Music and Math: The Orchestral Game Show

Wednesday, April 2nd and Thursday, April 3rd
10:00am and 11:45am
Symphony Hall, Phoenix
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Introduction

Counting, fractions, symmetry... must be math class, right? Guess again—it’s music! In this fast-paced concert, students will discover connections between music and math by listening to music from well-known composers. Get ready for music as you’ve never heard it before... you may just come away whistling some math!

If you’re reading this guide, you’re in luck: many of the quiz answers on the day of the concert can be found in these pages. So make sure you’re paying attention and reading carefully!

Acknowledgements

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Academic Content Connections

Materials in this packet, as well as information presented in the concert, will align with the following Arizona music and math standards:

**AZ Music Standards:**
- MU-ST1-CO1: Sing, alone and with others, music from various genres and diverse cultures.
- MU-ST2-CO1: Understand the relationships between music and other disciplines outside the arts
- MU-ST2-CO2: Understand music in relation to history and culture
- MU-ST3-CO1: Listen to, analyze, and describe music

**AZ State Math Standards:**
- Counting and Cardinality (K)
- Operations and Algebraic Thinking (1-4)
- Measurement and Data (K-5)
- Geometry (K-8)
- Number and Operations – Fractions (3-4)
- Ratios and Proportional Relationships (6-8)
Music is an incredible art form found everywhere: movie soundtracks, national anthems, on the radio. In its most basic form, we create music in the shower when we sing, or on a table when we tap a rhythm. In its most complex and extravagant form, we hear it in the concert hall; symphony orchestras perform the greatest compositions in the classical repertoire all over the United States on a weekly basis.

But all of this music—from a song in the shower to Beethoven’s 5th Symphony—completely depends on mathematic principals. Without math, there would be no music. The rules and equations of math help composers, or people who write music, organize and structure their pieces. To begin, let’s explore the concept of pitch.

Music is made up of many elements—rhythm, harmony, melody, timbre—but one of the most important elements is pitch, or how high or low a musical sound is. Think of it this way: a young girl typically speaks with a high voice, while a tall, older gentleman speaks with a much lower voice. We could say that the young girl’s voice has a higher pitch than the older man’s voice, which has a lower pitch (see below).
The distance between two pitches is called an interval. These intervals can be small (think of your house alongside your next-door neighbor's house) or large (think of a house at the end of the block) and everything in-between. Here's how a few intervals look in music:

We can't have a discussion about intervals without introducing the man who, according to legend, discovered the math plays a part in every musical interval. This famous man is Pythagoras, the Greek mathematician (you older students may remember him for his Pythagorean theorem).

Pythagoras (c. 570 BC—c. 495 BC)

Pythagoras, like a lot of scholars during his time, studied a lot of subjects. In addition to math, he was a philosopher and a scientist. According to legend, Pythagoras was walking by a blacksmith and heard hammers that sounded harmonious together. Intrigued by this, he asked the blacksmith about the hammers. The blacksmith told him... (see page 7)
Rhythm, or the pattern of sound through time, is another vital element of music, as is the **measure**, which is the framework on which rhythm is placed. These ideas can be complicated because music is so diverse and can be divided in many different ways. But for the purposes of showing the link between music and math, we’ll look at several simple rhythms. Much like fractions, these notes can be added together to form a whole:

<table>
<thead>
<tr>
<th>Note Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole note</td>
<td>Takes up a whole measure</td>
</tr>
<tr>
<td>Half note</td>
<td>Added together, they form a whole measure</td>
</tr>
<tr>
<td>Quarter note</td>
<td>Just like a dollar, it takes four quarter notes to make a whole measure</td>
</tr>
<tr>
<td>Eighth note</td>
<td>It takes eight eighth notes to make a whole measure</td>
</tr>
</tbody>
</table>

Noticing a pattern? Notes can be divided even more, to 16th notes, 32nd notes, 64th notes... and on and on. The combinations of these note values together create interesting rhythms.

**Mason Bates (b. 1977)**

Mason Bates is an American composer known for his work with orchestras and electronics. His pieces take the classical orchestra and add elements like synthesized sounds, creating a unique combination. In fact, he wrote music for the YouTube Symphony Orchestra in 2011, cementing his reputation as a forward-thinking classical composer. In addition to composing symphonic pieces, he also works as a DJ by night, working under the name DJ Masonic.
Music Notation as Math

On page 6, we learned that music note values can be read as fractions of a whole measure. This lesson introduces students to rhythm concepts, including the names and symbols associated with music notation. Students will fill in a chart that outlines names and meanings of rhythmic musical symbols. Then, using these symbols, they will clap rhythm sequences and compose their first compositions. They will also compare these rhythmic sequences to math concepts.

The Student Will:

1. Apply math concepts in fractions to musical notation recognition, and
2. Recognize and identify the following musical symbols and concepts: quarter rest, quarter note, half note, half rest, eighth notes, measure, bar line, double bar line, 4/4 time signature

Procedure:

- Ask students what they already know about rhythm. Have them brainstorm words associated with rhythm and write these on the board. Talk about the fact that rhythm is important in music because it provides structure to the melody or background accompaniment.

- Using fractions in math, discuss the math concepts in notation. Distribute fraction manipulatives and explain the relationship between notes and fractions. For example, one whole fraction circle is equal to two half-circles, just as one whole note is equal to two half notes. Show and have students explore the following relationships:

  - 1 whole note = 2 half notes = 4 quarter notes
  - 1 half note = 2 quarter notes = 4 eighth notes
  - 1 quarter note = 2 eighth notes = 4 sixteenth notes

- Have students practice mathematical equations using music notes. Write the following equations on the board and have students work in pairs with their manipulatives to solve the equations. Students can answer in notes or numbers:

  - half note + quarter note + quarter note = _____ (whole note)  \[ \frac{1}{2} + \frac{1}{4} + \frac{1}{4} = _____ (1) \]
  - whole note — half note = _____ (half note) \[ 1 - \frac{1}{2} = \frac{1}{2} \]

- Have students create equations for peers to solve. Working independently or in pairs, students should create an equation using notes. Students should double-check their equations, then switch with another students to try and solve each others’ equations.

Pythagoras: “The blacksmith told him...”

The legend of Pythagoras and the blacksmith’s hammers is ubiquitous, but there may be more fact than fiction in this tale. Have students do their own research, answering the following questions:

- According to the legend, what did Pythagoras learn from the blacksmith?
- How did this apply to music?
- What other theories exist?

  If your students are worried they’ll never find out the rest of the legend, don’t worry!

  We’ll present the whole story at the concert.
Melodies and Math

After reviewing basic music theory, students compose their own music for the touch-tone phone. The musical experience is enriched by further introduction and exploration of non-traditional music instruments, resulting in a group orchestration and performance.

**TSW:**

1. Experiment with creating electronic sounds
2. Demonstrate an understanding of 4/4 and 2/4 time by creating melodies using 4/4 and 2/4 time
3. Write numbers that correspond to those from the keypad in order to document an original melody
4. Play a melody using 2/4 and 4/4 time signatures
5. Create additional instruments using classroom-found materials

**Procedure:**

Play the video for Mason Bates’ *Warehouse Medicine* (link: [http://www.youtube.com/watch?v=wiZ1HhvZPjg](http://www.youtube.com/watch?v=wiZ1HhvZPjg))

Ask them the following questions:

- Is this music?
- How did the performer learn how to play this tune?
- What are some ways he could capture the musical notes for someone else to play the same song?
- What other electronic devices could be used to make similar sounds?
- What role does mathematics play in this performance?

Experiment with online touch-tone sound applications. Use the DTMF Tone Generator Applet ([http://courses.cs.washington.edu/courses/cse100/04au/misc/tones/dtmf.html](http://courses.cs.washington.edu/courses/cse100/04au/misc/tones/dtmf.html)) or search “DTMF Tone Generator Applet.” Give students a few moments to play random notes.

Create original touch-tone compositions. Divide the class into small working groups. Assign some groups 4/4 time (four beats per measure) and other groups 2/4 time (two beats per measure). Provide students with musical notation paper ([http://www.blanksheetmusic.net/](http://www.blanksheetmusic.net/)). Ask them to create an original composition (not a recreation of a known song). Ask them to record the notes as touch-tone numbers. Allow them to create their own notation for various lengths of notes as necessary. Check the work of each group for understanding of the assignment before moving on.

Explore the classroom for “found” instruments and add them to the composition. Allow students to be creative and innovative (instruments can be paint brushes, fluttering pages of a book, a coffee can, etc.). Instruments can also be found on their persons (zippers, hand clapping, etc.). Discourage them from using any traditional instruments you may have in the classroom.

Perform the original compositions. Ask each group to perform its original piece.