

Neural Engineering

Final exam

Name: _____

REMINDERS

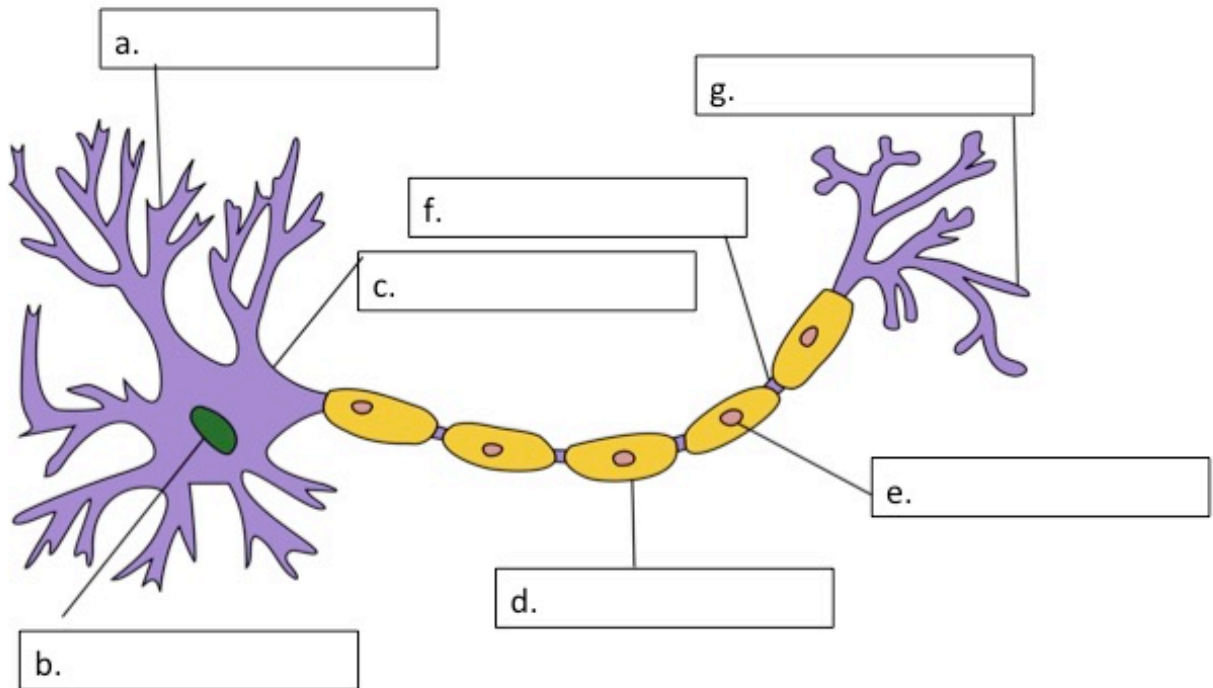
- Short answers should be limited to the space marked. Use the amount of space given for a question as a guide for how much detail to give.
- If a question is confusing, ask.
- Read the questions carefully and make sure you are actually answering what it asks for.
- Partial credit will be awarded for partial or partially correct answers. It's better to make an educated guess than leave it blank.
- A correct answer is a legible answer!

Score: _____/65

Section 1: Basic neuroscience

1. Below is a drawing of a neuron. Fill in the blanks naming each portion of the neuron. **(1 point per label, 7 points total)**

Note: Box D is referring to the entire long, skinny segment of the cell. Box E is referring to the blob surrounding the structure in D, not just the circle in the center. Box F is referring to the gaps between the blobs.



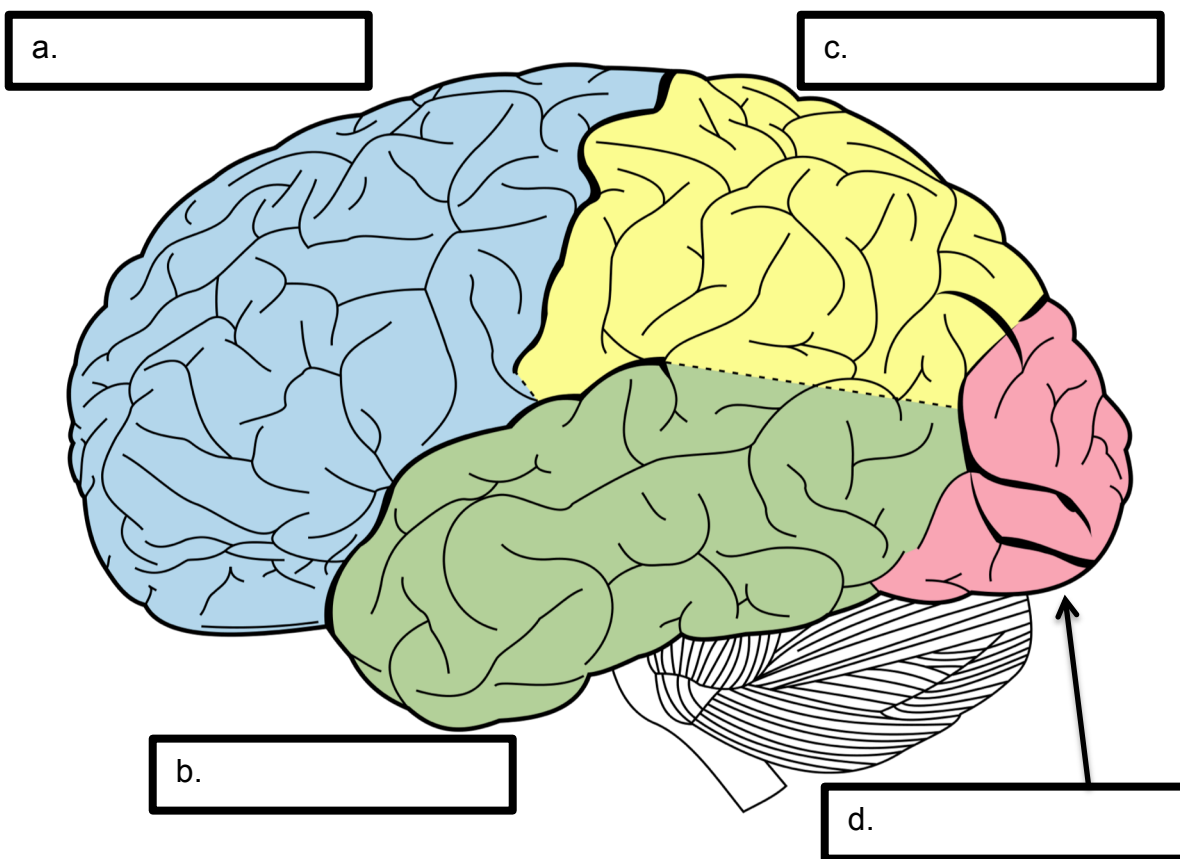
2. Which letter is at the location where a *chemical* signal is converted to an *electrical* signal? (Hint: not where the *electrical* signal is converted to *chemical* signal.) Circle answer. **(1 point)**

a b c d e f g

3. When the brain changes (due to learning, stimulation, or other processes), neuroplasticity occurs. Which of the following features of a neuron or synapse changes as a result of this process? Choose all that apply. **(1 point)**

- a. Change in number of neurotransmitter receptors
- b. Change in amount of neurotransmitter released
- c. Growth of a new neuron
- d. Growth of a new synapse between existing neurons
- e. All of the above
- f. None of the above

4. Label the four major lobes of the brain on the diagram below. **(1 point each, 4 points total)**



5. **(1 point each, 2 points total)**

Motor control functions are located in which lobe? _____

Somatosensory processing is located in which lobe? _____

6. What is the name of the lobe, not visible on this view, that processes pain and emotion? **(1 point)** _____

7. You are working in a clinic. A patient in their 70s comes in who has difficulty starting movements and has a noticeable tremor in their hands, but no cognitive symptoms.

a. What disease does this patient likely have? **(1 points)**

b. What area of the brain is damaged in this disease? What group of areas is this area part of? **(2 points)**

c. What is ONE treatment you could prescribe this patient? Broadly, what does this treatment do? Pharmacologic and engineering solutions are both options. **(3 points)**

8. There are three different types of muscle. Name them. How are they different (in location or function)? **(1 point)**

Section 2: Principles of engineering

1. Give any ONE reason why arm/hand control is a more difficult engineering problem than leg/foot control. **(2 points)**

2. Name two areas of engineering that are involved in neural engineering. What is one contribution of each? For example, materials engineering contributes battery designs. (You can reuse materials engineering with a different specific contribution if you wish.) **(2 points each area, 4 points total)**

Area A: _____

Contribution: _____

Area B: _____

Contribution: _____

Section 3: Sensory systems

1. How do cochlear implants transduce sound to a signal that human users can understand? **(1 point)**

- a. Mechanically bend the inner hair cells
- b. Electrically stimulate the spiral ganglion neurons
- c. Vibrate the tympanic membrane
- d. Amplify the sound wave as it travels through the ear canal

2. The density of sensory receptors is different in different parts of the body, and is especially high in the fingertips. Why does this matter for prosthetic design? How would you use this knowledge in your design? **(4 points)**

3. Most neural engineering devices include, or should include, a method of providing stimulation and feedback to the nervous system. Describe the following elements of feedback:

Sensory system affected (circle):

vision

hearing

vestibular

touch/proprioception

Specific sensory organ/receptor targeted **(2 points)**: _____

Goal of stimulation – what perception does the device TRY to provide? Be

specific. **(3 points)**: _____

What is a drawback or limitation of this system? What can it not do (or not do

yet)? **(3 points)**: _____

Name any one ethical consideration related to the use of this system **(4 points)**:

Section 4: Motor systems and BCIs

1. You are working with a tetraplegic patient who will receive a BCI of one of three designs. List any two biological and/or engineering challenges, and briefly how you would solve them. Example for a hand orthotic:

Challenge: detect and exert the desired level of pressure

Solution: detects muscle contraction level in the bicep, calculates fraction of maximum output, provides grip assistance

Design choice: exoskeleton muscle stimulation robotic arm

Challenge 1 (**2 points**): _____

Solution 1 (**2 points**): _____

Challenge 2 (**2 points**): _____

Solution 2 (**2 points**): _____

2. Name any one ethical issue related to the use of this system. (**3 points**)

3. List, in any order, four necessary and SPECIFIC components of any bidirectional brain-computer interface device. Example: protein-resistant electrodes implanted in brain.

Component 1 (**2 points**): _____

Component 2 (**2 points**): _____

Component 3 (**2 points**): _____

Component 4 (**2 points**): _____

EXTRA CREDIT:

What is one thing you wish we had either 1) covered more of, 2) covered earlier, or 3) did not talk about and you wish we had? (**Up to 2 points**)

What is your favorite fact or idea you learned in this class? (**Up to 3 points**)
