ECE 445F '97 FINAL

Question #1

Describe the following *(in point form and/or diagrams)*:
- purpose and main functions of the cardiovascular system, the central nervous system, and the gastrointestinal system.
- terms *voltage clamp* and *space clamp*. How can they be achieved in an experimental setting for intracellular recording of the transmembrane voltage in a squid axon?
- main features of the electrical control activity (ECA) in the canine stomach and small intestine. How are muscular contractions organized by the *electrical* and *chemical* control systems? [25 Marks]

Question #2

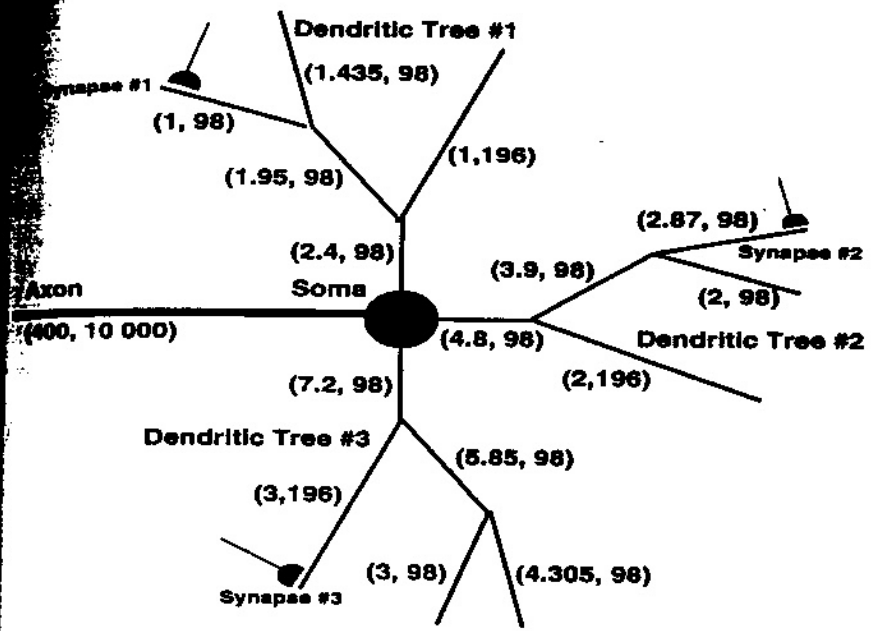
Consider a hippocampal neuron where an excitatory postsynaptic potential (EPSP) is generated at the terminus of the dendritic tree. The propagation of the EPSP along the dendrites causes the soma to fire an action potential which propagates along the axon. Derive mathematical expressions, *stating your assumptions*, to describe (a) the generation of the EPSP (taking *the effect of the sodium-potassium pump into consideration)*, and (b) the propagation of both the EPSP and the action potential. [25 Marks]

Question #3

Derive the **delta rule** for *error correction learning* in an artificial neural network represented by a *connected feed forward* network with one hidden neural unit, and two output neural nets. The hidden neural unit receives the set of inputs $\{x_i \mid i = 0, ..., p\}$, and all neural units have *sigmoidal* activation functions. [15 Marks]

Question #4

The branches of the shown neuron, are specified in terms of (diameter in μm, length in μm) and the axon is located along the x-axis with its terminus at the origin ($x = 0$).



The synaptic reversal potentials for the three synapses are $E_s = \{-10.5, -50, -90\}\ mV$, respectively. In each of the three synapses, presynaptic action potentials give rise to a constant synaptic conductance $g_s = 0.55\ mS/cm^2$, whereas the postsynaptic dendritic membrane has a resting membrane conductance $g_r = 0.56\ mS/cm^2$, and resting membrane potential $E_r = -72.46\ mV$. The dendritic intracellular resistance per unit length $r_{id} = 8\ M\Omega/cm$. The soma fires an action potential which propagates on the axon with a uniform velocity of 1 $mm/msec$, and it is described by $v_m(t) = 20\, e^{-\frac{t^2}{2}}$ where v_m is the transmembrane voltage in mV and t is time in $msec$. The intracellular and extracellular conductivities of the axon are 0.01 & 0.05 S/cm, respectively. Compute the following:

(a) The magnitude of the three postsynaptic potentials, and the type of the synapses.
(b) The diameter and electrotonic length of the equivalent cable of the three dendritic trees.
(c) The magnitude of the somatic potential.
(d) The strength and location of the axonal lumped monopole sources at $t = 5\ msec$.
(e) The extracellular potential at 5 mm above the middle of the axon. [35 Marks]