Georgia Institute of Technology

The George W. Woodruff School of Mechanical Engineering
Nuclear & Radiological Engineering/Medical Physics Program

Ph.D. Qualifier Exam

Spring Semester 2009

_____ Your ID Code

Radiation Therapy (Day 3)

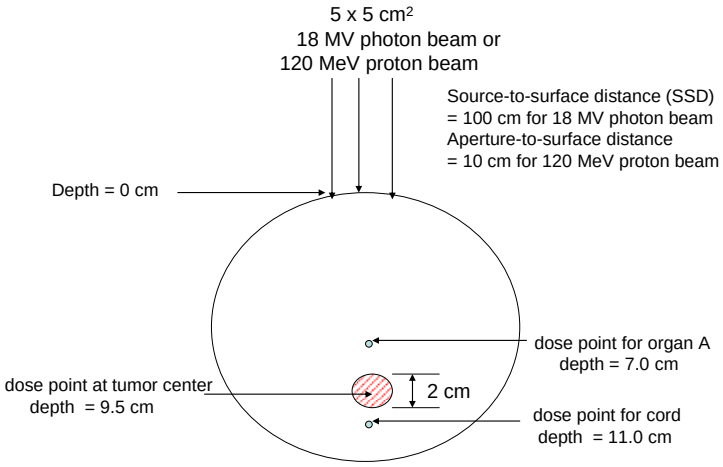
Instructions

1. Use a separate page for each answer sheet (no front to back answers).
2. The question number should be shown on each answer sheet.
3. ANSWER 4 OF 6 QUESTIONS ONLY.
4. Staple your question sheet to your answer sheets and turn in.

NRE/MP Radiation Therapy

Answer 4 of the following question.

1. Consider a hypothetical clinical case depicted in the following diagram:



Suppose you have options to treat this case either with an 18 MV photon beam or with a 120 MeV proton beam. The treatment goal is to deliver 2 Gy to the target, while minimizing the cord dose. Note that you are not allowed to change the beam setup as depicted in the diagram above for the problem. Provide your answers for the following questions:

a. What would be the dose to the organ A from each treatment scenario?

b. What would be the dose to the cord from each treatment scenario?

c. Which treatment would provide more uniform dose to the target, 18 MV photon beam or 120 MeV proton beam? Provide the reasoning for your answer. Provide your calculations as well if necessary.

Given:

For 18 MV photon beam, percentage depth doses (PDD) and tissue maximum ratios (TMR) for the 5 x 5 cm^2 are given as:

PDD @ 5 cm = 97.5, PDD @ 10 cm = 79.9, PDD @ 15 cm = 64.5
TMR@ 5 cm = 1.001, TMR@ 10 cm = 0.897, TMR@ 15 cm = 0.786
You may perform a linear interpolation of the above data if necessary.

For 120 MeV proton beam, the ratio of dose at the Bragg peak to dose at the entrance is 1.6 and the depth dose curve is approximately flat until the proximal tail of the Bragg peak. The proximal tail starts around 8.5 cm depth. The location of the Bragg peak is around 9.5 cm depth. The full width at half maximum (FWHM) value of the peak is about 0.5 cm. The range of the 120 MeV proton beam is about 10 cm.

2. Describe the TG-43 formalism for brachytherapy dose calculations. Provide a description of each parameter and function in this formalism. If you are unfamiliar with the TG-43 formalism, you may propose your own brachytherapy dose calculation formalism to handle both point and seed sources. Be sure to make only reasonable assumptions and simplifications for your own formalism.
3. A 6MV photon beam is used to treat a lung patient. Using the principles of KERMA, mass attenuation coefficients and stopping power ratios explain how the dose is deposited in the heterogeneous tissue.
4. A TAR (80 cm SAD) or a PDD (80 cm SSD) can be used to calculate the correct timer setting for a Co-60 treatment unit with an 80 SSD. Explain what a TAR and a PDD are and the method for obtaining each. What is the relationship between the two? What advantages or disadvantages do they have? Can both be used for a 6MV photon beam? What is the equation that would be used to calculate the Co-60 timer setting for an 80 SSD, depth of 10 setup? What is the equation that would be used to calculate the Co-60 timer setting for an 80 SAD, depth of 10 setup? If the SSD is 90 cm, what corrections are needed to deliver the correct dose for each of the methods?
5. In the AAPM Task Group 51 the dose to water at 10 cm depth due to a photon beam is given by the following equation:

$$D_w^Q = Mk_Q N_{D,w}^{^{60}Co}$$

where $M = P_{ion} P_{TP} P_{elec} P_{Pol} M_{raw}$

Describe the measurement setup for the determination of absolute dose. Explain in detail the purpose of each of the factors in the equation and the method and/or equation to determine its value. If the value is supplied by another, how is its value determined? How and why does the setup differ for the measurements to determine k_Q? When and why is a lead sheet used?

6. Describe how megavoltage x-rays and electrons are produced in a modern klystron linear accelerator. Describe all the major components of the linac and how the operate. How are both electrons and photons produced from the same machine? How are two different photon energies produced?