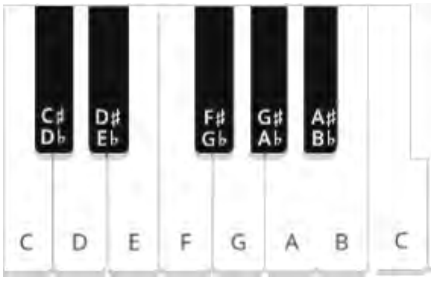
2. Musical Motifs

Glen Bull, Jo Watts, and Rachel Gibson

TuneScope (tunescope.org) is a code-based Digital Audio Workstation that can be used to compose and play music. For those interested in the technical details, TuneScope is an extension of the educational programming language Snap*!* (from the University of California, Berkeley) that uses the W3C Web Audio application program interface (API) to generate musical notes and instruments.

Topic 6.1 The Building Blocks of Music

An understanding of the basic building blocks of music is helpful in creating music in TuneScope. The Western chromatic musical scale consists of twelve notes. On a piano, these notes consist of seven white keys and five black keys. Pressing a piano key causes piano string to vibrate. For example, the note *C* in the middle of the piano keyboard vibrates at a rate of approximately 261 times per second. Because this note is near the middle of the piano keyboard, it is called *Middle C.*

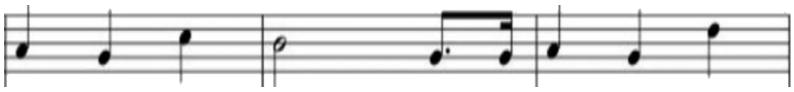


Higher rates of vibration are perceived as higher pitches. A span of notes on the piano keyboard that begins with one note (such as the note "C" in the illustration below) and ends in the same note name is known as an octave. The octave that begins with middle C is in the fourth octave (counting from the left) on the keyboard. This can also be written "C4" (where "C" refers to the note and "4" refers to the octave). A piano keyboard that can be used to explore octaves can be accessed at:

https://snap.berkeley.edu/snap/snap.html#present:Username=maketolearn&ProjectName=Piano

Pressing a piano key on the computer screen plays the note associated with that key.

When written, notes usually appear on a series of five parallel horizontal lines, known as the *staff*. Notes are grouped into *measures*. A measure consists of the notes between two vertical lines on the musical staff.



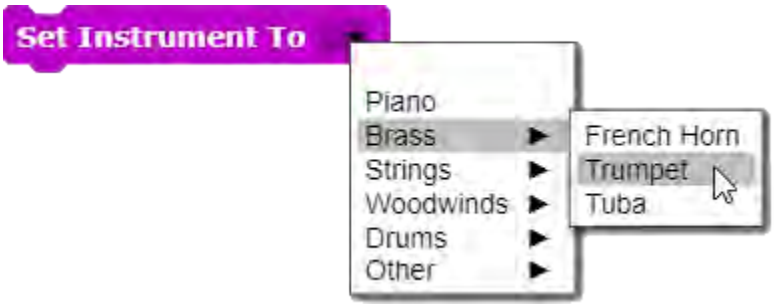
The *time signature* is the convention used in Western musical notation to signify the number of beats in a measure (also referred to as a musical bar) and to describe which note value is counted as a beat. The time signature is written in the form of two numbers stacked on top of each other: $\frac{4}{4}$, $\frac{3}{4}$, etc. (These are pronounced “four four.” “three four”, etc.) The first number specifies the number of beats in a measure and the second number indicates the duration of the note that is counted as a beat. For example, a 4/4 time signature indicates that there are four beats per measure and that each beat is a quarter note. A 3/4 time signature indicates that there are three beats per measure and that each beat is a quarter note. A 6/8 time signature indicates that there are six beats per measure and that each beat is an eighth note. A 4/4 time signature is sometimes described as *common time* because it is the most commonly used time signature.

Exploration 2.1 The Building Blocks of Music

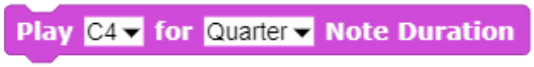
Use the piano keyboard created with sprites to explore the relationship of notes within the fourth and fifth octaves of the chromatic scale.

2.2 Musical Notes

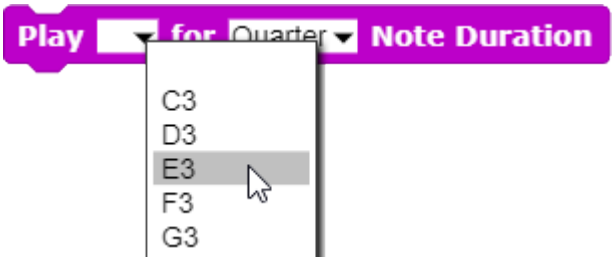
TuneScope can be used to access sampled instruments that can be used to play musical notes. These musical instruments are selected through the `Set Instrument` code block. This code block enables a musical instrument to be selected from a dropdown menu.



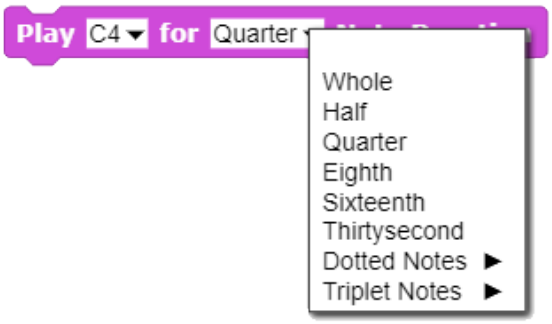
Once an instrument has been selected, the `Play Note` code block can be used to play a musical note.



A dropdown menu in the TuneScope `Play Note` code block can be used to select musical notes. (Note designations can also be typed directly into this input slot.)



A second dropdown menu is used to select the duration of the note. The note duration determines the length of time that the note is played.



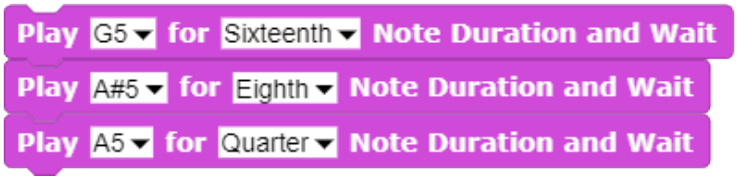
In most western music, a *quarter note* is considered to be one beat. (Why is one beat not a *whole note* rather than a quarter note? Because in 4/4 time, there are four beats per measure; a whole note is one *measure.)* Moving up the menu doubles the number of beats in the note. Moving down the menu halves the length. For example, a half note is two beats, while a whole note is four beats. In the other direction, an eighth note is half a beat. Dotted notes equal the duration of the named note plus the duration of the next shorter note. For example, a dotted half note would be equal in duration to a half note plus a quarter note, or three beats. Triplet notes divide the duration of two of the named notes into three equal durations. For example, a quarter note triplet would be three evenly timed notes played within the normal duration of two quarter notes.

Exploration 2.2 Musical Notes

Explore the voices of different musical instruments that can be accessed through the Set Instrument code block. Use the Play Note code block to play back notes using different instruments.

Topic 2.3 Combining Notes

The Play Note and Wait code block waits until one note is completed before beginning the next note. Several Play Note and Wait code blocks can be combined to play a series of notes. For example, the opening notes of the blues song *Crossroads* are G5, A#5, and A#5



The first note (G5) lasts for a sixteenth of a measure, the second note (A#5) lasts for one-eighth measure, and the third note (A#5) lasts for a quarter measure. C

Exploration 2.3 Combining Notes

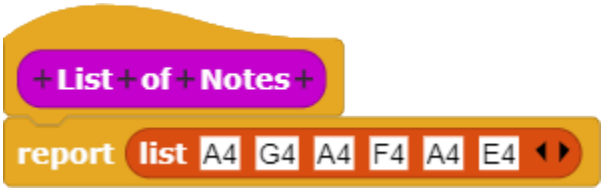
Create your own three-note sequence in TuneScope using the Play code block. You can either use notes from a favorite song or create your own combination of notes.

Topic 2.4 Playing a List of Musical Notes

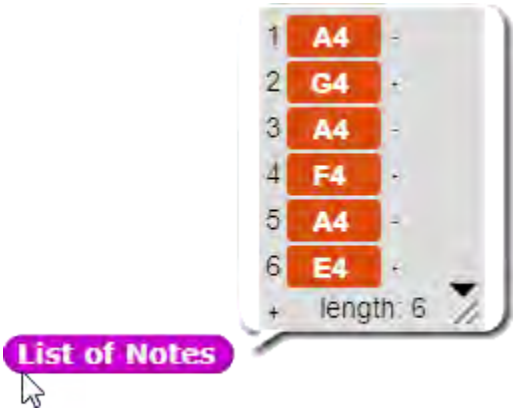
Since the music visualization in *Fantasia* begins with *Toccata and Fugue in D Minor*, this seems like an appropriate place to begin with musical visualization in Snap*!* A list of notes can be stored in a list:

Most computing languages have a mechanism for storing both variables and constants. Variables are program elements may need to change under program control – the length of a side in a squiral, for example. Constants are elements that will not change – the value of pi for example. In Snap! a reporter block can be used to store elements that will not need to change under program control.

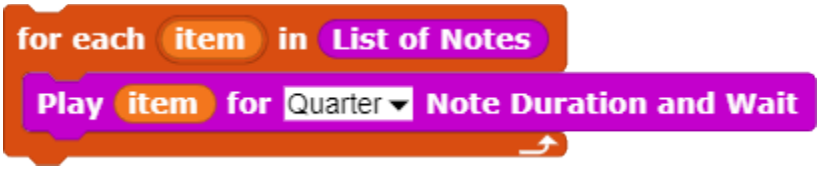
A reporter block can also be used to store a list of notes.



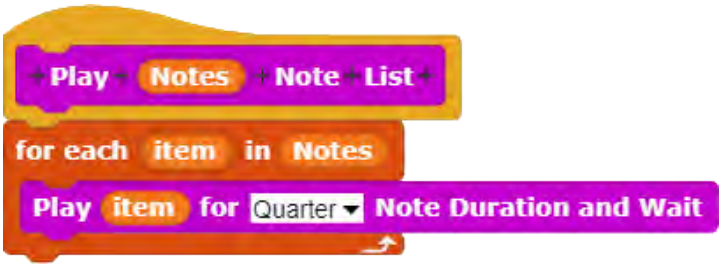
The reporter block can then be used to retrieve the list of notes when needed:



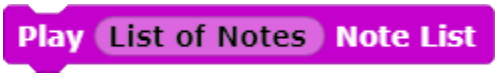
A loop can then be used to play each note in the list.



Storing a list of notes has two benefits: (1) The notes for all of the songs created in this way can be stored in a separate user-created category such as *Songs* in the blocks *palette*. (2) The reporter blocks containing the songs can be exported and shared with others. This method could be encapsulated in the form of a custom procedure.



This custom block can then be used to play any list of notes.



Computing Concepts

A For Each Item in List loop can be used to repeat a procedure using a different item from the list for each iteration. Six Play Note and Wait blocks could have been assembled to play the six notes in the list. The For Each Item in List loop simplifies the process by only requiring one Play Note and Wait block.

Exploration 2.4 Playing a List of Musical Notes

Create a list of notes. Then use the Play Note List code block to play the list of notes.

Topic 2.5 Playing a Musical Motif

A musical motif is a recurring musical theme. For example, in the movie *Jaws* the alternating notes of E and F create a sense of unease. Characters in a play or film are sometimes given a musical motif that becomes their musical identity. The opening notes of the Imperial March are played when Darth Vader appears in *Star Wars*.

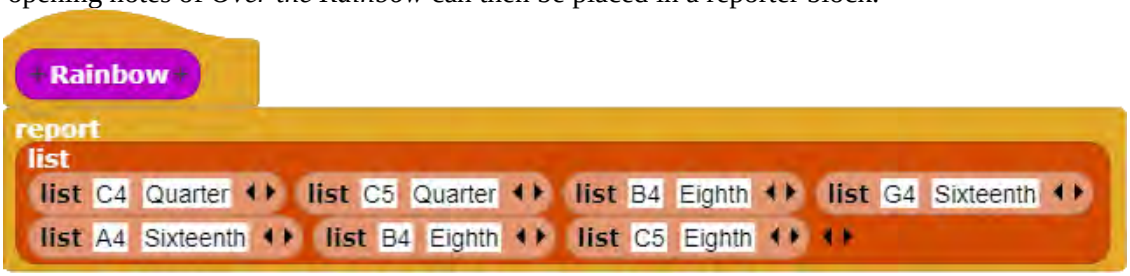
Each note in a sequence of notes has a specific duration associated with it. For example, the durations associated with the opening four notes of *Over the Rainbow* are listed in the table below.

Over the Rainbow	
Note	*Duration*
C4	Quarter
C5	Quarter
B4	Eighth
G4	Sixteenth
A4	Sixteenth
B4	Eighth
C5	Eighth

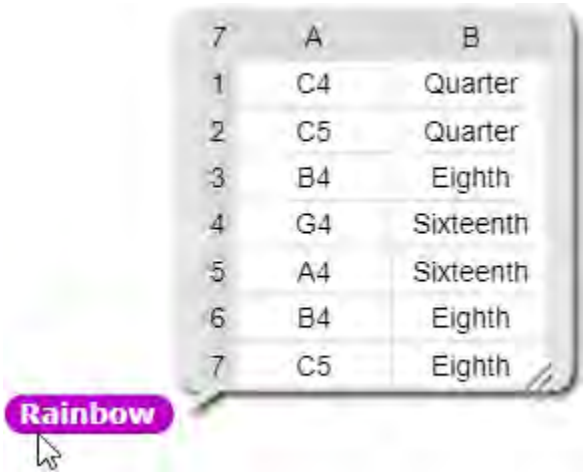
In the previous section, a series of notes were stored in a list. However, a duration also needs to be associated with each note. Each note and duration can be described in a list consisting of two items: the pitch of the note (*C4*) and the duration of the note (*Quarter*).

Each *note* consisting of a *pitch* and a *duration* can then be stored in a list of lists in the following manner.

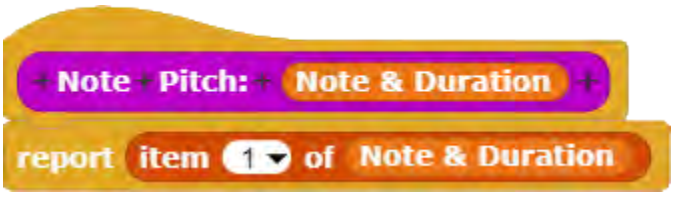
The opening notes of *Over the Rainbow* can then be placed in a reporter block.



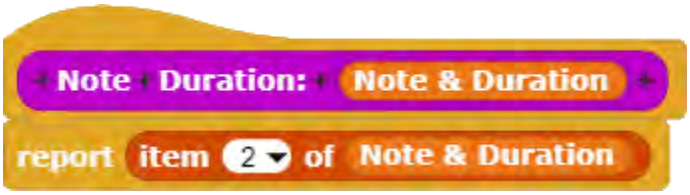
The reporter will return the lists of notes and durations.



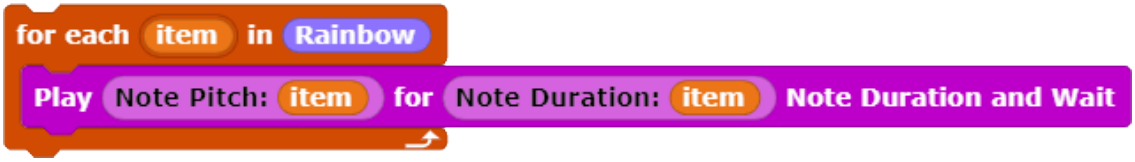
After developing a structure for recording the notes and durations of a musical motif, some tools for retrieving this information will be useful. The reporter block shown below retrieves the first item (i.e., the note pitch) of a combined "Note & Duration" pair.



A parallel reporter block retrieves the second item (i.e., the note duration) of a combined “Note & Duration” pair.



These tools can be used to retrieve the Note Pitch and Note Duration for each item in the list of opening notes of *Over the Rainbow*.



The `Play Motif` block works through the list of notes in the motif until it reaches the end of the list.

The list of notes and durations could have been stored in two separate lists, such as a list of “Rainbow Pitches” and a list of “Rainbow Durations” rather than as a combined list of notes and durations. This approach is certainly viable, but has two potential drawbacks:

1. One potential drawback is that the number of lists needed is doubled. That is not an issue for a single song. However, we have provided sample opening note sequences for a dozen songs (one for each of twelve musical intervals). For this many songs, it is more convenient to represent each song with a single list.

2. We have also found through experience that when there are separate note and duration lists for each song, inevitably the notes and durations become misaligned or mismatched. When the two elements are combined in a single list, it reduces the potential for errors of this kind.

The drawback of a combined list is that there is slightly more overhead in creating tools to retrieve the pitches and durations. However, these tools only need to be created one time (as shown above).

Exploration 2.5 Playing Musical Motifs

Play a musical motif from the list of four note sequences provided. Experiment with adapting or revising one of the sequences.

Topic 2.6 Creating a Musical Motif

Some background on sound and music theory is useful for music composition. In this case, a four-note sequence will be created for use as a musical motif. However, the concepts described are applicable to composition of music of any length.

When a guitar string is plucked, the string moves back and forth as it vibrates. The rate of vibration is known as the frequency. Each note has a characteristic frequency. When two notes are played, the ratio of the frequency of the first note to the frequency of the second note determines whether the combination is perceived as harmonious. Combinations of notes whose ratios of frequencies can be approximated by low whole number digits such as 3:2, 4:3, and 5:4 are generally perceived as more harmonious. This relationship was first observed in ancient times but contemporary songwriters make use of this relationship today.

The fundamental frequency of the note C4 is approximately 264 Hz. The note C5, which begins the next octave, is double the frequency of C4. The ratio of C5 to C4 is 2:1 and therefore is perceived as harmonious.

The span between C4 and C5 is divided into twelve intervals with seven white keys (C, D, E, F, G, A, and B) and five black keys (known as sharps and flats). An interval of four piano keys between musical notes yields a ratio of 5:4 and therefore is perceived as harmonious. Similarly an interval of five piano keys between musical notes has a ratio of 4:3 and also is perceived as harmonious. However, an interval of one piano key beween notes has a ratio of 25:24 and is generally perceived as inharmonious.

The table below lists songs that begin with each of the twelve musical intervals that are possible in the Western chromatic scale. As long as the intervals between respective piano keys remain the same, the first note can begin on any piano key. To simplify illustration of these relationships, the notes in the songs below have been shifted so that the opening note always begins with "C".

Songs that Begin with Each of Twelve Intervals						
Interval			*Song*	*Opening Notes*	*Harmonious?*	
1	C	C#	Jaws	C C# C C#	No	
2	C	D	It's My Life	C D C D C D C A G A	-	
3	C	Eb	Smoke on the Water	C Eb F C Eb F# F	-	
4	C	E	Saints Go Marching In	C E F G C E F G	Yes	5:4
5	C	F	Here Comes the Bride	C F F F	Yes	4:3
6	C	F#	Maria (West Side Story)	C F# G	No	
7	C	G	Star Wars Theme	C G F E D C G	Yes	3:2
8	C	G#	Johanna	C G# G C F G#	No	
9	C	A	My Way	C A C A G A	Yes	5:3
10	C	Bb	Somewhere	C Bb B F# D#	No	
11	C	B	Star Trek Theme	C B A# G# F# F E	No	
12	C	C	Over the Rainbow	C4 C5 B G A B C	Yes	2:1

In constructing this table, we found it easier to find well-known examples of songs that begin with intervals that are perceived as harmonious. The composer Leonard Bernstein liked the intervals of 6 and 10, creating the songs *Maria* (which begins with an interval of 6) and the song *Somewhere* (which begins with an interval of 10) for the musical play *West Side Story*. However, other examples of songs with these intervals often perceived as less harmonious did not immediately come to mind as we considered possible examples for inclusion in the table.

To create a harmonious motif, combine sequences of notes that have harmonious intervals between the notes. These are notes sequences that have frequencies in ratios of low whole numbers. To create a dissonant motif (for example, for a villain) combine sequences of notes that do not have harmonious intervals.

Exploration 2.6 Creating Musical Motifs

Create a harmonious musical motif (i.e., a four or five-note sequence). Then create a dissonant motif. Experiment with the effect of assigning different durations to the notes selected.

Topic 2.7 Recording Speech

The computer's microphone can be used to capture a sample of a naturally occurring sound. A sound recorder in Snap*!* is accessed through the *Sounds* tab to the right of the *Scripts* tab. (Note: on a Macintosh, you will be asked to give permission to access the computer's microphone the first time the sound recording capability is accessed.)

Once a sound has been recorded, it can be assigned any name that is appropriate.

Exploration 2.7 Recording Speech

Use the Snap*! Sound Recorder* to record and play back a phrase.