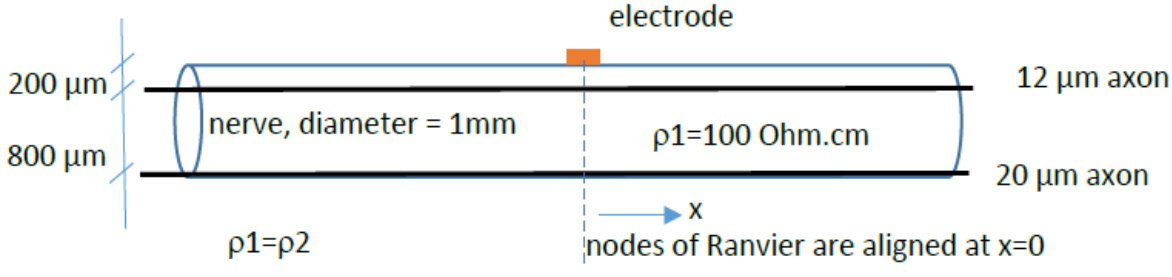
1- [25 points] In an unmyelinated axon, the voltage declines passively by distance following an exponential function when an action potential is generated at a point along the axon. Assuming the action potential peak-to-peak voltage is 100mV at the point of generation, and that 30mV membrane depolarization is required to initiate an action potential, calculate the longest distance (x), in multiples of the electrotonic distance, at which the original action potential can depolarize the membrane sufficiently to cause an action potential. (Hint: use steady-state cable equation).

2- A peripheral nerve is stimulated with a monopolar electrode implanted inside the subject's arm (see figure below). The nerve and the electrode are both deep enough inside the arm such that you can assume a single homogenous infinite medium, with a specific resistivity (ρ1) of 100 Ohm.cm. The diameter of the nerve is 1.0mm. The electrode is placed on the epineurium (on top of the nerve) and the closest axons inside the nerve near its surface are 200 µm away from the electrode. Consider a myelinated axon of 12 µm diameter near the surface and another with 20 µm diameter but positioned in a fascicle near the distant surface of the nerve. Assume that the nodes of Ranvier in each axon that are at the center are lined up at the same position under the electrode along the nerve. Assume that the specific resistances and capacitances for both axons are the same.

a. [25 points] Which axon has a lower stimulation threshold and how many times is the difference in stimulation thresholds? Hint: Write the activating function (the full formulation and not just the second derivative of extracellular voltage) for each axon and compare the magnitudes at the central nodes.

b. [25 points] Calculate how much the central node of Ranvier on the 12µm fiber needs to be shifted in positive x direction (or misaligned) from the contact such that both fibers have the same stimulation threshold?



3. [25 points] In order to increase the difference between the stimulation thresholds for the small and the large fibers, should we use a monophasic or biphasic stimulation waveform? Also, in order to further increase the difference between the stimulation thresholds, should we use short or long pulse widths, with biphasic stimulation waveforms? Explain each answer with references to the Figs. 3 and 2 in the attached paper (Gorman, 1983).