**Dr. Wang (35 points) Question 1 (15 pts**) [suggested time: 10 minutes]

a) What is a “psychometric function”? What does it represent? (3 points)

b) A subject is asked to perform the following tasks in psychophysics experiments. Sketch the psychometric function according to each task. Label x-axis and y-axis clearly. Explain how you would determine the detection threshold and frequency discrimination threshold from these psychometric functions, respectively.

Task-1: The subject places his/her finger on a mechanical vibrator and reports when he/she detects a vibration. The vibration stimuli are delivered at various magnitudes, from below detection threshold to above the threshold. (6 points)

Task-2: The subject places his/her finger on a mechanical vibrator and reports whether two consecutive sinusoidal vibrations have the same or different frequencies. (6 points)

**Question 2 (20 pts) [suggested time: 10 minutes]**

A sensory neuron is stimulated by a 50 Hz sinusidal stimulus (100 msec in duration, starting at time=100 msec). Below is a list of the time of occurrences (in msec) of spikes recorded from the neuron in response to 5 repetitions of the same stimulus. Recordings begin at time = 0 msec. and end at time = 200 msec.

Trial-1: [15 114 118 123 134 137 145 151 165 172 184]

Trial-2: [73 112 117 121 133 147 162 165 176 181 198]

Trial-3: [24 115 119 126 129 135 138 158 174 181 190]

Trial-4: [59 113 116 122 132 144 151 158 165 172 184]

Trial-5: [35 111 115 119 131 141 149 157 175 186 197]

a) Calculate mean firing rate (5 points)

b) Sketch and label the post-stimulus histogram (PSTH). Use binwidth of 10 msec, x-axis range [0, 200] msec. Is there “phase-locking” in the response of this neuron (please briefly explain your answer)?

**Dr. Young (35 points total)**

QUESTION 1:

Cells generally contain several types of voltage- or ligand-gated (i.e. neurotransmitter activated) ion channels. One way to classify them is according to the ions that pass through the channel. Give one or more functions for the following ion channels in excitable cells. Mention the typical reversal potential for this channel and tell how the reversal potential affects the function of the channel. (12 pts)

QUESTION 2: Inhibitory synapses usually contain a chloride channel. However, sometimes synaptic activation can lead to inhibition or excitation through the gating of potassium channels by a metabotropic mechanism. Give a possible sequence of steps for such a mechanism. (4 points)

QUESTION 3: Suppose a steady D.C. current I0 is injected into a very long membrane cylinder (like an unmyelinated axon), long enough that it can be approximated as infinite in length. The current is injected at point x=0. After the system comes to steady-state (meaning no time variation in the membrane potential), the membrane potential is given by $V(x) = r_l . \lambda . I_0 . e^{-\frac{x}{\lambda}}$, where ri is the resistance/length of the cytoplasm and λ is the length constant of the cylinder, as defined in class. (9pts)

(a) What is the input conductance of the cylinder in steady state, i.e. the conductance as seen by the electrode through which the current is injected? This value is called G∞ and is a useful parameter of the cylinder, whether it is infinite or not.

(b) How does G∞ vary with the radius a of the membrane cylinder?

(c) Suppose a (finite) cylinder with conductance G∞ branches into to two smaller cylinders. What should be the radii a branch (assumed equal for the two branches) of the smaller cylinders so that the sum of the G∞s of the branches is equal to the G∞ of the main cylinder? Surprisingly dendritic trees seem to branch in this way.

QUESTION 4: Consider synaptic democracy (SD), which means that synapses on neurons are adjusted to have roughly equal effect (e.g. EPSP size) in the soma. (10 pts)

(a) What is the problem? That is, why shouldn't synapses produce equal effects in the soma?

(b) Do NMDA receptors contribute to SD (yes/no)? If so how?

(c) Same question for chloride channels

(d) Same question for calcium channels.

**Dr. Kirkwood (15 points total)**

1) Input specificity and associativity are cardinal properties that make LTP an attractive learning mechanism. (6 points total) a) Explain what is input specificity and associativity. What is their potential benefit/function?

b) How do the properties of NMDA receptors account for input specificity and associativity?

2) Besides synaptic plasticity there is 'Metaplasticity. We discussed two of those mechanisms: the sliding threshold model (or BCM model) and synaptic scaling. Define them and point out their similarities. (9 points total)

**Dr. Hsaio (15 points total)**

1) Describe what is meant by the term specificity. Give two specific examples of specificity in the somatosensory system and describe how the afferent inputs achieve specificity. One example should be a large diameter fiber and the other should be a small diameter fiber. (9 points)

2) Why were areas 3a and 3b originally considered to be a single cortical area but are now considered to be different areas? In you answer include anatomical, and functions differences that suggest that these two areas are different. (6 points)