

Come Waltz With Me:
Learning to Code Music
with the TI-Innovator™ Hub

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Why “Coding”?

- » Computer programming career opportunities
- » Computer Science majors
- » Coding in other majors and professions

Why Coding in Math, Science, Engineering, or Humanities Class?

- » Sparks an interest in coding
- » Builds a foundation in coding
- » Strengthens understanding of concepts
- » Promotes creativity
- » Easy-to-learn coding on all TI graphing devices

Your Level of Experience and Goals?



UNIT 3: GETTING STARTED WITH TI-INNOVATOR™ HUB

Outputs: Light, Color and Sound

Skill Builder 3: Your first program with Sound

Learning to Code vs. Learning to Teach Coding



10 Minutes of Code

TI-84 PLUS CE WITH THE TI-INNOVATOR™ HUB

UNIT 1: SKILL BUILDER 3

TEACHER NOTES

Unit 1: Getting Started with TI-Innovator™ Hub

Skill Builder 3: Input and SOUND

In this third lesson for Unit 1, you will learn another method to get user input into a program and how to control the SOUND on the TI-Innovator™ Hub.

Objectives:

- Use the Input statement
- Control the frequency and timing of the speaker (SOUND)

Skill Builder 3: Input and Sound Statements

The TI-Innovator Hub has a built-in speaker called SOUND.

You control the sound coming out of Sound by sending a frequency value. Sound frequencies are measured in Hertz (Hz), or 'cycles per second'.



Skill Builder 3: Input and Sound Statements - cont.

Teacher Tip: The speaker is not loud intentionally in order to avoid classroom disruptions. The SET SOUND command accepts values for frequency and duration (in seconds). The frequency can be set from 1 to ???, but the 'audible' range is more limited. An interesting frequency is a low value like 5. You will hear the speaker click 5 times in one second. This will help explain Hz (cycles per second). At higher frequencies you will hear musical notes because this is the way our ears work. Pressure 'waves' through the air coming from a vibrating speaker cause our eardrums to vibrate and the brain interprets this vibration as sound.



10 Minutes of Code

TI-84 PLUS CE WITH THE TI-INNOVATOR™ HUB

Setting up the SOUND program

1. Start a new program, and name it SOUND1.
2. Add the **ClrHome** and **Input** statements from the prgm I/O menu.
3. After the **Input** command, use [A-LOCK] (2nd[ALPHA]) to type the string of characters "Frequency? ".
4. Turn off the alpha lock to type the comma.
5. Then add the variable that will represent the frequency, F
6. Add another **Input** statement to let the user enter the time for which the sound should play.

As with the COLOR program in the previous skill builder, you need to use the **eval()** function to evaluate the variables **F** and **T**.

Finishing up the SOUND program

1. Select **Send("SET...** and **SOUND** by pressing [PRGM]
2. Arrow over to the **HUB** menu, and select **1: Send("SET....**
3. Then select **6:SOUND**
4. Select **eval(** by pressing [PRGM][.]
5. Arrow over to the **HUB** menu, and select **6:eval(.**
6. Add the variable **F**, and close the parentheses.
7. Type a space (ALPHA[0]) and then add another **eval(** function for the variable **T**.
8. Add the variable **T**, and close the parentheses.
9. Close the quotes and the parentheses for the **Send(** command.

UNIT 1: SKILL BUILDER 3

TEACHER NOTES

```
NORMAL FLOAT AUTO REAL Radian MP
PROGRAM:SOUND1
:ClrHome
:Input "FREQUENCY? ",F
:Input "TIME? ",T
:█
```

```
NORMAL FLOAT AUTO REAL Radian MP
PROGRAM:SOUND1
:ClrHome
:Input "FREQUENCY? ",F
:Input "TIME? ",T
:Send("SET SOUND eval(F) e
val(T)")█
```


Programming Menus

```
NORMAL FLOAT AUTO REAL RADIAN MP
CTL I/O COLOR EXEC HUB
1:Input
2:Prompt
3:Disp
4:DispGraph
5:DispTable
6:Output(
7:getKey
8:ClrHome
9↓ClrTable
```

TI-84 Plus CE

```
NORMAL FLOAT AUTO REAL RADIAN MP
CTL I/O COLOR EXEC HUB
1:Send("SET...
2:Send("READ...
3:Settings...
4:Wait
5:Get(
6:eval(
7:Send("CONNECT-Output...
8:Send("CONNECT-Input...
9↓Ports...

0:Send("RANGE...
A:Send("AVERAGE...
B:Send("DISCONNECT-Output...
C:Send("DISCONNECT-Input...
D:Manage...
```

Name This Tune:

Where commands
are located:

prgm I/O
prgm I/O

prgm HUB #1
prgm HUB Settings
prgm HUB Settings

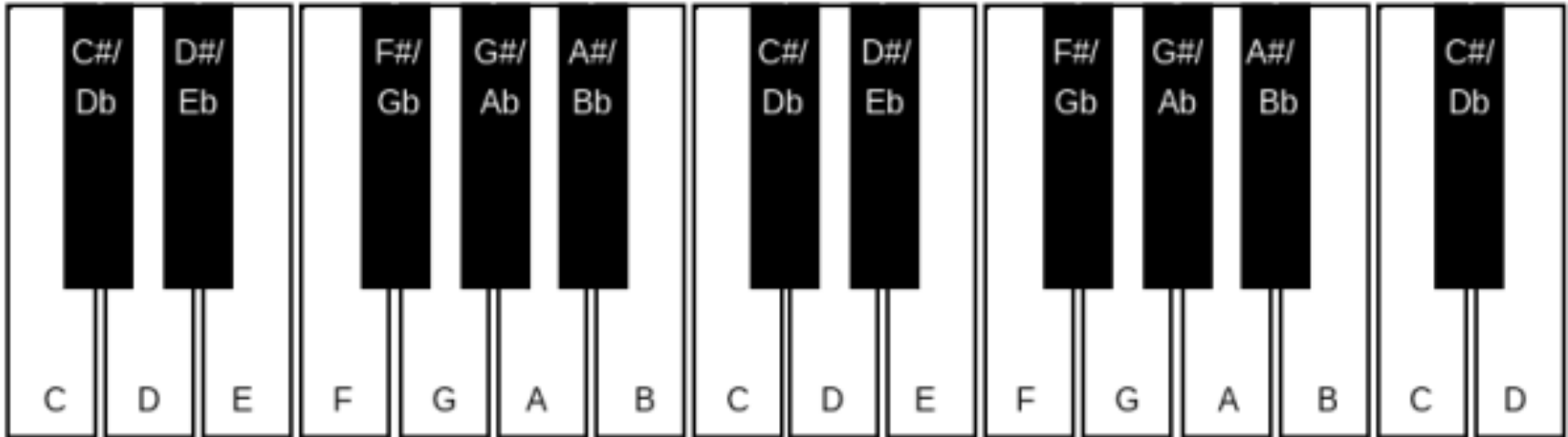
```
PROGRAM:TUNE  
:ClrHome  
:Output(5,4,"NAME THAT TUN  
E")  
:261.63→F  
:Send("SET SOUND eval(F),  
TIME 2")  
:Wait 2  
:392→F  
:Send("SET SOUND eval(F),  
TIME 2")  
:Wait 2  
:523.25→F  
:Send("SET SOUND eval(F),  
TIME 2")
```

Math and Music Connection

"There is geometry in the humming of the strings, there is music in the spacing of the spheres." — Pythagoras



Skill Builder 3: Loop Through the Musical Notes



(c) mymusictheory.com

- » Octave has 12 semitones
- » Frequencies make a geometric sequence
(Calculator demo)

Skill Builder 3: Loop Through the Musical Notes (cont.)

A3	A#	B	C	C#	D	D#	E	F	F#	G	G#	A4
220	233.1	246.9	261.6	277.2	293.7	311.1	329.6	349.2	370	392	415.3	440
$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$	$x^{12}\sqrt[12]{2}$
n=1	n=2	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	

- » Semitones one octave apart vary by a factor of 2. Note that A3=220 Hz, while A4=440 Hz.
- » Frequencies make a geometric sequence with a common ratio between terms of $2^{(1/12)}$.
- » The red notes above are the A major scale.

Skill Builder 3: Loop Through the Musical Notes (cont.)

Explore Code (10 minutes)

```
NORMAL FLOAT AUTO REAL RADIAN MP
PROGRAM: SOUND2
: 261.64 → F
:
: For(I, 1, 12)
: Send("SET SOUND eval(F) TIME .5")
: F * 2^(1/12) → F
: Wait .5
:
: End
```

- » Initialize F
- » Use For(loop to create semitones:
- » Replace the old F with the new F
- » Wait
- » Repeat

Skill Builder: Using Lists

Write a program to play a song

The Tennessee Waltz



The image shows a musical staff with two lines of music. The first line contains the lyrics "I was waltz - ing with my dar - lin' to the" and the chord list "G A B D G A B D G A B D". The second line contains the lyrics "Ten - nes see ___ Waltz ___" and the chord list "B A G E".

I was waltz - ing with my dar - lin' to the Ten - nes see ___ Waltz ___

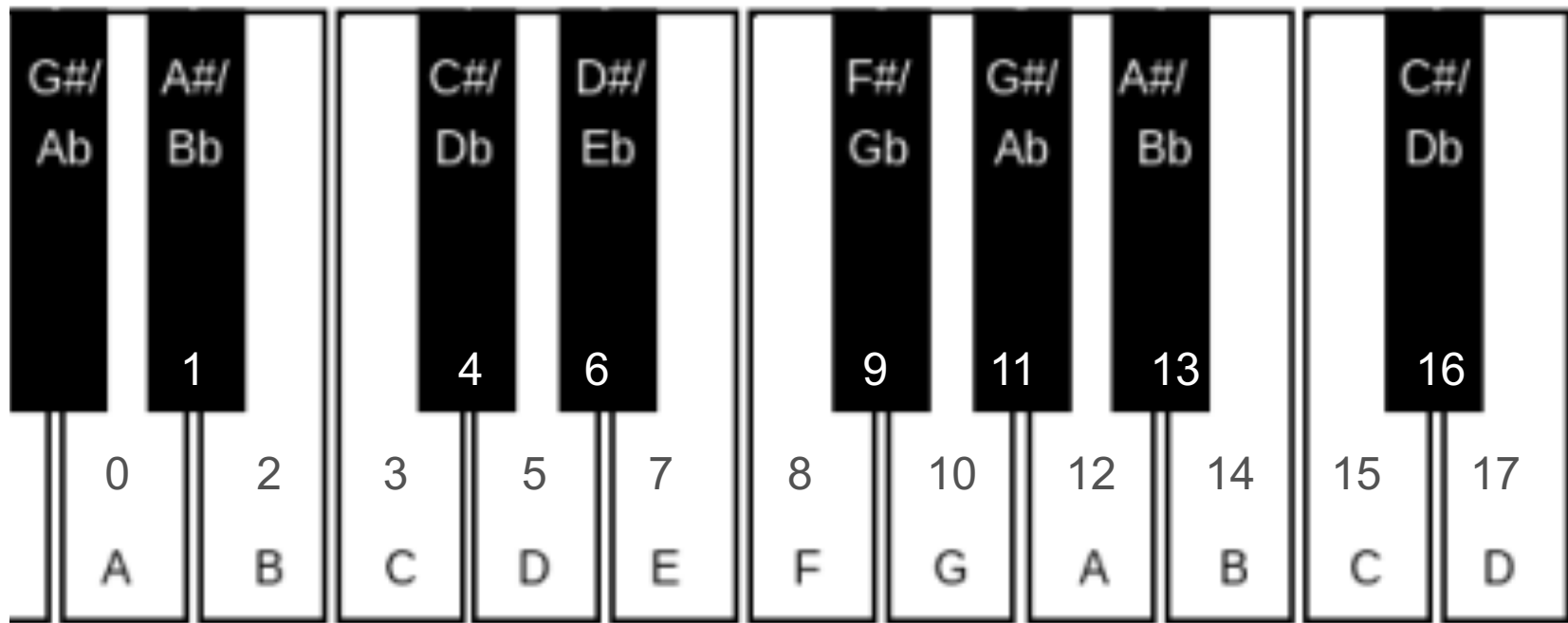
G A B D G A B D G A B D B A G E

Skill Builder: Using Lists (cont.)

Write a program to play a song

```
NORMAL FLOAT AUTO REAL RADIAN MP
EDIT MENU: [a]pha] [f5]

PROGRAM: WALTZ
:0→A
:2→B
:3→C
:5→D
:7→E
:8→F
:8→F
:10→G■
```



220 Hz

440 Hz

(c) mymusictheory.com

Skill Builder: Using Lists (cont.)

Write a program to play a song



I was waltz - ing with my dar - lin' to the Ten - nes - see _____ Waltz _____

G A B D G A B D G A B D B A G E

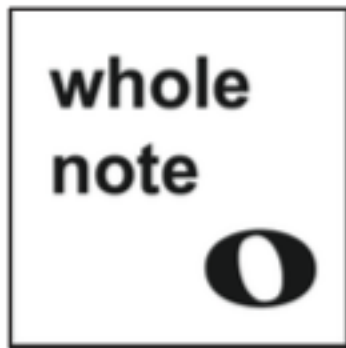
```
NORMAL FLOAT AUTO REAL RADIAM MP
EDIT MENU: [a.7pho.] [f5]
PROGRAM: WALTZ
:0→A
:2→B {G,A,B,D,G,A,B,D,G,A,B,D,B,A,G,E}->L1
:3→C
:5→D For(I,1,16)
:7→E Send("SET SOUND eval(220*2^(L1(I)/12))")
:8→F
:10→G■ End
```

What is going on with the tempo?

Skill Builder: Using Lists (cont.)

Write a program to play a song

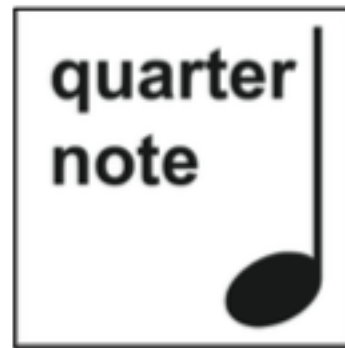
What IS going on with the tempo?



1



1/2



1/4



1/8

I was waltz - ing with my dar - lin' to the Ten - nes - see Waltz

G A B D G A B D G A B D B A G E

Skill Builder: Using Lists (cont.)

I was waltz - ing with my dar - lin' to the Ten - nes see _____ Waltz _____

G A B D G A B D G A B D B A G E

```

NORMAL FLOAT AUTO REAL RADIAN MP
EDIT MENU: [a] [pho.] [f5]
PROGRAM: WALTZ
:0→A
:2→B
:3→C
:5→D
:7→E
:8→F
:10→G■
    
```

PLAY... BUT...NOW...

What is going on with the pitch?

`{G,A,B,D,G,A,B,D,G,A,B,D,B,A,G,E}->L1`

`{1,1,1,3,1,1,1,3,1,1,1,3,1,1,2,2}->L2` Numerators

`{8,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8}->L3` Denominators

`:For(1,1,16)`

`:Send("SET SOUND eval(220*2^(L1(I)/12)) TIME`

`eval(L2(I)/L3(I))`

`:Wait L2(I)/L3(I)`

`:End`

Skill Builder: Using Lists (cont.)

Write a program to play a song

The image shows a musical score for the song 'Waltz' on a single staff. The lyrics are: 'I was waltz - ing with my dar - lin' to the Ten - nes - see ____ Waltz ____'. Below the staff, the chord progressions are listed: G A B D, G A B D, G A B D, B A, G E. The first four measures and the final measure are highlighted with a light red background.

```
NORMAL FLOAT AUTO REAL RADIAN MP
EDIT MENU: [alpha] [f5]
PROGRAM: WALTZ
:0→A
:2→B
:3→C
:5→D
:7→E
:8→F
:10→G■
```

```
:{G,A,B,D,G,A,B,D,G,A,B,D,B,A,G,E}->L1
:{1,1,1,3,1,1,1,3,1,1,1,3,1,1,2,2}->L2
:{8,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8}->L3
:For(I,1,16)
:Send("SET SOUND eval(220*2^(L1(I)/12)) TIME
eval(L2(I)/L3(I)")
:Wait L2(I)/L3(I)
:End
```

Skill Builder: Using Lists (cont.)

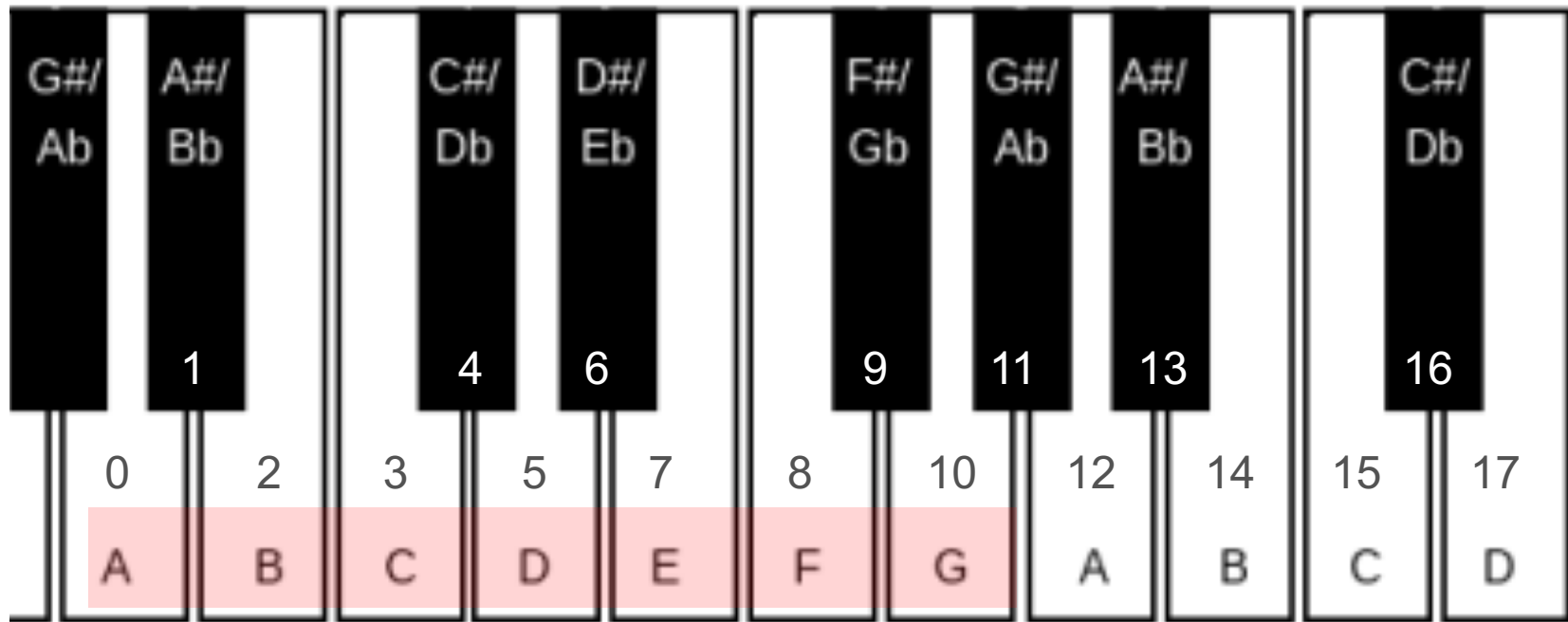
Write a program to play a song

-12]

[

+12

]



220 Hz

440 Hz

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Skill Builder: Using Lists (cont.)

Write a program to play a song

The image shows a musical score for a song. The lyrics are: "I was waltz - ing with my dar - lin' to the Ten - nes - see _____ Waltz _____". Below the lyrics are guitar chords: G A B D, G A B D, G A B D, B A, G E. The score is divided into five measures, each with a red background highlight.

```
NORMAL FLOAT AUTO REAL RADIANT MP
EDIT MENU: [a] [pha.] [f5]
PROGRAM: WALTZ
:0→A
:2→B
:3→C
:5→D
:7→E
:8→F
:10→G
```

```
:{G-12,A,B,D,G12,A,B,D,G,A+12,B+12,D+12,B+12,A,G,E}->L1
:{1,1,1,3,1,1,1,3,1,1,1,3,1,1,2,2}->L2
:{8,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8}->L3
:For(I,1,16)
:Send("SET SOUND eval(220*2^(L1(I)/12)) TIME
eval(L2(I)/L3(I)")
:Wait L2(I)/L3(I)
:End
```

Skill Builder: Using Lists (cont.)

Write a program to play a song

How might you code F#?

How might you code B flat?

I was waltz - ing with my dar - lin' to the Ten - nes see Waltz

G A B D G A B D G A B D B A G E

Diagram of a piano keyboard with keys numbered 0 to 17. Black keys are labeled with sharps and flats: G#/Ab, A#/Bb, C#/Db, D#/Eb, F#/Gb, G#/Ab, A#/Bb, C#/Db. White keys are labeled with letters: A, B, C, D, E, F, G, A, B, C, D. Numbers 1, 4, 6, 9, 11, 13, and 16 are placed on black keys. Numbers 0, 2, 3, 5, 7, 8, 10, 12, 14, 15, and 17 are placed on white keys. Red circles highlight the keys for F (white, 8) and B (white, 14), and the keys for F# (black, 9) and Bb (black, 13).

220 Hz

440 Hz

(c) mymusictheory.com

Skill Builder: Using Lists (cont.)

Write a program to play a song

- » Choose a song or phrase
- » Use lists to code pitches
- » For($I=1$, number of notes)
- » Use a Send("SET SOUND statement to evaluate pitches and check
- » Add another list (or 2) to code the tempo
- » Modify your Send(statement to evaluate times
- » Concert!

Skill Builder: Using Lists (cont.)

Write a program to play a song

Concert!



Discussion: Teaching Opportunities?

