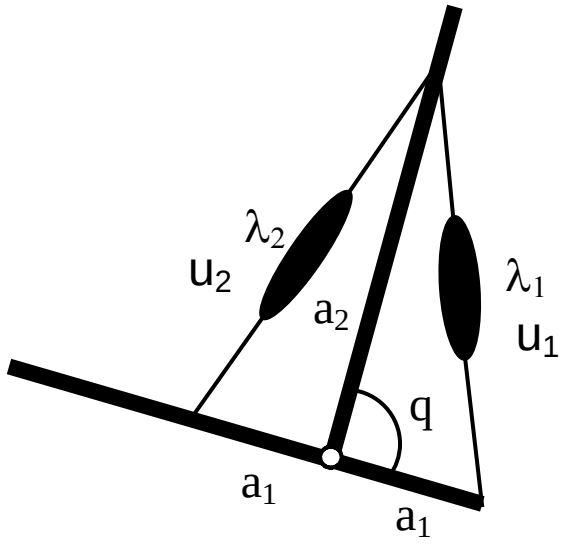
1. (4 points) A neuron in the posterior parietal cortex is sensitive to location of a visual stimulus on the retina, location of the eyes in the orbit, and location of the head on the shoulder.

a. (2 point) Suppose we keep the head and eye positions fixed and flash the visual stimulus along a line that goes through the center of the visual receptive field of the neuron. Plot the response of the neuron as a function of the distance of the visual stimulus to the center of the receptive field (you can assume the distance to go from -1 to 1).

b. (2 points) Now suppose that we move the fixation point to the left (so the eyes move to the left) and we repeat the experiment by moving a flashing stimulus along a line through the center of the visual receptive field. On the figure that you made for part (a), now plot a new trace that shows the response of the cell at this new eye position. (They are two possible answers, either one is acceptable)

2. (4 points) For the two muscle system below, length of each muscle is λ_i, joint angle is *q*, force produced by each muscle is ϕ_i, and torque produced by each muscle is τ_i. (note that $q \neq \frac{\pi}{2}$)



a. (2 points) Write λ_1 as a function of joint angle *q*

b. (2 points) If muscle 1 is producing force ϕ_1, what is the torque that this muscle is producing?

3. (1 point) Name two functions of glia cells.

4. (1 point) During voluntary contraction of a muscle, motor units that are recruited early are different from motor units that are recruited later. Give two examples of this difference.

5. (2 points) You are examining a split-brain patient as she is sitting facing you.

a. (1 point) You put up your right hand index finger and ask her to look at it. As she is

looking, you raise your left hand and briefly flash two fingers. You ask the patient, "How many fingers did you see?" What should the patient respond? Why?

b. (1 point) What if she was fixating a finger on your left hand and you flashed two fingers with your right hand?

6. (1 point) Suppose that you wish to reach for a pencil on a table but at the moment the image of your hand is not available on your retina. What kinds of information would your posterior parietal cortex need to estimate hand position in fixation centered coordinates?

7. (2 points) A stroke has affected the hand region on the **right motor cortex** of a patient. She now relies solely on the unaffected arm. You suggest that she enrolls in a constrained motion rehabilitation program. When she enrolls, which arm will be constrained (left or right)? Why?

8. (2 points) A volunteer sits on a chair with their elbow resting on a table while their hands are held palm up toward the ceiling. Their eyes are closed. They are instructed to try to match the elbow angle of their right arm with their left arm. You place a small vibrator on the biceps muscle of the right arm (this is an elbow flexor muscle, that is, when this muscle produces force, it will flex the elbow). What should happen in the left arm? Why?

9. (1 point) In the narcoleptic dog, what descending motor track is likely to be malfunctioning? Is this tract excitatory or inhibitory?

10. (3 points) A monkey is fixating a point at the center of the screen. His hand is holding a computer mouse. The cursor associated with the mouse is also at the center of the screen. A light flashes 5 cm to the right of fixation and then is extinguished. After a delay period, the monkey moves the cursor to the remembered location of the target. You are recording from cells in the visual cortex (V1), posterior parietal cortex (PPC), premotor cortex (PM), and the motor cortex (M1).

a. (2 points) Suppose that your cells in V1, PPC, and PM become activated when the light flashes. During the delay period, what change will take place in V1 and PPC cell's activity? Why?

b. (1 point) Suppose that during the delay period, your cell in PM is active at 30 spikes/sec. After the reaching movement is completed, the cursor is now at 5 cm to the right of fixation (the monkey continues to maintain fixation at the center target). After the reaching movement is completed, the PM cell's activity falls near zero. Another target flashes, this time 10 cm to right of the fixation. During the ensuing delay period, what will be the activity of the PM cell? Why?

11. (2 points) To produce a reaching movement, one may need to encode hand and target position with respect to fixation (x_h , x_t), compute a difference vector x_{dv} , compute how that change in hand position corresponds to changes in proprioception $\Delta\theta$, and then compute forces *f*.

a. (1 point) When one tries on a prism glass and makes a few reaching movements, what map(s) adapt?

b. (1 point) Suppose you are a good tennis player and are used to playing with racquets that are light. Your racquet strings break and you're forced to use a new racquet that happens to be the same shape but much heavier. What map(s) adapt?

12. (2 points) Sketch the receptive field (RF) of an auditory neuron and a somatosensory neuron (excited via mechanoreceptor on the finger tip). Explain how each type of RF is defined and measured.

13. (1 point) A 1.0 kHz tone is represented by the auditory system by more than one ways. What are two particular methods that the auditory system uses to represent the 1.0 kHz tone?

14. (4 points) What is the "orientation selectivity" of visual cortex neurons? Explain it with text and graph. How is it different from the selectivity of neurons in the visual thalamus (LGN)?

15. (3 points) Sketch the orientation column and ocular dominance column organizations in the primary visual cortex (V1). Which organization is topographical and which is computational? Why?

16. (1 point) If you are standing next to a loudspeaker that delivers a 100 Hz sinusoidal signal from a CD player, which of your senses can detect it? Why?

17. (1 point) Researchers often use neural activities (in response to a sensory stimulus) recorded from a particular cortical area as an indication that it is involved in the perception of the sensory stimulus. What do you expect an animal to experience if one electrically stimulates a particular spot in the auditory cortex where neurons' frequency selectivity is around 2.0 kHz?

18. (2 points) A mechanical probe is used to stimulate the receptive field of a mechanoreceptor located at the tip of a finger. Each stimulus has a rectangular waveform of duration 50 msec. Suppose spike (action potential) trains are recorded from a nerve connected to this receptor. Sketch the post-stimulus histogram (PSTH) of the spikes trains in response to multiple repetitions of the same stimulus. Consider two types of mechanoreceptors, "rapidly adapting (RA)" and "slowly adapting (SA)", respectively.

19. (2 points) An auditory neuron responds to a 200 Hz tone with "phase-locking", but responds to a 10 kHz tone without "phase-locking". Sketch inter-spike interval histograms for both cases.

20. (2 points) Auditory neurons in the brainstem nuclei MSO and LSO compute interaural time difference (ITD) and interaural intensity difference (IID), respectively. If a sound source is located at 22^o to the right of the mid-line, explain which nucleus (MSO or LSO) will be more likely to be excited when the frequency of the sound is 1.0 kHz or 10 kHz. Why?

21. (1 point) In order for an MSO neuron to extract interaural time difference, it is connected to both ears by "delay lines". Sketch a diagram showing the connections for two MSO neurons on the right side of the brainstem that detect sounds coming from 22.5^o and 45^o to the left of the midline, respectively.

22. (2 points) Sketch the ascending pathway from sensory receptors to primary sensory cortex for visual and auditory system, respectively. Indicate major processing stations along each pathway.

23. (2 points) Sketch the laminar structures of the sensory cortex and mark all layers. Indicate how the information flows from thalamus into the cortex and how it flows from one cortical column to another cortical column along the direction of cortical surface.

24. (2 points) In the rat, when the nerve that supplies motor commands to the muscles of the vibrissae are cut, neighboring motor regions in the rat's motor cortex appear to expand. For example, the neighboring forelimb region appears to grow. What is the neural basis for this expansion of the motor map?