BME 445 Spring 2019 – (There is NO Pre-Lab/Homework Due on Wed. March 27th for Lab #5)

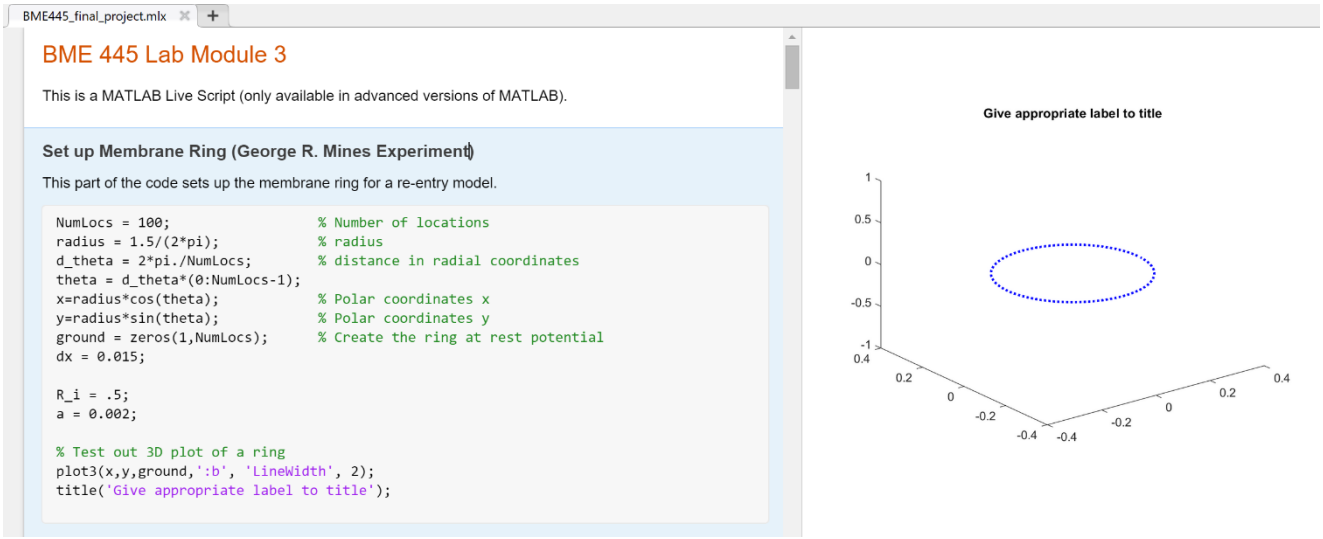
In the next three labs (Lab Module #3), you will learn how to develop and incorporate all the tools to assess a diseased state (i.e. re-entry over a ring) and develop a solution to address this condition. The work below is an elaborate re-creation of the scientific work by George R. Mines in the early 1900's!

Getting Started:

Before you begin: Download BME445_final_project.m (and BME445_final_project.mlx). You will also need the support files from Lab Module 1.

Lab #5 Goals:

First, we will examine if LiveScript Editor (the .mlx file) feature is available. This feature is available for Matlab 2016b and above.



You may use the virtual MATLAB access provided to you via IIT, or your own version. In the event that the live script is not available to you, you may still complete these activities using the .m files.

Some Background:

This lab commences with the reproduction of experiments performed by George R. Mines. A concise summary on Mines' experiment is available here (PLEASE READ THIS!!!):
https://physoc.onlinelibrary.wiley.com/doi/pdf/10.1113/JP270506

In the heart, question of a mechanism for abnormal impulse conduction was proposed by Mines around ~1913.

Mines documented the following experiment:

> *"Large dog-fish (Acanthias). Killed by decapitation. Spinal chord pithed. Heart excised and placed in a dish with blood…*
>
> *After half an hour the heart is beating well. Cut away sinus: the auricle and ventricle stop. Cut off auricle, slit it up to form a ring, spread it out on a glass plate, pour on serum and cover up with a vaseline watch-glass.*
>
> ***Pricking with a needle point provokes a strong contraction.** Wave runs around ring in each direction: **the waves meet on opposite sides of the rings and dies out**.*
>
> ***Repeated the stimulus at diminishing intervals and after several attempts started a wave in one direction and not in the other.***
>
> *The wave ran all the way round the ring and then continued to circulate going round twice a second. After this had continued for two minutes, extra stimuli were thrown in. After several attempts the wave stopped."*

Mines described this phenomena as "*circus movement*". This work laid the foundation of *re-entry*, a heart rhythm disorder. Labs #5-7 will introduce you to key tools to evaluate quantitative neural function using Cable Theory (Chapters 6,7 of P&B) and Field theory (Chapters 1,2 of P&B).

Lab 5 Tasks (Try working on these before the start of Lab #6 - Wednesday April 3rd):

This Lab 5 tasks are designed to be expository in nature; no specific instructions are given on how you may wish to approach this file. However, some basic guideline on how to effectively examine this project code is provided below (Tasks 1-3):

Task 1: Study this overall code.

Your team's first task is to study and understand how the overall code behaves.

Consider some input parameters: When prompted via input function, use '***Healthy Mode***' option and a total simulation duration of ***40 milliseconds***.

Task 2: Understand how the Cable Equations are set up for this system (this will be on Final Exam)

We define Matrix A, which is used to inter-relate the membrane potential experienced between adjacent nodes. While a detailed explanation pertaining to Matrix A setup outlining how the code below is implemented (Monday April 1 class), you may examine Matrix A:

Lab #5 Task 2. This part of the code sets up the Cable Equations.

```
% Matrix A will play a very important part of setting up
% the cable equations for this Final Project.

% Setting up Matrix A:
b1 = 1; b2 = 2;
A = [-b2, b1, zeros(1,NumLocs-3), b1; b1, -b2, b1, zeros(1,NumLocs-3)];

for k = 3:NumLocs-1
    B = 0*linspace(1,NumLocs,NumLocs);
    B(k-1) = b1; B(k) = -b2; B(k+1) = b1;
    A = [A; B];
end

A = [A; [b1, [zeros(1,NumLocs-3)], b1,-b2]];
% Matrix A is set.
```

For this Task 2, your team is tasked to obtain a general understanding of how this matrix is generated in the provided code.

In Lab #6, you will eventually be tasked to mechanistically explain the generation of Matrix A, which defines the inter-relation between each cable node in the circular disk.

Please attempt the following: Run the code and examine the matrix A. Please corroborate this with the Monday April 1st lecture notes (which will be posted as soon as possible).

Task 3: Re-create George R. Mines' Unilateral Block Experiment

The following code below makes a slight variation to the Matrix A, and thereby allowing the unidirectional block condition (i.e. disease model).

Lab 5 Task 3 - Modification for Unidirectional Block (Disease Model)

```
% unidirectional block (Disease)
if mode_flag == 2 || mode_flag == 3
    % In Lab #5, you are tasked to comment on the purpose of this modification.
    A(2,1) = 0;
    A(2,2) = -1;
end
```

Under this diseased condition, your task is to manipulate the timing and position of the second stimulus current in order to model a re-entry.

```
tdelay2 = input('Time of 2nd stimuli: ');
Nstim_pos2 = input('Location of 2nd stimuli: ');
```

Determine what combination of `tdelay2` and `Nstim_pos2` will enable you to generate a re-entrant circuit as described by Mines. Your goal is to identify the re-entrant condition (i.e. position and timing) for stimulus current #2, which will enable your team to next approach to develop a treatment for this disease (i.e. program a defibrillator)!

A significant hint is provided in Lecture #2 supplement (slide 3 animation). This .gif is also uploaded via SLACK.