Homework 1
Graphing in MATLAB
Due: 9-7-05

The following homework requires you to use MATLAB to graph several functions. You are required to use all 3 methods we discussed in class (ezplot, vectors, function m-file), but you can choose which method you use for each problem.

To submit your homework, you may either print out all MATLAB code and results (graphs, explanations, etc.), or you can e-mail your results to vicki@mathpost.asu.edu. If you are e-mailing your results, please be sure to include your name and the problem number in your filename. All homework is due at the beginning of class on Wednesday, September 7.

Neuron Communication

1. In the FitzHugh-Nagumo model of how neurons communicate, the rate of change of the electric potential v (measured across the cell membrane) with respect to time is given as a function of v by $f(v) = v(a - v)(v - 1)$, where a is a positive constant.
    a. In this model, we can adjust the value of a to fit any data that we have. Use MATLAB to graph this function when $a = 0.25$ and $0 \le v \le 1$. Save a copy of your graph to turn in.
    b. If $a = 0.25$ and the potential across the membrane is measured to be 0.2 at some point in time, what will happen to the potential? What will happen to the potential if it is measured to be 0.3?
    c. When $a = 0.25$ and $0 \le v \le 1$, what is the maximum rate of change of electric potential v with respect to time?
    d. If our data shows that the maximum rate of change of electric potential with respect to time is actually smaller than the value you found in part b, how should we adjust our model? (*Hint:* We can adjust the value of a. You need to determine if a should be higher or lower than 0.25.) Provide justification for your answer.
    e. Explain the meaning of the parameter a in terms of the electrical potential across a nerve cell membrane.

Immune System Activity

2. The activity of an immune system invaded by a parasite can be described by $I(n) = \dfrac{an^2}{b + n^2}$ where n measures the number of larvae in the host, a is the maximum functional activity of the host's immune response, and b is a measure of the sensitivity of the immune system.
    a. Use MATLAB to graph this function when $a = 0.5$ and $b = 10$.
    b. Describe what effect the parameter a has on the graph. Also, describe what this means in terms of the immune system and the larvae in the host.
    c. Describe what effect the parameter b has on the graph. Also, describe what this means in terms of the immune system and the larvae in the host.

Homework 1
Graphing in MATLAB
Due: 9-7-05

Neuron Membrane Potential

3. A model of neuron firing involves the function $J(z) = \frac{1}{1+e^{-1.3(z-4)}} - \frac{1}{1+e^{5.3}}$, where z is the neuron membrane potential, and the net threshold for a neuron to fire is at $z = 4$. Use MATLAB to graph this function. At what values of z and J does J change from increasing at an increasing rate to increasing at a decreasing rate?

Cellular Chemistry

4. The release of a chemical neurotransmitter as a function of the amount C of intracellular calcium is given by $L(C) = \frac{aC^n}{k + C^n}$, where n measures the degree of cooperativity, k measures saturation, and a is the maximum of the process.
    a. Use MATLAB to graph this function when $n = 4$, $k = 3$, and $a = 100$.
    b. What effect does the parameter a have on the graph?
    c. When we change the degree of cooperativity, what effect does this have on the graph? What does this mean in terms of the neurotransmitter?

Electricity

5. In a series resistance-capacitance *DC* circuit, the charge differential Q on the capacitor as a function of time (where $t = 0$ is the moment the circuit is energized by closing a switch) is given by the equation $Q(t) = CV(1 - e^{-t/RC})$, where C is the capacitance of the capacitor, V is the voltage of the power source, and R is the resistance of the resistor.
    a. Use MATLAB to graph this function for C=20 microFarads (μF), V=12 volts (V), and R=5 Ohms (Ω). Using these units, time should be measured in micro-seconds (μs) and charge will be measured in coulombs (C). Note: you will need to find an appropriate time scale on which to plot this function.
    b. How long does it take for the capacitor to charge to 90% of its maximum?
    c. How does the graph change if you increase the resistance? Explain what this means in terms of the circuit.