not be part of it.

Ask students which two of the three remaining simple waveforms (B,C,D) they think make up waveform #1.

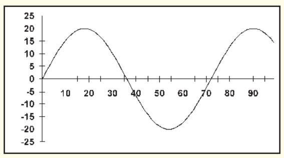
Ask them to look at the height of waveform #1, which gets up to almost 40 units. Help them to see that since the height of waveform B is 20 and the height of waveform D is 5, there is no way to combine them and get waveform #1. Thus waveform #1 must be made of waveforms B and C.

Ask them to do the remaining three waveforms on their own.

Wrap up with a discussion of the concepts of "wavelength" and "amplitude" as applied to the activity.

Answers

Waveform #1:
B and C



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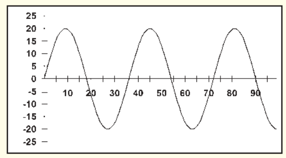

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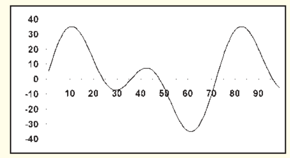
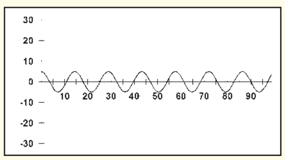


Waveform #2:
A and C



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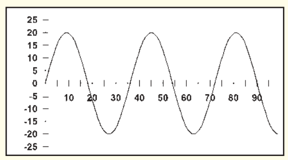

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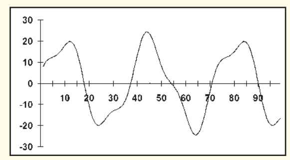
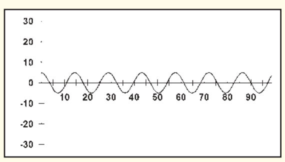


Waveform #3:
A and B



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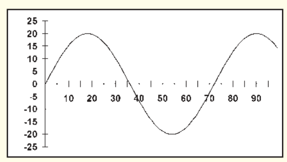

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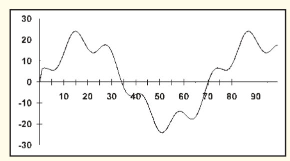
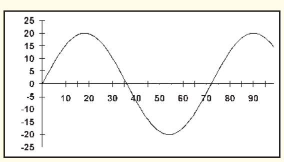


Waveform #4:
B and D



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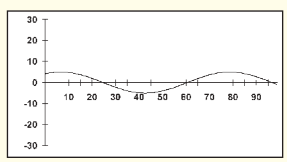

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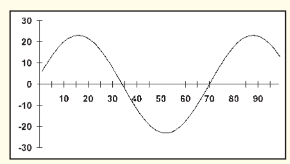

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