October 2006

Time Allowed: 3 hours

INSTRUCTIONS

- There are a total of SIX questions.
- Each of these six questions is worth 10 marks.
- Write your answers in the book provided.
- You may request additional answer books from the invigilator.
- All questions are to be attempted.
- Answers should be given from a radiotherapeutic physics viewpoint.
- Hand all papers to invigilator, no papers are allowed to be taken from the exam room. THIS INCLUDES EXAM PAPERS

1. Consider a 12MeV electron beam incident on a water phantom at 100cm FSD. The field size on the phantom surface is 10cm x 10cm, with the final defining aperture of the applicator 5cm above the water surface.
   (a) Draw a labelled diagram showing representative isodose curves for this beam (2marks)
   (b) Discuss how the dose distribution for this beam would be affected by:
      i. decreasing the field size
      ii. increasing the phantom surface obliquity

      Your explanation should include labelled diagrams. (4 marks)
   (c) Discuss the effect that the following would have on the isodose curves for this beam
      i. underlying bone
      ii. an air cavity (4 marks)

2.
   (a) Briefly discuss the concepts of the physical, biological and effective half lives of a radionuclide. State the relationship between these concepts. (2 marks)
   (b) List the desirable features of a radionuclide for therapeutic use as an unsealed source.(3 marks)
   (c) Name two (2) therapeutic radionuclides that are used as unsealed sources. For each give a clinical indication. (2 marks)
   (d) Briefly discuss how the dose to target tissues and critical organs can be estimated for radionuclide therapies. (3 marks)

3.
   (a) Give an explanation for the Bragg Peak of a proton beam. (2 marks)
   (b) Briefly explain how a proton beam can be modulated for clinical use. (3 marks)
   (c) Stereotactic radiation therapy for small intracranial lesions can involve a single fraction (stereotactic radiosurgery) or multiple fractions (stereotactic radiotherapy), using a combination of a linear accelerator, stereotactic apparatus and multiple narrow beams. The stereotactic process includes the following four (4) steps:

      • head immobilization
      • imaging
      • target localization
      • treatment setup and delivery

      i. Describe one type of stereotactic frame. (1 mark)
      ii. Describe the use of the stereotactic frame in each of the four (4) steps listed above. (3 marks)
      iii. What is the achievable degree of accuracy (millimetres) in target localisation (1 mark)

4.
   (a) Cs tube with an activity of 45MBq and an air kerma strength of 5.00μGym^2h^{-1} was mistakenly left in the drawer of a wooden desk for 24 hours before being discovered. A female radiation oncologist occupied the desk for 8 hours at an average distance of one (1) metre from the source. Explain how the average radiation dose to the oncologist can be calculated. Compare this to the recommended dose limit.(4 marks)
   (b) Describe the ALARA principle and its application to medical practices. (2 marks)
   (c) What are the basic principles to minimise exposure when using sealed radioisotopes? Give examples of the application of these principles in clinical practice and their relative importance. (4 marks)

5. The photons used in clinical radiotherapy can interact with matter in one of four important processes – Photoelectric Effect, Compton Scattering, Pair Production and Photonuclear Reaction.
   (a) Select three (3) of these processes and for each in turn:
      i. Describe the interaction using labelled diagrams. (4 marks)
      ii. Comment on factors that influence these interactions. (4 marks)

(b) Give an example from clinical radiotherapy practice which illustrates one of these interactions. (2 marks)

6. Write brief notes and where appropriate include the units for the following:
   (a) exposure
   (b) dose
   (c) equivalent dose
   (d) activity
   (e) wedge factors
   (f) linear stopping power
   (g) inverse square law
   (h) dose build-up
   (i) anisotropy factor
   (j) field size a. (1 mark each)