

# NEUROTECHNOLOGY & BRAIN-COMPUTER INTERFACE

RESEARCH LAB



For more details, visit: [www.discoverSTEM.info](http://www.discoverSTEM.info)

## » CURRICULUM



### DSNTBCI01 :: The Nervous System

Inspired from **PSYCH242 Theoretical Neuroscience**  
Stanford University

- Central Nervous System (CNS)
  - The Blood Brain Barrier
- Peripheral Nervous System (PNS)
  - Somatic Nervous System | Autonomic Nervous System
    - Sympathetic Nervous System | Parasympathetic Nervous System
  - Sensory Division
  - Motor Division

### DSNTBCI02 :: The Brain at Cellular Level

Inspired from **PSYCH242 Theoretical Neuroscience**  
Stanford University

- Neurons
  - Dendrites | Axons | Synapse
- Neuronal Communication: Anatomy & Physiology: Neural Communication, Synaptic Transmission
- How Neurons Communicate
- Neural Networks: From The Brain To AI (What Are Neural Networks)
- Neural Network 3D Simulation
- Glial Cells: Neurosciences
- Neurochemistry
  - Neurotransmitters: Neurotransmitters - What Are Neurotransmitters And What Do They Do In The Body?

- Receptors: 2-Minute Neuroscience: Receptors & Ligand
- Exercise:** Design the Central Nervous System of Future Cars.

### DSNTBCI03 :: Neuroanatomy & Brain Organization

Inspired from **PSYCH242 Theoretical Neuroscience**  
Stanford University

- Brain Anatomy
- Grey and White Matter
- Brain Development
  - Embryonic Brain Development
- Brain Divisions
  - Forebrain | Midbrain | Hindbrain

### DSNTBCI04 :: Brain Diseases and Disorders

Inspired from **PSYCH242 Theoretical Neuroscience**  
Stanford University

- Brain and Mental Health
- What Can Go Wrong?
  - Neurodevelopmental Disorders | Neurodegenerative disorders | Psychiatric disorders
- Neurodegenerative Disease: The Coming Epidemic:
- Parkinson's Disease: How it might be stopped:
- Neurodegenerative Disease: A Potential gene therapy for ALS

**Exercise:** Brainstorming on Ways to Generate Handwritten Text from Brain Activity.

## DSNTBCI05 :: Introduction to Brain Computer Interface (BCI):

- What is the definition?
- What are the types of BCI's?
- Invasive
  - Semi-Invasive (ECoG) | Non Invasive | MEG | PET | fMRI | fNIRS | EEG
- Components
  - Brain activity | Signal acquisition | Preprocessing | Feature Extraction | Classification | Translation | Feedback device
- Applications, Examples & Limitations
- Ethics & Safety
- Future of the field

**Exercise:** Designing Futuristic Applications of Brain Computer Interface.

## DSNTBCI06 :: BCI Applications:

- NeuroEntertainment
  - Neurogaming | NeuroToys | Art | Virtual Reality
- Security
  - Brain based authentication
- Biofeedback Therapy:
  - Anxiety | Sleep Improvement | ADHD | PTSD
- Cognitive Training
  - Performance Optimization | Brain Ageing | Early Development | Mindfulness | Accelerated Learning | Enhanced creativity
- Rehabilitation
  - Stroke Recovery | Addiction | Rett Syndrome
- Diagnostics
  - Concussion | Alzheimer's | Epilepsy

**Exercise:** Designing Bi-directional Communication through Brain Computer Interface.

## DSNTBCI07 :: Introduction to Unicorn BCI Headsets

- What to look for in a headset.
  - Number and Placement of Electrodes | Sampling Rate | ADC Bits
- Using BCI Device
  - Unicorn BCI
    - Headset | Charging & Usage
    - Putting on a Headset
      - Positioning
      - Using Gel
      - Starting the software
      - Connecting a headset with software
      - Reading the EEG Data
    - Using Unicorn Suite
      - Unicorn Speller to spell a word using P300
      - Unicorn Blondy Check
      - Moving a Sphero robot using Unicorn Speller suite
      - Motor Imagery Exercise

**Exercise:** Use BCI Application to Spell Words, Move Robots and Perform Blondy Check.

## DSNTBCI08 :: BCI Signal Processing

- What is Preprocessing? | Why is preprocessing needed?
- Importing Data
  - FIF | EDF / EDF+ | Other standard formats | Other non-standard formats (CSV / .mat)
- Removing Bad Channels and Interpolation
  - What is a 'bad' channel? | How to spot a bad channel | How to remove a bad channel from the data | Interpolation | Filtering
- Downsampling | Background | Downsampling raw data in MNE | Notes on downsampling
- Re-referencing | How are references chosen?
- Artifact rejection and correction
  - Types of artifacts | Rejection based on visualization
- Preprocessing for High Density (Research EEG) vs Low Density (Consumer EEG)
  - Channel Removal | Using Event-Markers | Data Quality | Referencing and ERP Shape
- Introduction to EEG & Generation of EEG
- Origin, significance, and interpretation of EEG

**Exercise:** Use Unicorn BCI to Generate EEG Artifacts and Identify them on the Chart.

## DSNTBCI09 :: Extracting Neural Oscillations from EEG data

- What are Neural Oscillations?
- Why do we produce neural oscillations?
- So why do neural oscillations matter?
- How do we extract neural oscillations as a feature of our EEG data?
  - Importing, reading, and formatting data | Preprocessing | Epoching data

**Exercise:** Collect EEG Data of Your Team Member and Identify Alpha, Beta, Theta and Gamma Oscillations on the Chart. Read their Frequency and Amplitude.

## DSNTBCI10 :: Event Related Potential (ERP)

- Goals
- Feature Extraction
  - What is feature extraction | Which features to extract
- Event-Related Potential
  - What is an event-related potential | How to record an ERP with EEG | How to use ERP's | How to generate an ERP | The P3 family of ERP's | History of P3-based BCIs
- Types of ERP (P300 | SSVEP | Motor Imagery)

**Exercise:** Using Instructions as attached, through UDP connection, turn a LED ON and OFF using either of P300 or SSVEP.

## DSNTBCI11 :: Future of BCI

- New Emerging Technologies
  - Introduction | Reading | Writing | Read/Write
- Applications and Public Perception
  - Healthcare Applications | Wellness Applications | Outlooks

**Exercise:** Brainstorm and List 10 Future Ways BCI System can Make Life Easier for Human.