MA+H music™

ASSIGNMENT & READING

The following is a sample student assignment and brief excerpts from the 156 page textbook.

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A BIGGER WORLD

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Student Guide – Assignment Checklist Sample

Assignment 6—The Science of Sound - Part I

_____ Use the multimedia glossary to learn to define and pronounce the vocabulary contained in the following sections of Chapter 8: *Introduction, Investigating Sound, and Waves on a Vibrating String*.

_____ Review the study questions for these sections. These will help guide you as you read so you will know some of the important information that you should remember.

_____ Read Chapter 8 - *The Science of Sound sections: Introduction, Investigating Sound, and Waves on a Vibrating String* in the *Math & Music* textbook.

_____ Use the multimedia lessons—***Physics of Sound*** and ***Physics of Music*** in the ***Science of Music*** section, and the subtopics *Structuring the Scale, Frequency Ratios,* and *Ancient Scales* in ***Scales*** in the ***Mathematics of Music*** section.

_____ Complete the Experiment—*Waves* in the subsection *Waves on a Vibrating String*

_____ Complete the Experiment— *Phase Reversal* in the subsection *Waves on a Vibrating String*

_____ Complete the Experiment—*Waves Part II* in the subsection *Waves on a Vibrating String*

_____ Complete the Experiment—*Fundamentals and Overtones* in the subsection *Waves on a Vibrating String*

_____ Complete the Experiment—*Interference* in the subsection *Waves on a Vibrating String*

_____ Write the definitions for the vocabulary on your vocabulary list for these sections (labeled Part I). Try to use each word in a sentence to make sure that you understand its meaning.

_____ Write your answers to the study questions for these three sections.

Math & Music – Table of Contents

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Excerpt from Chapter 1: MATHEMATICS OR ARITHMETIC

You are most likely in your teen years. You are maturing into an adult. This is a process whereby you gain broadly based knowledge and begin to acquire that trait we call wisdom. As you progress beyond arithmetic, you are acquiring the wisdom that we sometimes call mathematical maturity. This text and the programs that supplement it are intended to implement your mathematical maturity. They should begin to fill a bit of the reserve of knowledge that should someday earn you the most coveted of accolades, wise.

accolade - an approving mention; award

You have been exposed to arithmetic. Learning arithmetic is like learning to sketch with charcoal. You can represent things in a pleasing way, but you cannot achieve the glory of a painting, such as Rembrant's *The Night Watch*. Such paintings sparkle with color which charcoal is incapable of capturing.

Rembrant Harmenszoon van Rijn - 1606-1669, Dutch baroque artist, one of the greatest painters in Western art

Figure 1 Rembrant's *The Night Watch*

Photo by Corel Corporation

Mathematics brings color to numbers. With mathematics, we can describe the atom, explain musical harmony, and understand lenses. We can analyze the motion of a vibrating string and describe the effect of tension, string density, and length on the sound that the vibrating string produces. With mathematics, we can calculate the path of a missile, the orbit of a planet, or the time to fire retrorockets to bring a shuttle back to Earth. At the frontiers of science there is much interest today in producing something called a unified theory. This would be one theory embracing all forces in nature. This, if accomplished, would be for science what the glory of the Sistine Chapel is to art. It would be a picture of the universe painted on the basis of numbers. It would explain with mathematics the equivalence of all forces known to humankind. This is where mathematics can lead you. This exposure is where you begin.

You should wonder, "Why do I need to understand mathematics or music?" There is an old adage, "Ignorance is bliss." This is true of most animals, but humans are endowed with an instrument we call the mind. As you discover your mind and the power it bestows upon you, you will discover a bigger world, a world in which you will find more interesting ideas than you have ever known.

To illustrate the power of the mind and the power of mathematics, consider a scientist of the Renaissance named Galileo.

heresy - a belief at variance with the recognized tenets of a system, church, school or party

Galileo was the first to use a telescope to view the stars and planets. His discoveries in astronomy put him in conflict with the church and he was arrested, tried, and convicted of heresy. He was told to discontinue his work. At great risk, he investigated the science of motion inventing a water clock to time moving bodies. He produced a book called *Two New Sciences*. His descriptions of his findings are difficult for us to read. His findings were presented in a long series of statements such as:

> If two particles are carried with uniform motion, but each with a different speed, the distances covered by them during unequal intervals of time bear to each other the compound ratio of the speed and time intervals.

This is but one of many propositions that are necessary to describe a relationship which, with more fully developed mathematics, may be written as:

$$d = v\,t$$

or distance traveled equals the **product** of the velocity and the time.

succinct - concise

In this way, mathematics is a language. It is the language that describes observed physical laws in a precise and succinct way. This is the insight and the color mathematics brings to science.

We will try to show you what mathematics is, how it works, and how it developed. At first it may appear difficult and not in any way related to real life. But, if you study it, and as much else as you can master, someday you will be wise.

Mathematics is many things. It is a set of tables that tell us that 6 times 4 is 24. It is a set of rules that tells us about addition. It is a language that describes the world of science. It is a part of music. It is full of games and riddles. It is a vast, unexplored world.

Humans have spent centuries learning about mathematics. They first learned to count, then to measure. As their knowledge grew, they found new uses for mathematics. Humans seldom explored mathematics without seeking to fill a need.

Excerpt from Chapter 2: EARLY NUMBER SYSTEMS

Number is like color. It is an abstract idea. You may think of a blue balloon or a blue car or even blue sky, but if we take the object away the color goes with it. Color is easy to recognize as a characteristic of an object, but to think about the color without the object is difficult. Numbers are abstract ideas also. This is probably why the ideas about how numbers behave have come to our species so late in our history.

Where and how numbers were invented is lost in antiquity. However, if we look at ancient cultures, we can see some of the history of numbers and perhaps catch a glimpse of their origins. A study of ancient numbers helps us to understand some of the subtle points about the number system that we use.

The Western hemisphere was found by Columbus about 500 years ago. This seems to a young person almost an eternity. Think of 500 years as one unit of time. If we seek the origins of written numbers, we must go back in time eight to ten units of 500 years.

The Egyptian Number System

Over 4,000 years ago, two different groups of people began to use symbols to record words and numbers on durable surfaces. One group was settled along the Nile River. We know them as Egyptians. They probably had ancient ties to the Nubians and other peoples from the interior of Africa.

Figure 2 Hieroglyphic Inscriptions from the Tomb of Mereruka, Saqqara Memphis

Photo by Corel Corporation

Excerpts from Chapter 8: THE SCIENCE OF SOUND

Hold your hand in front of your face. Wave it back and forth as fast as you can. Do you hear anything? Obviously not. You are however, generating the condition in the air that would produce sound if your ears were tuned to the frequency of your hand. There is no sound only because there is no receiver nearby that can inform an organism that sound is present.

Consider what you do as you move or vibrate your hand and you will have made a great step forward in learning why a vibrating string produces sound. Wave your right hand back and forth. As your hand moves to the left, your palm compresses the air in front of it. As it moves back to the right, there is a slight vacuum created as your palm leaves the space it occupied. If you can move your hand back and forth 5 times a second, it is vibrating with a frequency of 5 times per second or we say you have a frequency of 5 hertz.

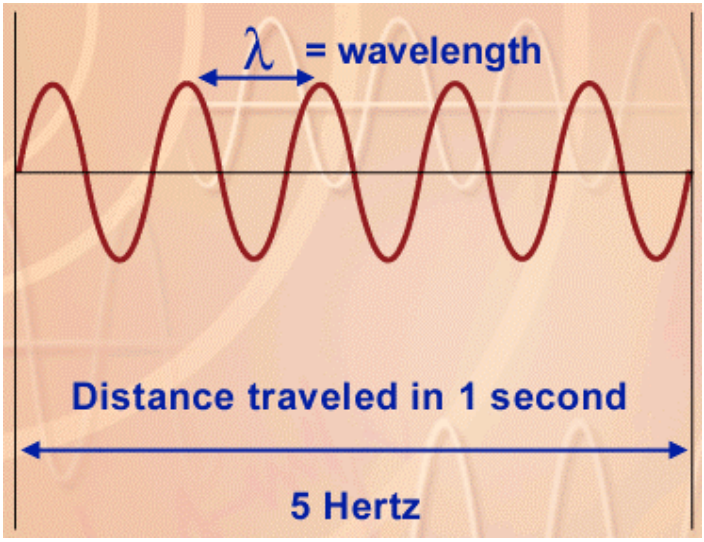

Figure 3 Sound Wave

Photo by AlignMark

If your ear could hear sounds with a frequency of 5 hertz, waving your hand as fast as you can would produce a very low sound. However, your ear cannot detect less than about 16 vibrations a second so waving your hand produces no sound.

Go to the subsections ***Structuring the Scale*** ***Frequency Ratios*** and ***Ancient Scales*** in the multimedia exercise - **Scales** in the **Mathematics of Music**

The generation of sound means very little unless you know about frequency. Run the sections of the ***Scales*** program that cover frequency.

Go to the multimedia exercise - **How We Hear** in the **Science of Music** section.

Tympanic is from the Greek word tumpanon meaning drum.

Anatomy of the Ear

Your ear is a delicate, sensitive instrument. The outer ear, the **pinna**, is well adapted to gather very slight variations in air pressure and funnel them into the channel called the external canal that leads to the ear drum, also called the **tympanic membrane**.

The external canal transmits the pressure variations that are sound waves to the eardrum or tympanic membrane. The pressure vibrations set the tympanic membrane into motion and activate a system of bony levers that rest against the tympanic membrane.

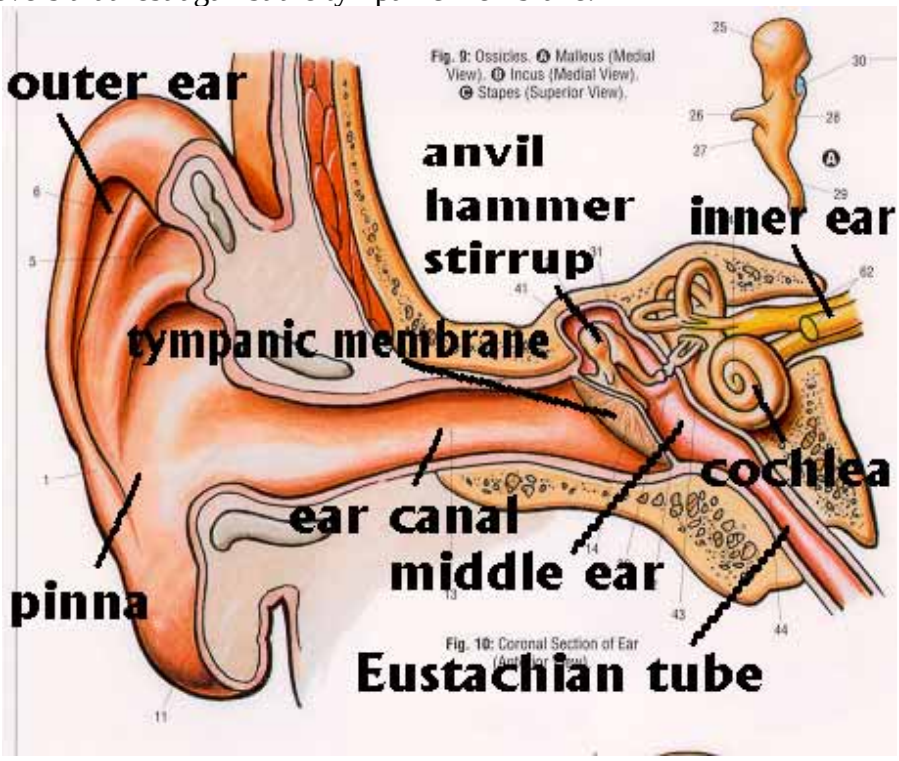

Figure 4 Diagram of Ear

Excerpts from Chapter 9: APPRECIATING DIFFERENT MUSICAL STYLES

Go to the multimedia exercise - **Harmony** in the **Mathematics of Music** section.

Nearly everyone likes music. We hear music as we ride in our cars, wait in a dentist office, or shop. Music is everywhere. Still, music is difficult to define. The word itself is from the Greek word *muse.* In Greek mythology, there were nine muses. They were daughters of Zeus and each presided over an art or science. Music is one of the arts.

There are many different aspects of music. Some of these we have explored. You should have learned from early chapters about some of the characteristics of sound. Now we must ask, "What characteristics of sound are used to change sound into music?"

The street is full of sound. Most of it is not music. A policeman's whistle produces sound, but it does not produce music. A pasture full of bleating sheep produces much sound, but no music. A symphony orchestra warming up to play produces sound. Usually, it is not music. What aspects of sound are controlled to convert sound to music?

Musical Scales

Go to the multimedia lessons - **Music Around The World** and **Music Through Time** in the **Journeys In Music** section.

As you move around the world, you will hear a wide variety of musical forms. Most will be played on the scale of Ptolmey, the same scale you created by using ratios of frequencies. A few will use the Gaelic scale and some may use a scale called a minor scale.

In spite of the fact that most of the music you hear will be composed on a single scale, there will be great variety of forms or styles used. If you could travel back in time, you would also encounter a great variety in musical forms. Each age has musical styles that are peculiar to itself.

Review the multimedia lesson - **Scales** in the **Mathematics of Music** section.

Each musical style has its own structure and each is enjoyed by some group somewhere. Each scale uses intervals that are about the same. These intervals may come naturally since the human voice seems to pick out these intervals when we sing.

The notes of the scale of Ptolemy are listed below with the intervals, that is, the ratios of the frequency of the notes to the frequency of the note C. If we begin our scale on C, the scale has no sharps or flats. This is called the key of C.

Excerpt from the Appendix — Composers

Essay
A World Populated by Beethovens, Bachs, and Mozarts.

Bach, Beethoven, and Mozart, were a trio who wrote for eternity. Each was an individual, each a genius, and each a personality to be accommodated. How much richer the world is to be able to listen to *Ein Kleiner Nachtmusik*, a *Brandenberg Concerto,* or the Ninth Symphony. Creation of such master works is rare, special and for such luxury we must be eternally grateful. Genius is a rare gift and those who have it must know themselves and the strength of their talents. But what if we were all of that ilk?

Each of these was endowed with talents far in excess of that of ordinary people. Still each had weaknesses. Beethoven was ill mannered and usually dirty. Mozart would not accept responsibility for his debts or for his familie's needs. Bach's hot temper engaged him in a duel. What kind of world would this be if we were all like these great musical composers?

Most of life's tasks do not require great genius to accomplish. Most jobs are routine and though innovation is sometimes desirable, constant or superfluous innovation produces instability. A flock of 1,000 sheep with 1,000 leaders would be totally out of control. For most of us, it is as essential that we learn to follow good leadership as it is essential for the geniuses to be allowed the freedom to develop their special talent.

It is the responsibility of the flock to be educated sufficiently to recognize genius and to identify and support strong leadership. This demands broad and deep exposure to the acquired knowledge of humankind. It demands training in science, art, history, language and the development of logical thought patterns.

We are for the most part a great flock. Occasionally, one of us displays a trait which we call genius. A world filled with genius would be a hard place to live. A world without genius would be a dull place to live.

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