Names: ____ Date: ________ Per: ______

The Sound of Sine Mini-Project

Objective: To combine your knowledge of trigonometry, sound, and culture to create a "soundboard" for a focus topic of your choice. Think like an artist's paint palette – what would some of the building-block sounds be for the focus you chose?

Topic Choice #1: Video Game Music

When video games first became popular, they had a sound generator that used combinations of sine waves to create electronic music. While computation and space limits meant these often only used a relatively small number of waves and tracks, these simple building blocks could create complex and iconic songs.

For your soundboard, you will construct equations for five different soundwaves & explain what their role might be in a video game (bass note? "ping" from picking up an item? The screech of an enemy?)

Explore:

- Watch the visualization of the waves used to create the classic "Legend of Zelda (Theme)" by Koji Kondo

https://www.youtube.com/watch?v=gKXGDuKrCfA&feature=youtu.be

1. How many different tracks were used to create the song?

2. What wave shapes & patterns do you see?

Building square and sawtooth waves

https://www.audiologysource.com/additive-synthesis/

3. What is the pattern in the equation for building a square wave?

4. What is the pattern in the equation for building a sawtooth wave?

https://kconrad.math.uconn.edu/math1132s10/sawtooth.html

5. This link uses a slightly different approach to building a sawtooth wave. How is this pattern different from the one you found in 4?

Create:

After looking at the different possible wave shapes and sequences in 1-5, try coming up with your own pattern for adding/subtracting sine waves. Have at least one button on your soundboard use a combination of sine equations. Include an overall description of what type of game these sounds might be used in, any patterns you explored in building this, and any successes or difficulties in building the soundboard.

Use the 5-note soundboard at the link below to test your equations and build your soundboard. You may also want to use the 3-note chord builder to test combinations from the sounds you chose.

https://www.geogebra.org/m/xrp6uwpx

You may also wish to use the virtual oscilloscope to determine the frequencies for common notes.

http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/oscilloscope_description_tutorial_sounds_frequency.htm

Record the equations and role in the game in the chart below (an example is provided)

Equation (Example): j(x)=sin(2 π*100 x)+sin(2 π*150 x)	Role (Example): This sound might be played if a player made a mistake
1. f(x) =	
2. g(x) =	
3. h(x) =	
4. j(x) =	
5. k(x) =	

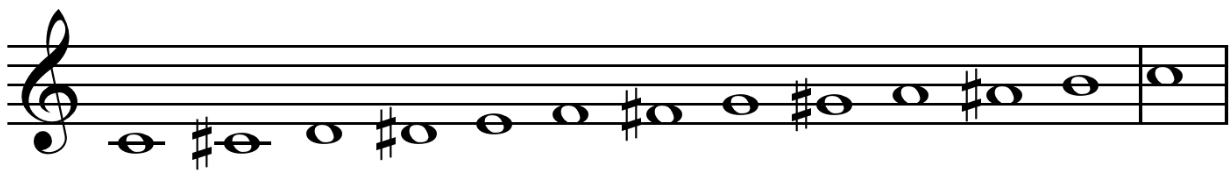
<u>Analysis of one equation:</u> Choose one equation (or part of one equation, if you added several sine functions together) from above and sketch it below. Label the amplitude and period on the graph, and explain how it connects to the coefficients in the equation.

<u>Soundboard Description:</u>

<u>Reflection:</u> (do this after the presentation day)

Topic Choice #2: Chords & Scales

If you were taught music in the Western tradition, you may have learned that sounds are organized into 12 different notes (a "chromatic scale") often written like this:



While this is a great way to organize possible notes for a song, it isn't the only way!

For your soundboard, you will research different ways that scales can be created. You'll then write equations for five different notes in a scale of your own design & explain what influences and ideas you used in your scale (is it drawn from the scales used in a certain part of the world? Did you want to convey a certain type of mood or emotion with these notes? Did you find an interesting pattern in how to build one note from the other?)

Explore:

- **Pentatonic** ("penta" = 5, "tonic" = tones) scales are common in many cultures, showing up on almost every continent (the wikipedia page for "pentatonic scale" lists over 50 different musical traditions!) Use the link below to explore the pattern these scales are often built on:

  https://www.lightnote.co/music-theory/pentatonic

1. What were the ratios used for each note in the pentatonic scale?

2. If we instead wanted the first note to be played at 50 Hz, what would the frequencies of the other four notes in the pentatonic scale be?

Different scales:

3. Choose one type of scale from the list on the wiki page and do some more research about it – how many notes does it have? Are those notes embedded in the chromatic scale, or do they use tones that aren't on a typical keyboard? Include the links to other websites or resources you used

   https://en.wikipedia.org/wiki/Scale_(music)

Create:

After exploring some of the possible scales and how they are built, come up with your own scale that has (at least) five notes. Describe one or two chords you can build using these notes, and what influenced your choice of these equations. Include a short name/description for each note – you can give them the common Western names for tones from the 12-note scale, or choose your own names for each note.

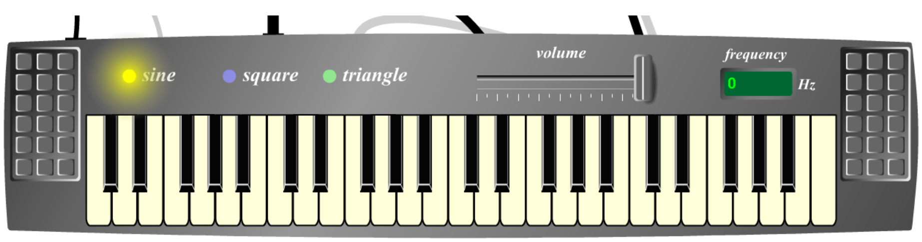
Use the 5-note soundboard at the link below to test your equations and build your soundboard. You can also test combinations of up to 3-notes in the chord builder found at the same link.

https://www.geogebra.org/m/xrp6uwpx

You can also look up the frequencies (in hertz) of different notes from the chromatic scale at the link below:

http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/oscilloscope_description_tutorial_sounds_frequency.htm

The keyboard is available here for you to take notes on which keys & frequencies you explore:



Record the equations and description of the notes in your scale (an example is provided)

Equation (Example): $f(x)=\sin(2\pi*261 x)$	Note name Middle C on a chromatic scale
1. f(x) =	
2. g(x) =	
3. h(x) =	
4. j(x) =	
5. k(x) =	

Analysis of one equation: Choose one equation (or part of one equation, if you added several sine functions together) from above and sketch it below. Label the amplitude and period on the graph, and explain how it connects to the coefficients in the equation.

Soundboard Description:

Reflection: (do this after the presentation day)

Optional Challenges / Deep Dives

Option 1 (Video Game Music) Deep Dive:

While the waves used in videogame music are relatively simple and "electronic"-sounding, there are ways to mimic real-world instruments using combinations of sine waves – but it is often a very complicated task, filled with many sine equations!

A sound spectrum shows which frequencies (in hertz, along the x-axis) are present in a sound and at what intensity (amplitude, y-axis).

Examine some of the graphs of the sound spectra for violins and pianos. See if you can recreate any of the equations for the spectra based on the graphs – does the result sound close to the original instrument? Why or why not?

Piano sound spectrum:

https://www.youtube.com/watch?v=5xjD6SRY8Pg

Violin analysis (check out the charts on pages 33-34):

https://physicslearning2.colorado.edu/QOTWSite/services/demos/demosh4/h4-31ExtendedEssayFinal.pdf

Mimicking a bass note in wolframalpha (enter this equation):

play sum((1/n)sin(2*pi*(100+n)t)),n=1 to 30

Option 2 (Chords & Scales) Deep Dive:

Optional Challenge / Deep Dive: Watch (30 mins) "Math of Musical Scales" parts 1,2, and 3 by Patrick Reynolds. Try to integrate some of the concepts he uses into the creation of your scale.

https://www.youtube.com/watch?v=TGAB-0ZDVZY

https://www.youtube.com/watch?v=ylDWgG7pgxw

https://www.youtube.com/watch?v=DbBaaob9_gI

Name: ____ Date: ______ Per: _______

Rubric: Sound of Sine Mini-Project

Standard	Level of achievement	Description
CCSS.MATH.CONTENT.HSF.TF.B.5 Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.* CCSS.MATH.CONTENT.HSF.IF.B.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.** SWO: Critical Thinking	4 Thoroughly meets standards	The equation analyses thoroughly demonstrate an understanding of the effects of changing the leading coefficient on the amplitude and the inner coefficient on the period of a trigonometric equation. Descriptions of patterns used to create waveforms / scales are accurate. Correct vocabulary is used and applied consistently in each explanation.
	3 Meets standards	The equation analyses demonstrate an understanding of the effects of changing the leading coefficient on the amplitude and the inner coefficient on the period of a trigonometric equation. Descriptions of patterns used to create waveforms / scales are mostly accurate. Correct vocabulary is used and applied in the explanations. May include minor errors in computation or written equations.
	2 Approaching standards	The equation analyses demonstrate partial understanding of the effects of changing coefficients on the amplitude and period of a

		trigonometric equation, but knowledge is applied inconsistently or incorrectly in the explanations. Descriptions of patterns used to create waveforms / scales are partially accurate but contain inconsistent / incorrect computations or conclusions
	1 Not yet approaching standards	The equation analyses and patterns used in waveform/scale generation do not demonstrate understanding of the effects of changing coefficients on the amplitude and period of a trigonometric equation
	0 No attempt	No evidence of attempting the problems
Standard	**Level of achievement**	**Description**
SWO: Communication	4 Thoroughly meets standards	The soundboard descriptions and exploration questions are written with correct grammar, clearly labeled diagrams, and coherent, clear, and detailed arguments in the descriptions of choices made in building the soundboard
	3 Meets standards	The analyses and descriptions are written with generally correct grammar, clearly labeled diagrams, and coherent arguments in each analysis. There may be minor mistakes or gaps in explanation, but these do not affect the overall strength of the arguments

	2 Approaching standards	The analyses and descriptions include multiple grammatical errors, labeled diagrams, and partially coherent arguments in each analysis. Some mistakes, gaps, or contradiction are present in the explanations that detract from the overall strength of the arguments
	1 Not yet approaching standards	The analyses and descriptions include many grammatical errors. Diagrams may be missing labels or difficult to decipher, and mistakes, gaps, and contradictions are present that weaken the arguments given.
	0 No attempt	No evidence of attempting the problem