ASSIGNMENT 2 — MODELLING ACTION POTENTIALS
All Aboard the Spike Train!!!

For all questions below, provide all programming code and plots in the report.

1. Program the Hodgkin-Huxley Model (12 marks):
   a. Perform Euler integration to solve the HH model (i.e., the Na and K channels, not Ca or $K_{(Ca)}$) using the parameter values in the lecture slides.
   b. Use the following Initial Conditions: $E_{soma0}, m0, h0, n0, t0 = -70 \cdot 10^{-03}, 0, 1, 0, 0.$
   c. Solve for 0.2s with a time-step of 0.00001s, with $I_{ext} = 1.0 \cdot 10^{-10}$.
   d. Plot the membrane potential and each of the channels (K, Na_m, Na_h) over time. 10 marks.
   e. Show on separate plots plot phase space for each possible pairing of states (e.g., E_{soma} vs. K, K vs. Na_m, etc.). 1 mark
   f. Solve the equations using odeint and plot the membrane potential. 1 mark

2. Program the Ekeberg Model (**Graduates Only**, 12 marks):
   a. Perform Euler integration to solve the Ekeberg model (i.e., the Na, K, Ca, CA_{AP}) using the parameter values in the lecture slides.
   b. Use the following Initial Conditions:
   $E_{soma0}, m0, h0, n0, q0, CaAP0, t0 = -70 \cdot 10^{-03}, 0, 1, 0, 0, 0, 0.$
   c. Solve for 0.2s with a time-step of 0.00001s, with $I_{ext} = 2.0 \cdot 10^{-9}$.
   d. Plot the membrane potential and K, Na_m, Na_h, Ca, CA_{AP} over time. 6 marks
   e. What is the minimum I_{ext} needed to elicit an action potential within 0.2s? why? 1 mark
   f. At what value does the external current get high enough where the action potentials are no longer repeatedly generated within 0.2s? why? 1 marks
   g. Find and report the time (in seconds) of each membrane potential peak. 1 mark
   h. Why does CA_{AP} become greater than 1, unlike the other differential equations (e.g., K, Na_m)? 1 mark
   i. Calculate and report each inter-spike interval (isi) in seconds (the time between each peak). 1 mark
   j. Calculate the nerve firing rate in Hz for each isi ($Hz = 1/s$). 1 mark