Catch A Wave

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Grade Level: 10-12

Time Allotment: One 90-minute block

Overview: In this lesson students will create a sinusoidal curve by humming into a microphone and then finding the note they hummed (or one close to it) by calculating the frequency of the curve. They will then learn about waves and their properties and will draw conclusions about the effect amplitude and period have on the graph of these trigonometric functions. Finally, the students will find an equation for the line of best fit for the curve that they created by humming. This lesson should follow an introduction of the standard form of trig functions such as $y = A \sin (Bx + C) + D$ or $y = A \sin (B(x - C)) + D$, where A, B, C, and D are real numbers and will be used to show a real life model for these types of functions. Notice that the VA SOLs use the sine of the sum of X (or BX) and C and most textbooks use the sine of the difference of X and C.

Subject Matter: Algebra II/ Trigonometry

Learning Objectives:
The student will be able to:

- Collect, graph, and interpret data
- Graph trigonometric functions
- Find the amplitude and period for variations of the sine and cosine functions
- Create a sinusoidal curve by using a microphone and CBL
- Use technology and mathematics to improve investigations

Standards:
This lesson correlates with Virginia Standards of Learning available at
http://www.pen.k12.va.us

AII/T.26 The student, given one of the six trigonometric functions in standard form (e.g., $y = A \sin (Bx + C) + D$ or $y = A \sin (B(x - C)) + D$, where A, B, C, and D are real numbers), will:

* state the domain and the range of the function;
* determine the amplitude, period, phase shift, and vertical shift; and
* sketch the graph of the function by using transformations for at least a one-period interval.

The graphing calculator will be used to investigate the effect of changing A, B, C, and D on the graph of a trigonometric function.

Media Components:

ITV Program:
Elements of Physics: Waves: Sound and Electromagnetism: "The Nature of Waves"(02:20) http://www.unitedstreaming.com

Web sites:
http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=86
This site has a 30-day Free Trial period or you may launch one gizmo per day from this site. This web site allows students to experiment with graphs of trigonometric functions. It also allows students to see the effect period, vertical and horizontal shifts, and amplitude have on the graph.
http://mystery.sonoma.edu/alien_bandstand/
The Alien Bandstand web site allows students to learn more about sound waves produced by musical instruments.

Materials:

- Tuning fork (with frequency between 200 and 300 HZ) or you may hum for this activity. (I prefer to let the students hum.)
- Vernier Microphone
- Overhead TI-82 or 83 graphing calculator and viewscreen
- Calculator Based Laboratory (CBL) (Available from http://www.ti.com)
- TUNE program for the graphing calculator loaded onto the overhead graphing calculator. (The program TUNE can be downloaded from the disk that comes with the CBL or you can use the program TUNED from the disk that comes with the book, Real World Math with the CBL System by Brueningsen, Bower, Antinone, Brueningsen, Texas Instruments.) If neither of these is available, you can use the program MCRPH, which is found at the end of this lesson.

Prep for Teachers:

- Prior to teaching, bookmark the web sites and print off Exploration Guide: "Translating and Scaling Sine and Cosine Functions" – Activity B from the Explore Learning website. http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=86
- Check for necessary software and plug-ins; Internet Explorer 4.x or 5.x, or Netscape 4.x, with Macromedia Flash or Shockwave plug-in installed. Quick Time or Windows Media Player is also needed.
- Download the ITV Program from UnitedStreaming.com. Familiarize yourself with the audio and visual cues used in the Learning Activity portion of the lesson.
- Follow the directions for setting up the microphone, CBL, and Graphing Calculator found under Introductory Activities.

- Download the program TUNE or TUNED into the TI-82 or 83 overhead calculator using the GraphLink computer program and the disk from the CBL packet or the disk from the book Real World Math with the CBL System. If you do not have access to these programs you may enter the program MCPHN found at the end of the lesson.
- Practice hooking up the CBL to the microphone and graphing calculator.
- Run the TUNE, TUNED or MCPHN program and familiarize yourself with the program.
- Practice the CBL activity, "Name that Tune" from the CBL Workbook found at http://education.ti.com/downloads/pdf/us/cblwork.pdf
- For background information on this lesson you may download and view the United Streaming Video Clip: *Math Factor: Building Trigonometric Models: Graphing Trigonometric Functions The ABCs of Graphing* (10:47)
- The Teacher's Guide with the United Streaming Video *Math Factor: Building Trigonometric Models: Graphing Trigonometric Functions* has a nice assessment on pages 3 and 4 of Chapter 7: Trigonometric and Circular Functions

When using media, provide students with a **FOCUS FOR MEDIA INTERACTION**, a specific task to complete and/or information to identify during or after video segments, Web sites or other multimedia elements.

Introductory Activity: Setting the Stage

Step 1: Open the Web site, Alien Bandstand found at http://mystery.sonoma.edu/alien_bandstand/. Click on *Play the Game*. At the welcome screen, if this is your first time, create a new user; otherwise, load an existing user and submit. Choose the appropriate configurations for your computer and click on *Solve the Mystery*. You will see a video mailbox near the bottom of the screen. Click on it. In the video mailbox, you will see a link labeled, *Composer Althea Geary*, *All About Waves*. Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "Today we will explore sound waves and their importance in scientific discovery. Let's listen as Althea Geary gives us a graphical interpretation of sound. I want you to listen for the first type of sound she discusses, what instrument produced it, and describe its graph." Click on Althea Geary's name. Have the volume turned up as the video begins immediately.

Pause the video after Ms. Geary says, "O.K. Hear that pure tone? Its waveform looks like this-clean and simple." **Ask**: "What was the first type of sound and how was it produced?" (An electronic organ produced the pure tone.) **Ask**: "What was the shape of the graph?" (A wave) Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "Listen as Ms. Geary describes how she can play music that has no sound and be able to describe the accompanying graph." **Resume** the video.

Pause after Ms. Geary says "…and we hear silence." **Ask**: "What caused the silence and what did the graph look like?" (A second sound wave was added but offset by exactly

one-half cycle. The graph looked like a series of ovals.) Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "What happens when a second wave is introduced with a different period?" **Resume** the video.
Pause the video after Ms. Geary says, "We hear a beat or a resonance." **Ask**: "What did the different periods produce?" (A beat or a resonance) Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "Describe the difference between an electronically produced pure tone and a natural sound." **Resume** the video and play the rest of the segment. **Ask**: "So, what was the difference?" (A natural sound is the compilation of dozens of individual tones, which can be taken apart layer by layer and analyzed.)

Say: "So, now that we know what the graph of a sound wave is supposed to look like, let's see if we can create one that looks similar to those that Ms. Geary showed us. We are going to use a microphone hooked up to the CBL and graphing calculator. Someone will hum into the microphone and this in turn will produce a graph. We will run the experiment over and over until we get a curve that looks like the first one we saw in the previous video clip, a sine wave."

Ask a volunteer to come forward to hum into the microphone.

Connect the CBL to the TI-82 or 83 graphing calculator using the unit-to-unit link cable. Make sure the cable ends are completely inserted in the I/O ports on the bottom of each unit. Connect the Vernier microphone to Channel 1 of the CBL. Turn on the CBL and calculator. Run the program TUNE, TUNED, or MCRPHN and follow directions on the calculator screen. Hum into the microphone or strike the tuning fork on your knee or palm of your hand (just not on a hard surface) and hold it close to, but not touching, the microphone. Press ENTER on the calculator to start collecting the data. The resulting Pressure vs. Time plot should look like a sine or cosine curve and if it doesn't, repeat the activity until you get a similar plot. If you are humming this might take several attempts but it goes very quickly. To run the program again, press 2^{nd} , MODE, ENTER,. 1:COLLECT DATA, ENTER, SEE DIRECTIONS? 2: NO, ENTER

Press TRACE and move along the graph that has been created. You are going to try and find the period of this curve, so pick two peaks of the graph that are at about the same height and first trace over to the one farther to the right and record the value of x. An easy way to do this is to go to the home screen of the calculator (2^{nd} MODE) and press X ENTER. Then go back to the graph and trace along the graph to the peak to the left of the one you just recorded and go to the home screen and type – (minus) X. This will give you the difference between the two x values. To determine the frequency you must find the multiplicative inverse of this difference. An easy way to do that is to just use the x^{-1} key. This will give you the inverse of the difference of the period and thus the frequency. Have students record the value of the frequency and label it F. Check the frequency against the following chart to see what musical note was played or hummed. *Note: For the TUNED or TUNE programs, Pressure is stored in L5 and Time (in seconds) is stored in L2, if you use the MCRPH program the data are stored in L1 and L2.

Note	Frequency (f) in Hz
C	262
$C^{\#}$ or D^{b}	277
D	294
$D^{\#}$ or E^{b}	311
E	330
F	349
$F^{\#}$ or G^{b}	370
G	392
$G^{\#}$ or A^{b}	415
A	440
$A^{\#}$ or B^{b}	466
B	494
C (next octave)	524

Tell the students that now that we have determined what note was played or hummed, we will later try to fit an equation to the graph of their note.

Learning Activity

When using media, provide students with a **FOCUS FOR MEDIA INTERACTION**, a specific task to complete and/or information to identify during or after video segments, Web sites or other multimedia elements.

Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "First, I would like for you to listen for the explanation of a wave and then we are going to explore the different components that make up an individual wave." **Play** the Streamed Video *Elements of Physics: Waves: Sound and Electromagnetism:* **"** The Nature of Waves," and **PAUSE** the video at 0:50 after you hear the narrator say, "What moves outwards with the wave is not the water, it is the energy of the disturbance."

Ask: "So what do you think a wave is?" (Accept all answers. Some answers might include the following: A wave is a means of transporting energy. A wave is a traveling disturbance that carries energy from place to place. Students might say that wind causes a wave or that the energy of the falling stone makes a disturbance in the water and that disturbance creates a wave.) Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "Next I would like for you to listen for the two basic types of waves." **Play** the video and **Pause** at 1:14 when you hear the narrator say "…but all waves have some common characteristics."

Ask: "What were the two types of waves mentioned in the video?" (Transverse and Longitudinal) Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "Now I want you to listen for the common characteristics of waves?" **Play** the video and Pause at 2:13 when you see the list of common characteristics of waves. **Ask**: "What are those common characteristics?" (Wave Length, Frequency, Amplitude, and Velocity)

Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "Now I want you to describe each of those characteristics: Wave Length, Frequency, Amplitude, and Velocity." **Rewind** video to 1:14 and **Play** the video and **Pause** at 1:25 after you hear the answer to wave length. **Ask**: "What does "wave length" mean?" (The distance of one complete wave)

Ask: "What is the frequency?" (Frequency is the number of wave cycles in a given unit of time, usually measured as the number of waves per second (Hertz)) **Resume** the video and **Pause** at 1:39 after you hear the answer.
Ask: "What is the amplitude of a wave?" (Amplitude is the maximum difference of the disturbance or the height of the wave) **Pause** at 1:48 after hearing the answer.

Ask: "What is the velocity of a wave?" (Velocity is the speed of the wave, found by multiplying the wave length and the frequency together.) **Pause** at 2:00 after hearing the answer.

Ask students to summarize what they have learned from this video clip. Provide students with a **FOCUS FOR MEDIA INTERACTION** by saying: "Let's see if we are correct in our summarization." **Play** the rest of the video clip. The summary should include the following:

- There are 2 types of waves- Transverse and Longitudinal.
- A wave is a traveling disturbance that carries energy from place to place.
- There are four characteristics of all waves: Wave Length, Frequency, Amplitude, and Velocity.

Culminating Activities

I. Explore the effect each part of a trigonometric equation has on the graph.

1. Go to the following website: http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=86
2. Click on >>Launch Gizmo!
3. If you click on Extra Materials, you will see a tutorial for using this activity.
4. Hand students a copy of the Exploration Guide and have them work through the questions to discover what effect A, B, C and D have on the trigonometric equation: $y = A \sin (B(x - C) + D$, where A, B, C, and D are real numbers
5. Have students slide the sliders for A, B, C, and D to visualize the effect each of these real numbers has on the appearance of the graph.

II. Analyze the collected data.

Students will now try and write an equation for the sinusoidal curve that they created with the microphone and CBL. Students should return to the graph of the data and press 2^{nd} DRAW 3:HORIZONTAL to draw a horizontal line on the screen. Use the arrow keys to move it up or down to find the maximum and minimum heights of the

curve. Subtract the two values and take half of the difference. This value will be called A for amplitude. Another way to find this number is to trace along the curve to the maximum height (or perhaps you want to find the mean of the peaks of the curve) and go to the home screen and press ALPHA 1 which will give you the y value of that point, which is an approximate value of the amplitude, if the graph is centered along the x axis. Have students record the value of the amplitude and label it A.
The frequency (F) was found in the Introductory Activity. Students should now press Y= on their calculator and enter the values they got for the Amplitude and Frequency for A and F in the following equation: y=A sin(2pi* F(x - C))+D Students will then enter various numbers for D and C to find the equation that best fits their graph. C will move the graph to the left or right depending on whether it is positive or negative and D will move the graph up and down. They can start with C=0 and then choose other values to find the equation that best matches the graph. They should record this equation and review what effect each part of the equation has on the graph.

Note: A good review of these concepts can be seen on the United Streaming Video Clip: *Math Factor: Building Trigonometric Models: Graphing Trigonometric Functions The ABCs of Graphing* **(10:47).** It would be beneficial for those students who miss class that day to view this video.

Assessment: There are some good problems on the Blackline Masters from the United Streaming video if you want to download them and print them off for your students.

Cross Curricular Extensions:
Music:
Have students write a tune using the frequencies given on the Frequency Chart

Science:
Study other types of waves such as the Electromagnetic Spectrum

Community Connections:
Invite a musician to class to discuss pure tones and the different frequencies of notes.

Have students play the game Alien Bandstand to learn more about high-energy-waves.
http://mystery.sonoma.edu/alien_bandstand/

MCPHN Program for TI 82 or TI 83

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PlotsOff
Func
AxesOn
ClrHome
{1,0}->L6
Send(L6)
{1,1,1}->L6
Send(L6)
ClrHome
Disp "PRESS ENTER TO"
Disp  "START COLLECTING"
Disp  "DATA."
Pause
{3, .0002, 99, 0, 1, 0, 0, 0, 1}->L6
Send (L6)
ClrDraw
Get(L2)
Get(L1)
L2-2.5->L2
ClrHome
.001->Xscl
min(L1)->Xmin
max(L1)->Xmax
.2*(max(L2)-min(L2))->A
.1->Yscl
min(L2)-A->Ymin
max(L2)+A->Ymax
Plot1(xyline,L1,L2,.)
Text(4,1,"PRESSURE"):Text(54,69,"TIME(S)")
Stop
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