

Timbre Lab

Teacher's Guide

Topic:

Sound and Music

The following information is provided to the student:

Question:

What is the relationship between the richness of an instrument and the quantity of overtones within the sound? How can instruments be grouped according to their richness and purity?

Purpose:

To determine the relationship between the richness of an instrument sounds and the quantity of overtones found within the sound and to group the instruments according to their richness or purity.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion . The Data section should include the provided table. The Conclusion/Discussion should group instruments according to those which sound relatively *rich* and those which sound relatively *pure*. The relationship between the subjective sense of the sound and the objective observation of the quantity of overtones should be discussed. The discussion should reference specific examples from the Data section as supporting evidence.

Materials Required:

Computer interfaced microphone; toy music keyboard.

Description of Procedure:

Student lab groups are provided with a music keyboard and a computer interfaced microphone. The microphone is prepared to *capture* sound from the keyboard. The volume of the keyboard is adjusted to a low level. Students play the C₄ key for an instrument and make a judgment of its relative richness. They then sample the sound and conduct an FFT analysis to determine the dominant frequency and the accompanying overtones. The resulting sound spectrum is sketched. Overtones with a very low amplitude are ignored. The process is repeated for other instruments in an effort to determine if there is a relationship between the richness of a sound and the quantity of overtones which are detected.

Alternative Materials and Procedure:

Students could bring in their own instruments and samples of sounds could be recorded and analyzed using the computer interfaced microphone.

Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

Suggestions, Precautions, Notes:

1. Toy keyboards can often be purchased at department stores for \$10 or less. The best prices can be found during the Christmas season. They typically have 30 or more keys stretching across nearly

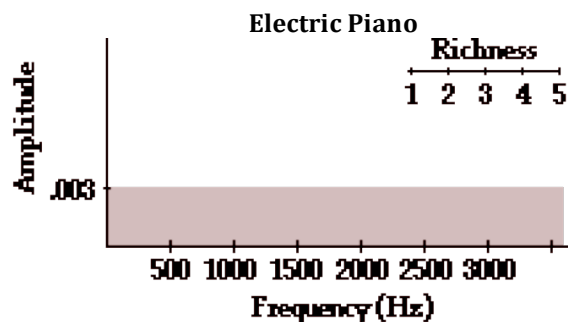
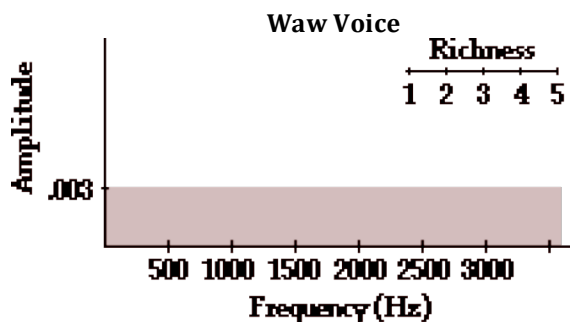
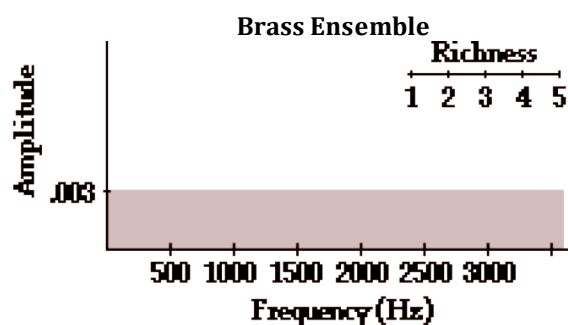
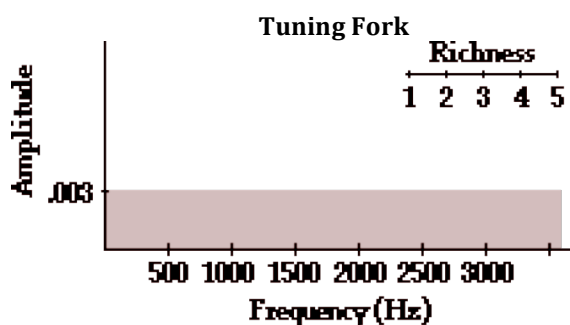
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three octaves. The inexpensive variety typically have synthesized sounds for a variety of musical instruments. There are usually a few other features which give students great pleasure and teachers much aggravation.

2. Most software which accompanies computer interfaced microphones have the capability of conducting a fast Fourier transform (FFT) analysis of a complex waveform. The result of an FFT analysis is that the complex waveform is resolved into a series of dominant frequencies; the frequency values and their relative intensities is typically presented as a sound spectrum chart. Overtones which are of a very low intensity level (amplitude) can be considered negligible in terms of their ability to affect the sound which is perceived.
3. If needed, this lab can be done as a demonstration lab in the following manner. The sounds are played and students make judgments about the relative richness of the sounds. Once all sounds have been played, the computer interfaced microphone is used to view the sound spectrum of the instruments.
4. Depending on the quality of the keyboard, the synthesized sounds which it produces for the various instruments may or may not bear a strong resemblance to the actual sound of the instrument. If doing the lab as a demonstration lab, use the best keyboard that is available.
5. Depending on the keyboard which is available to students, the instruments which are sampled may differ from those listed in the Auxiliary Materials section. Experiment in advance to find instruments which range from very rich to very pure. A tuning fork could be used as an example of a very pure sound. A referee's whistle could be used as an example of a very rich sound.

Auxiliary Materials:

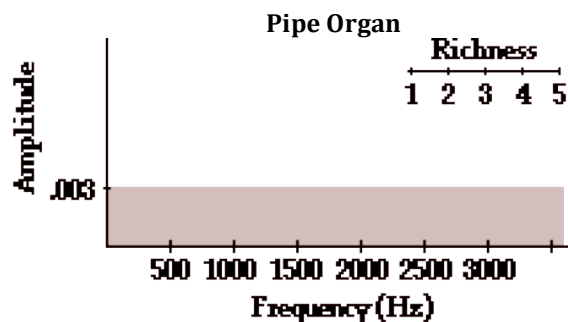
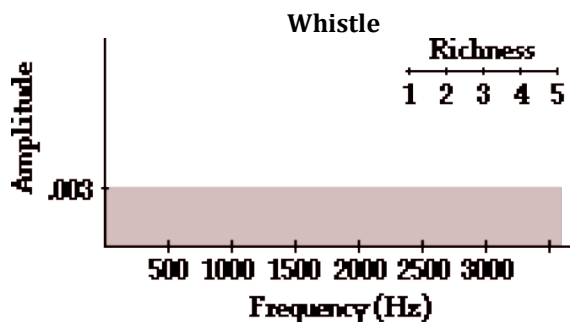
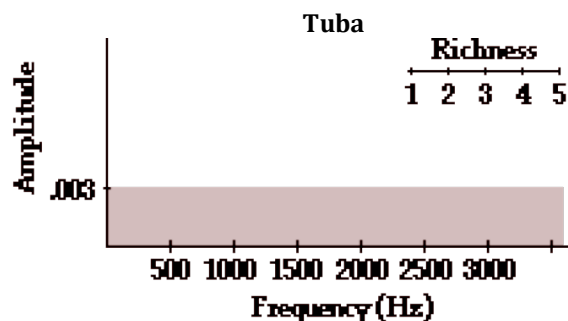
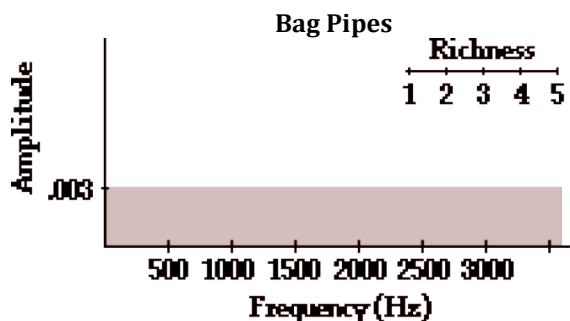
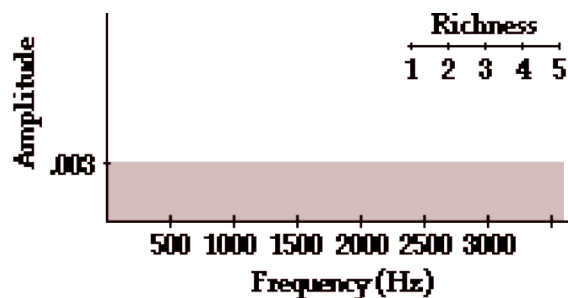
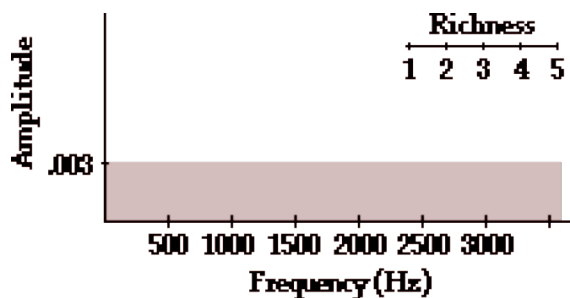
The following page is provided to the student for completion and inclusion in the Data section of their lab notebook.



Flute

Glass Harmonica

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Scoring Rubric:

S10. Timbre Lab	Score
<ul style="list-style-type: none"> ___ Included, labeled and organized all parts of the lab report. ___ Data section includes the completed table; the results of the frequency analysis (FFT graph) are reported; the variety of significant frequencies produced by an instrument are displayed on the spectrum chart. Results are reasonably accurate. ___ Conclusion/Discussion groups several instruments into two categories - relatively rich sounding and relatively pure sounding. The relationship between the quantity of overtones and the subjective sense of the sound is discussed; made reference to specific data as evidence to support this relationship; discussed how the referenced data supports the conclusion. 	<p>___/___</p>

Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

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<http://www.physicsclassroom.com/Class/sound/u1113a.cfm>

Connections to Minds on Physics Internet Modules:

There are no sublevels of Minds on Physics which pertain to the topic of timbre and sound quality.