Rhythms & Tunes: Pan Pipes

To actually create a tune, we need to have a set of tones or notes that vary in pitch to create a scale. One scale is called the Pentatonic Scale. Note the beginning of this name: Penta—just like pentagon, so it is probably no surprise that this scale has 5 tones. The pentatonic scale shows up in native music from cultures all over the world. It contains the five most commonly used pitches in simple songs and folk melodies.

There are lots of songs that can be played using only six distinct tones, the five notes from the pentatonic scale and a sixth note that is an octave above the lowest pitch. A good resource for pentatonic songs is Beth’s Music Notes: http://www.bethsnotesplus.com/2012/02/pentatonic-songs.html. Many of those songs require more than one octave of notes, but there are some that don’t.

Pythagoras is credited as being one of the first people to study the mathematical relationships that occur in the pentatonic scale. He found that the pitches in this scale are based on multiplication and division by $\frac{3}{2}$ and $\frac{2}{1}$. We are going to use his method to create a set of pan pipes with six pipes tuned to a pentatonic scale. (The extra one is an octave above the lowest pitch.) A great resource for more about the history of the pentatonic scale can be found at Ancient Origins: http://www.ancient-origins.net/artifacts-ancient-technology/mystical-pentatonic-scale-and-ancient-instruments-part-i-bone-flutes-020826

Calculating the scale ratios:

We will start by calculating the relative lengths using the method given by Pythagoras.

If we start with a length of 1, then the octave pitch will be twice as long or 2. Those will be our two extremes—the shortest and the longest. We need four more lengths to complete our list.

Now to find the other lengths on our list, we will follow these steps:

Using a length that we already have, multiply by $\frac{3}{2}$.

- If the number you get is between 1 and 2, then that number becomes part of our list.
- If it is less than 1, then multiply by 2 to get a value between 1 and 2.
- If it is greater than 2, then divide by 2 to get a value between 1 and 2.

Using the same length, divide by $\frac{3}{2}$.

- If the number you get is between 1 and 2, then that becomes part of our list.
- If it is less than 1, then multiply by 2 to get a value between 1 and 2.
- If it is greater than 2, then divide by 2 to get a value between 1 and 2.
Let’s do an example together:

Starting with 1, we multiply by $\frac{3}{2}$

\[
\frac{1}{1} \times \frac{3}{2} = \frac{3}{2}
\]

Because $1 < \frac{3}{2} < 2$, we include that value in our list, and we have: \[\frac{1}{1} \quad \frac{2}{1} \quad \frac{3}{2}\]

Now we will use division:

Again starting with 1, we divide by $\frac{3}{2}$

\[
\frac{1}{1} ÷ \frac{3}{2} = \frac{1}{1} \times \frac{2}{3} = \frac{2}{3}
\]

Because $\frac{2}{3} < 1$, we multiply by $\frac{2}{1}$ and get $\frac{2}{3} \times \frac{2}{1} = \frac{4}{3}$ which is a new value, so it goes on our list.

Now our list includes \[\frac{1}{1} \quad \frac{2}{1} \quad \frac{3}{2} \quad \frac{4}{3}\]

Complete the list by following this same process starting with $\frac{3}{2}$ and then starting with $\frac{4}{3}$. If you get a value that is already in the list, then just continue. You will know that you are done when you have six different values in your list. When you have all six, write them below in order from 1 to 2.

\[\frac{1}{1} \quad \_ \quad \_ \quad \_ \quad \_ \quad \frac{2}{1}\]

Calculating the pipe lengths:

1. Our shortest pipe length will be 100 mm. To find the length of the other pipes, multiply each of the values on the ordered list by 100. Round to the nearest millimeter. Record your pipe lengths here.

   100 mm \[\_ \quad \_ \quad \_ \quad \_ \quad \_ \quad \_ \]

2. You can use any colors that you want, but some of the songs that I have for you are color coded. If you want to match the order of those colors, then from longest to shortest the colors are red, purple, orange, green, blue, and red again.

3. Mark each length on a new pipe, and cut perpendicular to the pipe.

4. Complete all six pipes.
Sealing the pipes:
1. For each pipe cut a strip of tape that is roughly square, and one about twice as long as the width of the tape.
2. Put the cut end of a pipe perpendicular to and centered on the square piece of tape. Fold both sets of opposite corners up to touch the pipe and then rotate it through your fingers. You will seal the tape to the side of the pipe and have four little “wings” of tape showing. Take the longer strip and wrap it around the bottom edge to cover the wings and finish the seal. Test your pipe by blowing straight into it; no air should escape the pipe.

Sounding the pipes:
1. Hold each pipe vertical and touching the middle of your lower lip.
2. Purse your upper lip and blow across the top like you might if you were blowing across the top of a bottle.
3. You should get a clean sound. Play around with location of the pipe and your lips until you get a clean sound. If you aren’t getting any sound or it is not clear, the pipe is likely leaking air.

Putting the pipes together:
1. Cut two lengths of weather strip each about 10 cm long. Peel the paper off of one strip.
2. Starting about 1 cm from the end of the weather strip, stick the pipes perpendicular to the strip in order of length with 1-2 cm of the open end of each pipe above the strip. All of the open ends should be in a line, and the taped ends will be uneven. The pipes should be roughly the same distance from each other with a little bit of space between each one.
3. Once all of the pipes are on the tape, peel the paper from the second piece of weather strip and lay it on the pipes to create a sandwich. Cut away any extra weather strip leaving about 1 cm on each end.
4. Using some twine, start at middle of the pipes, leave a bit of twine, and wrap around the weather stripe two times. Then wrap diagonally across the next pipe continuing until you reach the end. Wrap around that end 2 times, and then wrap diagonally back to the other end, crossing the twine that is there. Finish by wrapping back to the middle of the pipes and tying the ends of the twine together. Trim away the extra twine. Your wrappings should be snug. Your pipes are complete.
Pentatonic Scales

In terms of a typical major scale, the major pentatonic scale uses the 1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}, 5\textsuperscript{th}, and 6\textsuperscript{th} tones. Here is a chart that shows the notes in the pentatonic scales based on each major scale. We will add the octave tone (or 8\textsuperscript{th} note) to our pan flutes.

You don’t have to read music to play our flutes; all you need to read are numbers. We will write the tab (the list of notes by number) using 1, 2, 3, 5, 6, 8 to stick to the position of the notes in the major scale. You can also color code the numbers on the tab to correspond to the colors of the pipes on your instrument if you color coded your pipes.

You will need to recognize note durations to get the rhythm of a tune. The chart here gives you the duration of each type of note and the relationships among them. More fractions at work! The names of the notes represent how long each note lasts in a four-beat measure. That means that the quarter note is the basis for counting by ones. The relationships here can lead to some great discussions of the relative values of each of these types of notes in relation to their fraction names.