ITC02A: Intro. to Sound & Audio; 音と音声入門: Spectrum Analysis Worksheet

Student ID:	Name:

Purpose: Familiarization with iPadOS operation, multitasking, and basic audio capabilities. Introduce Signal Scope Pro (MultiTool: Oscilloscope, FFT, Spectrogram, Signal Generator), Wolfram|Alpha (including networked operation via Wi-Fi).

Capture parameters are set via the gear icon near the top right of each tool. Display parameters are set via the graph icon near the top right.
These parameters can all be adjusted in realtime (while running, toggled via play triangle ▸ in top left).
Set Appearance to taste (Black, Blue, White).

0. Launch (5. Audio ▸) Signal Scope Pro.

(That means it's on the 5th screen in the "Audio" folder.)

Pull down from the top of the screen (but not bezel) to access the find function.
Type in the (beginning of the) name of the app you want.
Tap to launch.
Double-tap the home button to switch among multitasking apps.

1. Invoke the **Oscilloscope** ("Oscope," leftmost of functions across the bottom).

Tool Options (graph icon in top right) ▸ Oscilloscope: Autoscale: Auto (making time scale automatic), Time Scale: 10 ms/div.
Press play button in top left to turn on capture.
Sing or hum a tone.
Pause the display ( ) to "freeze" the signal.
Measure the time of one period (use any periodic feature: peak–peak, trough–trough, zero-crossing–2nd next zero-crossing), using cursor-indicated time in the top left of the display.
Alternatively, measure the time of, say, 10 periods and divide by that count.
Convert to frequency (by taking reciprocal period):

First, calculate the approximate value in your head: _____

Then use a calculator: _____

Then use Wolfram|Alpha (a separate app): just type in the frequency including units and check out the (networked) response.

Can a bat hear that frequency? _____

2. Invoke the **FFT** (Fast Fourier Transform, spectrum analysis) function (second leftmost of functions across the bottom). Analyzer Options (gear icon in top right) ▸ Min Frequency: 0 Hz, Max Frequency: 3000 Hz.

Confirm microphone as input (top left).
(Microphone for iPad is near the top left corner when facing the tablet in landscape orientation with home button on right.)

Pause to freeze; ▸ to resume sampling.
Tap and slide to place a data cursor.
Unpinch (2-finger gesture) to zoom out.
Double-tap to reset display zoom; double-tap again to turn off data cursor.

Peak tracking toggled on and off with triple tap.

What is the frequency of the lowest sound you can (comfortably) make with your voice? _____
How about the highest? _____

Enter these frequencies into Wolfram|Alpha.
What are the closest musical notes? _____, _____

3. Pure tone: FFT and tuning fork

Use a tuning fork to play a tone.
What is the nominal frequency of the tuning fork? (Hint: see the embossing on its stem.)

_____
(Include the units, which should be equivalent to cycles/second or cps.)

Use the FFT Analyzer to characterize the tuning fork tone.
FFT Analyzer Options (gear icon ⚙): Set FFT Frequency Res (short for "Resolution") to 10 Hz or so (the coarser [bigger] the faster, a consequence of "the uncertainty principle")
FFT Analyzer Display (graph icon 📈): Set FFT Cursor Options: Harmonic Cursors: 1
Use the cursor to find the peak.
What is the frequency of the measured peak (which might not be exactly the same as the nominal stimulus because of sampling and analysis artifacts)?

_____

The FFT plot has 2 dimensions, an independent variable on the horizontal axis and a dependent variable on the vertical axis.
What are the dimensions (examples of dimensions: frequency, intensity, length, level, magnitude, mass, power, pressure, time) of the vertical (dependent variable) and horizontal (independent variable) FFT analysis axes?
_____ vs. _____
What are the units (examples of respective units above: Hz [hertz], W/m^2 [watts/square meter], m [meters], kg [kilograms], W [watts], Pa [pascals], s [seconds]) of these axes?
_____ vs. _____

4. Signal Generator (second from rightmost [behind "… More" at bottom])

Adjust slider range (in the "Tone:" settings to nominal range of human hearing, around 16 Hz to 16 kHz or 20 Hz to 20 kHz.
Adjust Amplitude (towards the bottom of that screen) to no attenuation, 0 dB.
What frequency range can you personally hear at close distance (half a meter or so) from the tablet?
_____ up to _____

Set harmonic cursor (as above) to 10 or so.
Set Type to waveform (with squarewave and sinusoid ∿ signs).
Set Periodic Waveform to Sinusoid, Triangle, Rectangle (with 50% duty cycle: quare wave), Sawtooth.
Note the overtones (harmonics) in the FFT plot.
(Tap the display to enable the harmonic cursors, and slide to the fundamental frequency.)
Which waveforms have only odd harmonics? _____
Which waveforms have both odd and even harmonics? _____