CENTRAL SCIENTIFIC COMPANY

OPERATING INSTRUCTIONS

Doppler Effect Demonstrator
No. 71942-24

1. Purpose

The Doppler Effect Demonstrator (71942-24) is a device for demonstrating the Doppler effect, which is the apparent change in the frequency of a wave motion (such as light or sound) which occurs when the source and the observer are in motion relative to each other. The frequency will apparently increase as the source and the observer move toward each other and will apparently decrease as they move away from each other.

2. Description

The Doppler effect demonstrator consists of three tuning forks with respective resonant frequencies of 256 Hz, 512 Hz, and 1024 Hz. Each tuning fork has a hole in its handle. Also supplied are a rubber hammer and a 30-meter roll of cord. Be sure you have removed all these items from the package.

3. Theory

The Doppler effect is named after the Austrian physicist Christian Doppler (1803-1853), who is known for his experiments with sound waves. The term refers to a phenomenon most students will have noticed — the apparent change in pitch of a sound as the source of the sound approaches the observer and again as it goes away. Students may have noticed this happening when a vehicle with a siren (like an ambulance or a police car) goes by.

What we refer to as “pitch” is the number of sound waves arriving per second at our ears. The number of sound waves received per second increases as the source approaches the listener and decreases as the source moves away. The result is that the apparent pitch becomes higher as the source approaches and becomes lower as the source recedes.

4. Operation

Caution! Before you perform this demonstration, make sure all your students are standing far enough away from you that they can’t be hit by the tuning fork as you swing it in a circle. Also, make sure you’ve tied the cord very securely through the hole in the handle of the tuning fork; if this cord is not securely fastened, the fork could come loose and fly across the room, possibly striking someone.

This demonstration is performed most effectively in a very quiet room.

To use the Doppler effect demonstrator, cut off a piece of cord slightly more than 150cm long. You will tie one end of the cord to a tuning fork and you will hold the other end of the cord to swing the fork in a circle with a radius of 150cm.

Tie on end of the cord through the hole in the handle of one of the tuning forks — for example, the 512Hz fork. Secure the cord firmly so that the fork does not fly away when swung. In one hand, hold the tuning fork (by its handle) and the loose end of the cord. Using the other hand, hit the

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prongs of the fork hard with the rubber hammer. Now, grip the loose end of the string, release your hold on the tuning fork handle, and swing the tuning fork in a horizontal plane above your head.

Ask the students to observe the time required for the fork to make one revolution and to note changes in pitch as the tuning fork comes toward them or goes away from them. Repeat the procedure with the other tuning forks and again question the students.

In Section 3 we stated in a general way that the apparent pitch of the sound will become higher as the source approaches and lower as the source recedes. The effect can be shown mathematically by the following example.

Let ‘s assume that the whirling fork takes one second to make a revolution. The linear distance it will travel in one revolution will be π times the diameter of the circle, or

$$\pi \times 300\text{cm} = 942.5\text{cm}$$

Consider the speed of sound in air at 20° Celsius to be about 34,000cm per second.

The actual wavelength of the sound is 34,000/512, or 66.4cm. The time of one complete vibration of the tuning fork is 1/512 second. Between successive vibrations, the tuning fork moves a distance of $d = vt$, or

$$942.5 \times 1/512 = 1.8\text{cm}$$

When the whirling fork is moving toward the students, the distance between the crests of the sound waves is shortened by the distance traversed during one vibration of the tuning fork — 1.8cm in the example given above. Thus the wavelength decreases to 64.6cm.

The velocity of sound in air is the same whether it is emitted by a body in motion or by a body at rest. The velocity of a wave

equals its frequency times its wavelength ($v = n$ l). Solving for wavelength (l), we find that wavelength equals 34,000/64.6, or 526.3 vibrations per second. This represents an increase of 14.3 vibrations per second over the 512 Hz which is the tuning fork’s resonant frequency.

Conversely, when the tuning fork is moving away from the students, the distance between the crests of the sound waves is lengthened by the distance traversed during one vibration of the tuning fork. Again, this distance is 1.8cm. Thus, the wavelength increases to 68.2cm. The frequency becomes 34,000/68.2 = 498.5 vibrations per second, which is a decrease of 13.5 Hz.

So, to sum up these results, when the 512 Hz tuning fork is in motion it has an apparent frequency of 526.3 Hz when it is moving toward the students and an apparent frequency of 498.5 Hz when it is moving away from them. Your students can similarly calculate the apparent frequency changes with the other tuning forks in the set.

5. Maintenance

The Doppler Effect Demonstrator needs no special maintenance. If you should have any problem with this apparatus, please contact Central Scientific. To ensure better service, please do not return any equipment to Central Scientific Company until we have sent you authorization.

Revised 2/90

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