Electroencephalography (EEG) is a physiological method to measure the electrical activity of the brain. It is typically a non-invasive method, meaning no insertions have to be made to the skull. In a typical EEG, electrodes are placed along the scalp. When neurons send action potentials to other neurons, ions move inside the cells, which causes a voltage change across the cell membrane. This individual change in voltage is too small to measure, but the following EPSP (excitatory post synaptic potential) that occurs for a smaller group of neurons (~1000+) can be measured by electrodes on the surface on the scalp if the voltage change is caused by groups of pyramidal neurons to encourage the direction of energy flow to be parallel to the orientation of the pyramidal cells. The electrical activity recorded at the scalp can be represented as the sum of postsynaptic potentials. This summated activity can be represented as a field of positive and negative poles, like a dipole. The dipole vector is parallel to the orientation of the pyramidal cells generating the activity. Negative dipoles are maximally sensed when they are perpendicular to recording electrodes, which records the signal.

EEGs have numerous medical applications, specifically in diagnosing epilepsy. Patients suffering from it experience disorganized signalling between neurons, which the EEG can record. Strokes and tumors are all able to be diagnosed by it, however use for those purposes has been reduced in recent years with the widespread use of MRI machines. Despite EEG having less spatial accuracy when compared to more complex equipment like MRI, its significantly higher temporal resolution is the primary reason it is used.

In our seminar, we will be discussing the exact physics involved in measuring a moving charge within the brain and other fundamental aspects of how an EEG works. We will analyze how physics is applied to make an effective tool, and how engineers were able to make it so light and compact compared to other similar brain imaging tech. Variants on EEG, such as Evoked Potentials (EG) may also be explored. These use similar technology for different purposes in different fields of study on the brain. Its role in creating brain-computer interfaces may also be explained as an extension of the seminar if time permits.

Sources:

“Neuroscience: Science of the Brain”, British Neuroscience Association, European Dana Alliance for the Brain

“Brain Facts: A primer on the brain and nervous system”, The Kavli Foundation, Gatsby, Society for Neuroscience

“Fundamentals of Physics”, Reznick and Halliday

“Principles of Neural Science”, Kandel, Schwartz, and Jessell

“Handbook of EEG Interpretation”, Tatum, Husain, Benbadis, Kaplan