Name: **Date:**   **Class:**
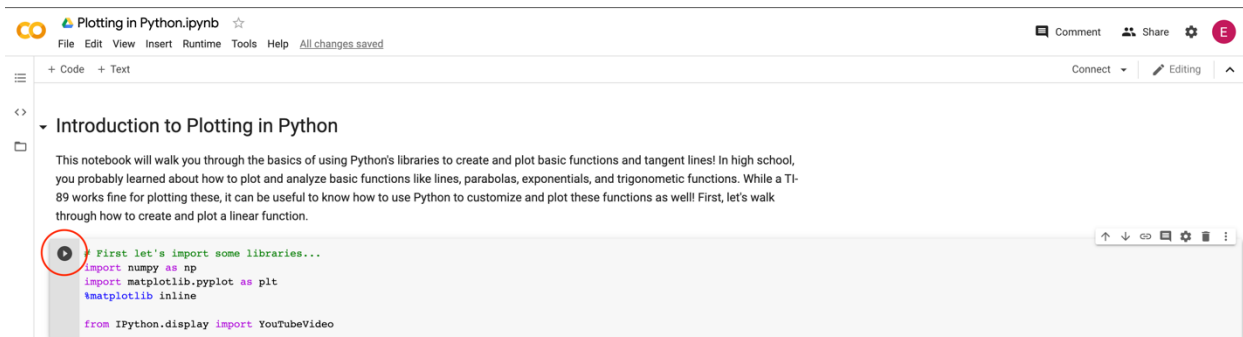
Analyzing Brain Waves Jupyter Notebook Activity Answer Key

Directions
Open the file **AnalyzeBrainWaves_NOTEBOOK.ipynb** in <u>Google Colaboratory</u> by selecting "File->Open Notebook" (NOTE: You will need a Google Account to use Google Colaboratory.) Read each cell (block) of text and run each cell of code by clicking the play button on the left side of the block as indicated by the red circle in the figure below.   **Important note**: The data you will examine in this worksheet is **actual EEG data** collected for research. This data will not perfectly resemble the waves we saw in the slides—there is noise in the data, making it harder to read. When you complete this notebook and worksheet, keep this in mind! As you read, watch, and run each cell, answer the following questions. This is a graded assignment.

1. ***EEG Background.*** Watch the video "Ride the (Brain) Wave" by Brainfacts.org that is linked in the notebook.

    a. List and briefly describe the five types of brain waves discussed in the video.

    i. Delta – deeply sleeping, waves are slow with high amplitude

    ii. Theta – daydreaming, drifting into sleep

    iii. Alpha – relaxed, approaching a meditative state

    iv. Beta – focused and engaged

    v. Gamma – extreme concentration, focus, brain is working at high capacity, waves are faster with low amplitude

2. ***Plotting an EEG.*** Run the first code cell. When you are prompted to open a file, select **EEG_Example1.csv** *or* **EEG_Example2.csv**. Then, run the remaining two code blocks to view the four plots. Each plot corresponds to a **channel**, or a different location of the brain.

    a. Looking at all four channels, what similarities do you notice? Why do you think these similarities exist?

    All four channels have the same general trend (peaks occur at the same time)
    Peaks of activity (like turning the head, reading a book, etc.) may cause spikes in voltage/electricity in all four of the brain regions shown (NOTE: any plausible explanation may receive full credit here, we have just provided an example answer.)

    b. Look closely at the **area of highest activity** (or the area with the largest, most rapid spikes) across all of the channels. Which of the four channels has the strongest activity in this area? Using the titles of the plot as a guide, what area of the brain would you guess has the highest activity in this area?

    The first plot (left frontal lobe) has the strongest activity.

3. ***Power spectral density.*** Run the cell titled "**Calculate and plot the power spectral density of the EEG signals.**" Then, use the plot to answer the following:

    a. At which frequency is there a "spike" in power contribution? What is significant about this frequency in regard to power outlets (**HINT**: look up the frequency of a power outlet and think about the sensitivity of the EEG recording device)?

    Gamma—the frequency of a power outlet is 60 Hz, and the EEG recording device picked up the signal from a nearby power outlet.

    b. Of the four EEG channels, which channel contains the most power? How do you know this (**HINT**: each channel is represented by a different-colored line)?

    EEG_1 contains the most power because its line is above the other three in the PSD plot.

4. ***Band-pass filter.*** Run the code cell in the section titled "**Band-pass filter the EEG to get waves**." Then, use the plots to answer questions 3, 4, and 5.

    a. In the EEG signal associated with the **Left Frontal Lobe**, at which time (in seconds) is there the most **power** from **delta waves**? How did you find this (**HINT**: look at the plot that has "Delta Power" labeled)?

    ~450 seconds—the maximum value of the third plot is at ~450 seconds.

    b. In the EEG signal associated with the **Right Occipital Lobe**, at which time (in seconds) is there the most **power** from **gamma waves**? How did you find this?

    ~500 seconds (end of the plot)—the maximum value of the third plot is at ~500 seconds.

    c. Using the EEG signal associated with the **Right Frontal Lobe**, observe the plot labeled "**Spectrogram**." Each point in the spectrogram represents a fraction of power to frequency (if the point is blue it represents a negative value, and if the point is green it represents a positive value). As the **frequency** is increased, what can you say about the value of the power-frequency fraction based on the plot?

    As the frequency is increased, the power-frequency fraction becomes more negative (more blue).