Our senses of sound and of light are two of the most prominent senses that we use to understand the world. Both of these senses share the common dimension of time. In this project we will explore time and space through the transformation of sound into light. You will build a device to visualize an audio (e.g. music) signal. Just as music is perceived through the cochlea in our inner ears and processed in several parts of our brain, principally in the auditory cortex, we will follow a similar process of detection and analysis through the microcontroller. The conversion of an audio signal into a visual signal requires contemplation about how we have come to know both sound and light.

The purpose of this project is to introduce you to several concepts, namely the simple powering of LEDs, using shift registers to add more outputs, multiplexing LED arrays, capturing audio line level signals, and Fourier transform of time to frequency. Specifically, you will develop an audio visualizer that takes in an audio signal from an mp3 player, computer, or cell phone, uses Fast Fourier Transform (FFT) to extract frequency bands (4 or more) and visualizes them on an array of up to 40 LEDs. You will also develop a custom method of using the LED array to visually communicate the audio to the user.

**STEP ONE**
In the first step, you should familiarize yourself with the operation of a single LED by following the ‘Blink’ example that comes with Arduino.

Deliverables:
- None

**STEP TWO**
In the second step, you should familiarize yourself with the operation of the Serial-to-Parallel Shift Register (595) to control several LEDs by following the ShiftOut example. Optionally, you can use the Serial Peripheral Interface (SPI) outputs (MOSI, SS, SCK) on the Arduino board to increase the speed of the data shifting, as the SPI is hardware based and is significantly faster than the General Purpose Input-Output pins (GPIO). You should write a sketch which cycles through the LEDs creating a Larson Scanner. You will also create a Fritzing layout with 24 LEDs using only 3 Arduino pins and 3 shift registers.
- Larson Scanner: [http://lmgtfy.com/?q=larson+scanner](http://lmgtfy.com/?q=larson+scanner)

Deliverables:
- Video of your Larson Scanner linked/posted to the class blog (per team)
- Fritzing Breadboard sketch file of your 24 LED setup uploaded to T-Square (per individual)
- PNG Export of your 24 LED Fritzing Breadboard sketch uploaded to T-Square (per individual)

**STEP THREE**
In the third step, you should familiarize yourself with multiplexing of LEDs. Using the provided acrylic laser cut jig, assembly and solder together a 4x4 matrix of LEDs. Then use the 4x4 array in the Instructables tutorial on multiplexing with a shift register to control the matrix with only 3 pins. You should test your design by sending a pattern of 4x4 frames in sequence to form a simple animation of at least 6 frames.

Deliverables:
- Image of your 6+ frame animation worksheet linked/posted to the class blog (per team)
- Video of your 6+ frame animation linked/posted to the class blog (per team)
- Zip file of Arduino animation code linked/posted to the class blog (per team)
STEP FOUR
In the fourth step, you should familiarize yourself with audio signals, which fluctuate between -1.5V and 1.5V. You should follow the Instructables tutorial on audio input, but only use the DC offset circuit, (basically just a voltage divider) to lift the signal to be positive voltage between 0V-5V, which can be read by the analog input of the Arduino microcontroller. For this you will also use FFT to extract the audio frequency band values using the 8-bit fix_fft algorithm. Create 8 frequency bands and connect 8 LEDs to your Arduino. If the audio levels in one of the 8 bands passes a predefined threshold, then turn on the associated LED.


Deliverables:
- Photo of physical breadboard with your DC offset circuit posted to class blog (per team)
- Video of your 8 LED Audio Visualizer (ideally with music using a 3.5mm y-splitter) linked/posted to the class blog (per team)

STEP FIVE (FINAL STEP)
In the fifth step, you will design a custom method of visualizing input audio using the computed frequency band intensities onto some collection of LEDs (minimum 4, maximum 40). You may use the LEDs provided, or source (i.e. purchase) your own. You may use also source an LED driver board if you wish to offload the LED processing.

Deliverables:
- The audio visualizer
- A 5-minute in-class team presentation of your audio visualizer concept, device, and demo
- An 11x17 print-out documenting your visualization concept, used for the presentation
- The 11x17 print-out as a PNG file linked/posted to the class blog
- 2-5 Images/Videos with descriptions of the design process linked/posted on the class blog
- 2-5 Images/Videos with descriptions of your prototype linked/posted on the class blog