

**BME 599a – Applied Electrophysiology Midterm
(Thursday 10/12/00 09:30)**

Time : 45 minutes

Name : MARKING PRECEDENT

Points : 70

USC ID : _____

Note : When asked for short written answers please pay attention to the number of points allocated. In these questions this is indicative of the number of statements that should be supplied.

1. State two reasons why the cortical neurons in a cerebral sulcus would contribute less to scalp-recorded monopolar EEG signals than those located on the convex surface of a cerebral gyrus.

1) neurons in sulcus are further away – electrical field density decreases with distance in sulci (2)

2) orientation of sulcul neurons is parallel to EEG electrode montage plates – therefore source & sink are equidistant from plates, vs. gyrul neurons where axial current flow is perpendicular to plates & therefore detected (2)

2. Which of the following amplifier specifications would be best suited to recording signals from a nerve cuff electrode (circle the correct answer/s) ?

a) very high input impedance

b) DC to 100 kHz bandwidth

c) 1 to 10 kHz bandwidth

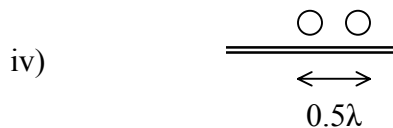
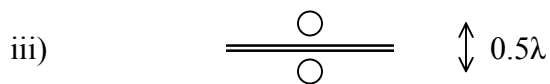
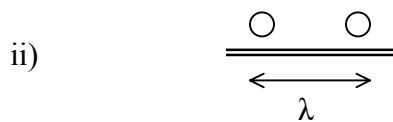
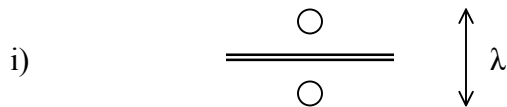
d) single-ended input vs. ground

e) lowest noise voltage at the expense of higher noise current (5)

3. The wavelength of an action potential on a nerve fiber is λ .

a) The largest signal amplitude will be recorded by a bipolar pair of electrodes with which of the following 4 configurations ? : ii (2)

b) The lowest current amplitude necessary for stimulation threshold will be obtained by a bipolar pair of electrodes with which of the following 4 configurations ? : ii (2)



4. Functional Electrical Stimulation (FES) has 4 main integrated aspects : power supply, control (command and coordination), muscle stimulation, and feedback. For each, list one currently available technology, together with one major advantage and one major disadvantage.

a) **power supply** :

modality : *car battery*

advantage : *large amounts of power ; easily available on wheelchairs*

disadvantage : *cannot implant ; not suited to mobile patients* (3)

b) **command signals** :

modality : *joystick control*

advantage : *non-implantable (no surgery) ; simple to control*

disadvantage : *limited controllable parameters ; repeated & accurate reapplications* (3)

c) **muscle stimulation** :modality : **cutaneous electrodes (/ nerve cuff electrodes)**advantage : **no surgery (/ low power requirements ; accurate)**disadvantage : **repeated & accurate reapplications required (/ requires implantation)** (3)d) **sensory feedback** :modality : **nerve cuff electrode (/ RF transmitter-detector pair)**advantage : **accurate & specific to a particular nerve (/ can be calibrated post-op. & reset as nec. (implantation must be precise, but not necessarily accurate)**disadvantage : **specific to a particular nerve ; requires surgery (/ requires surgery)** (3)

5. Considering Magnetic Stimulation, please select the correct sections in each statement :

a) a field gradient in the order of $2 / \textcircled{10} / 200 \text{ V.m}^{-1}$ is required to stimulate axons ;b) a coil current in the order of $30 / 300 / \textcircled{3000} \text{ A}$ would be required to produce such a field gradient ;c) can be effectively used diagnostically by assessing motor responses to central stimulation / therapeutically to defibrillate supraventricular tachycardia / therapeutically to control a paralyzed limb .

(3)

6. Choose whether True or False. Super-Conducting Quantum Interference Devices (SQUIDS) :

a) are used to detect magnetic field changes for recording Magneto-Encephalograms (MEG's)

 T / F

b) may be used for Transcranial Magnetic Stimulation

 T / F

c) can be used to detect epileptogenic foci interictally

 T / F

(3)

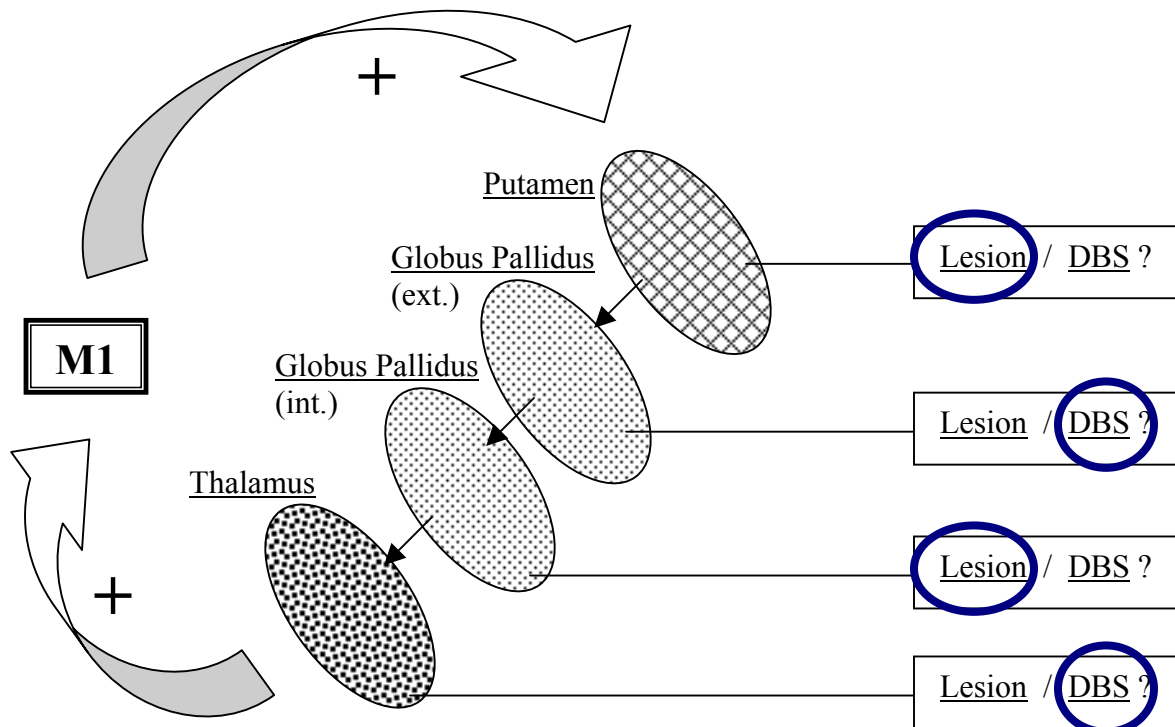
7. Give 2 physiological processes that can be monitored as a change of Impedance. Indicate how each could be used clinically / practically, and what signal change you would expect.

a) physiological process : **respiration / breathing (/ perfusion)**use : **monitoring respiratory rate, (eg) for sleep apnoea (/ flap viability)**signal change : **increased impedance on inspiration (/ decrease impedance with increase in perfusion)** (3)

- b) physiological process : *perspiration (/ muscle viability)*
 use : *polygraph testing ('lie detector') (/ assessing burn necrosis)*
 signal change : *decrease in impedance with perspiration (/ decrease in impedance with electrical injury)* (3)

8. Stereotactic Surgery allows us to gain access to a variety of areas in the thalamus and basal ganglia of the extrapyramidal motor system which may be either "paced" (stimulated) or "lesioned" (destroyed) :

- a) Consider each area shown diagrammatically below and choose whether lesioning or deep brain stimulation (DBS) would be the correct modality for reducing the dyskinesia of Parkinson's disease if that area alone were to be operated (ignore the effects of the subthalamic nuclei and substantia nigra) :



(4)

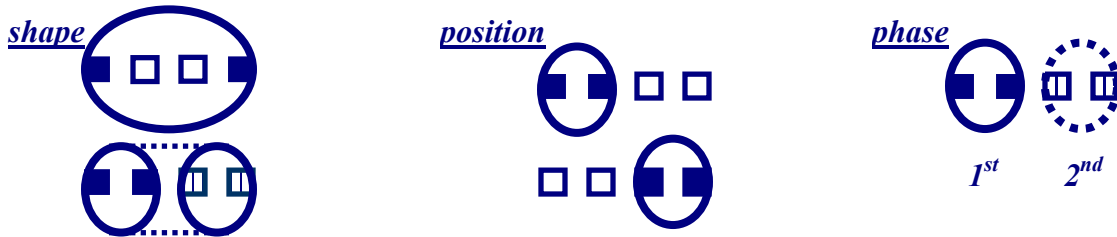
b) What is the concept behind the multicontact "cigar-band" electrode that can be utilized in such cases ?

1) *4-channel electrode (has 4 contacts, which can be selected in various combinations post-implantation)*



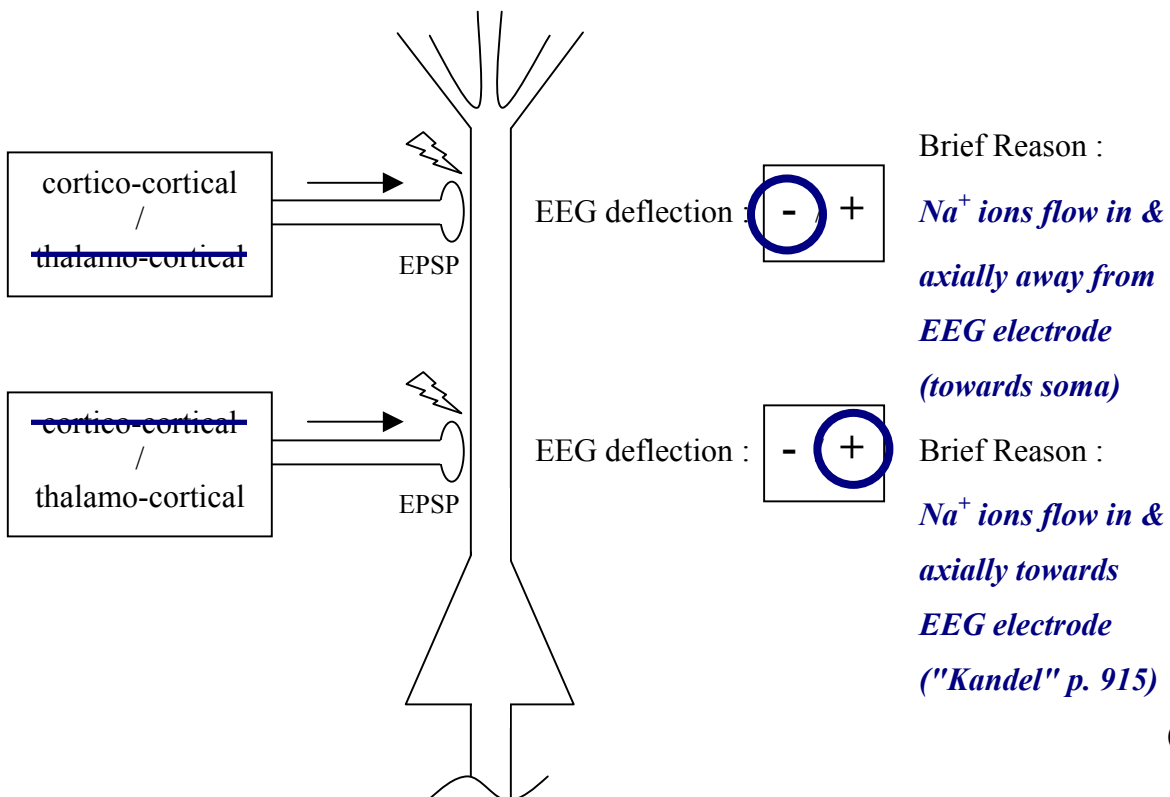
2) *can be used for monopolar stimulation & can select which works best to obtain a specific desired stimulus response without repositioning*

3) *can be used for bipolar stimulation, allowing for adjustment by choice of pairs according to desired field shape, position, & phase*



(3)

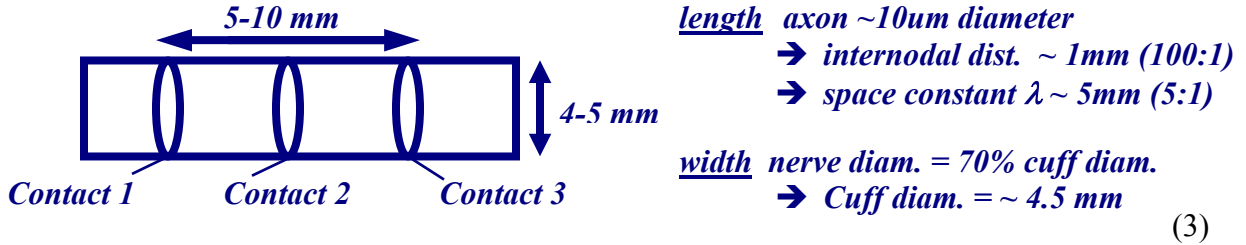
9. Pyramidal neurons in the cortex generally receive connections at 2 levels. By deleting the incorrect terms in each box and providing brief reasons where requested to, demonstrate how this would influence EEG recordings (assuming Excitatory Post-Synaptic Potentials at different levels) :



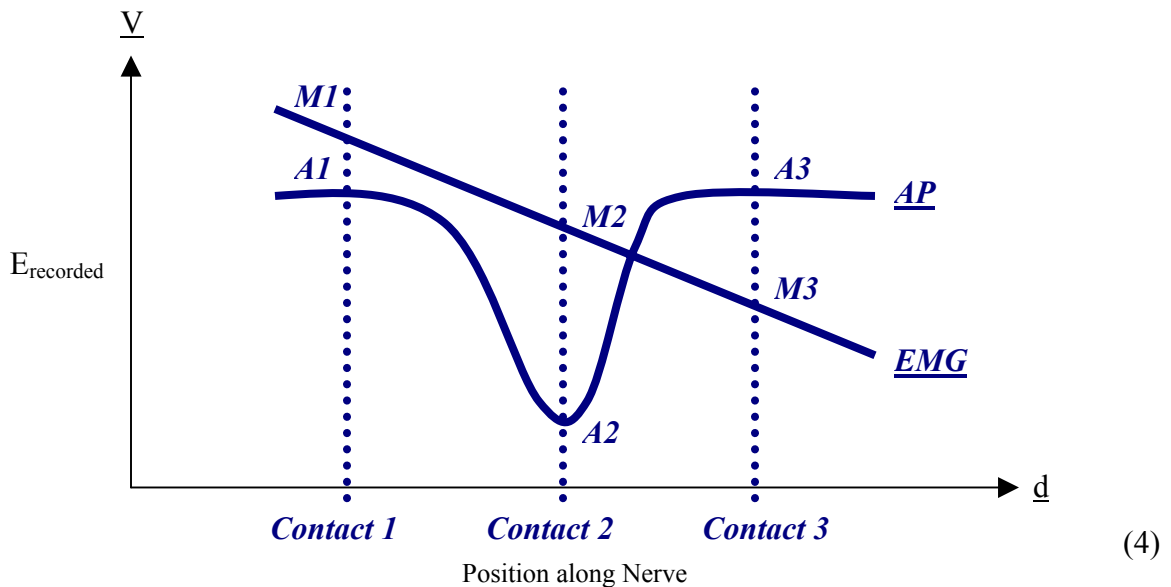
(6)

10. Considering nerve cuff electrodes :

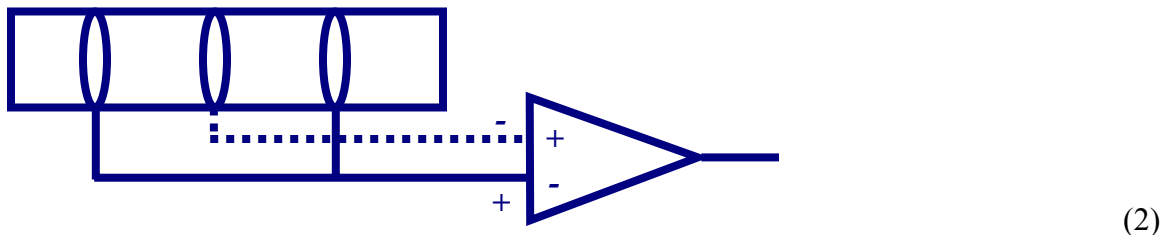
- a) Draw an engineering diagram of a nerve cuff suitable for optimal recording of nerve activity from large myelinated axons in a 3mm diameter nerve, with rejection of EMG interference. Show approximate values for all important dimensions.



- b) Show graphically the signals that would be generated on each electrode contact when an action potential in the nerve produces a maximum signal whilst nearby muscle fibers generate interference :



- c) For a) & b) above, show graphically how you would connect the amplifier and explain why it would record selectively as designed.



EMG noise from outside cuff - therefore linear : Eqtn (A) : $(M1 + M3) / 2 - M2 = 0$

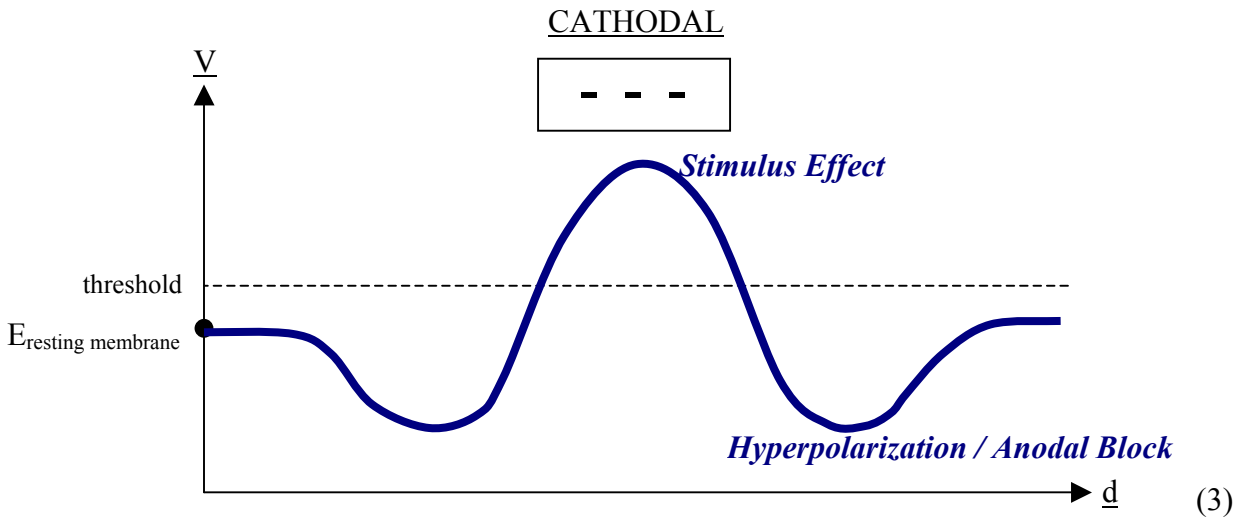
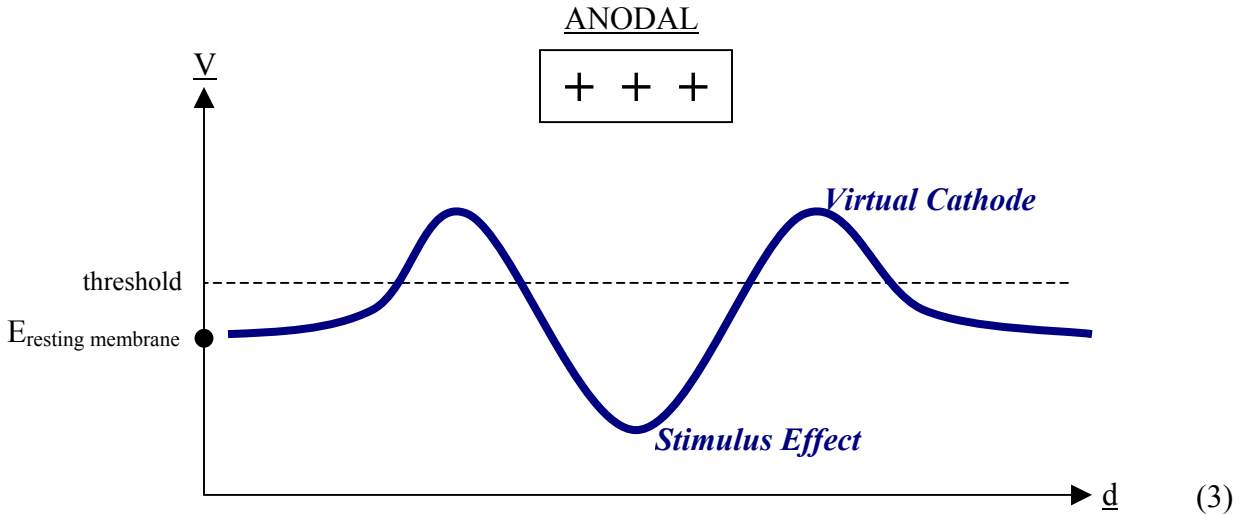
AP signal inside cuff : Eqtn (B) : $(A1 + A3) / 2 - A2 = |AP|$

Sum of (A) & (B) : $(Contact\ 1 + Contact\ 3) / 2 - Contact\ 2 = |AP|$

(2)

11. Compare Anodal Stimulation and Cathodal Stimulation :

- a) by graphing membrane voltage (V) against distance along the axon (d), and labeling the salient changes in each.



- b) which would produce a lower threshold for eliciting an action potential and why ?

- 1) *Cathodal Stimulation (although more risk of latency through hyperpolarizations)*
- 2) *Direct cathodal stimulation reaches threshold more easily than ...*
- 3) *Anodal stimulation - which relies on Virtual Cathodes (of $\sim 1/2$ the absolute magnitude of the anodal stimulus) to initiate the AP* (3)

[NOTE : if asked which for faster / more effective propagation – answer would be Anodal (because no areas of hyperpolarization which AP's must cross as with Cathodal)]

[TOTAL : 70]