The Royal Australian and New Zealand College of Radiologists

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FRANZCR Examination Part I

Radiation Oncology

Radiotherapeutic Physics

September 2008

Time Allowed: 3 Hours

INSTRUCTIONS

- There are a total of SIX questions.
- Write your answers in the book provided.
- All questions are of equal value. Sections within questions are not necessarily of equal value.
- All questions are to be attempted.
- You may use diagrams, tables or lists in your answers.
- Grid paper has been provided for optional use.
- 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.

Question 1

a) Define ACTIVITY, APPARENT ACTIVITY and SPECIFIC ACTIVITY as used in radiation therapy. Provide the unit of measurement for each of these terms. (2 marks)

b) For each of the following radionuclides Caesium-137, Cobalt-60, Iridium-192, Strontium-90 and Iodine-125: (5 marks)

i) identify the type of emissions produced, give a brief description of their energy spectrum, and state the half-life of each radionuclide.

ii) give one clinical use for each of these radionuclides.

iii) describe the source construction for each radionuclide which makes it suitable for the clinical use given in part (ii).

c) Describe two types of radioactive equilibrium that occur. Provide one example of each type and its practical application. (3 marks)

Question 2

a) Modern linear accelerators are operated by electronic systems that can deliver radiotherapy treatments without human intervention apart from the command to start. In a system where electronic transfer of radiotherapy data is routine, describe two potential problems that can lead to errors in radiation treatment delivery. (3 marks)

b) In 2004 the Japanese Society for Therapeutic Radiology and Oncology found that "7 out of 8 accidents were related to updated radiotherapy treatment planning (RTP) systems".
Using your knowledge of RTP systems, describe two scenarios where the inappropriate implementation of an updated system may lead to radiation incidents. (3 marks)

c) While the important radiation incidents are usually thought to be overdoses, underdosing also constitutes an incident. Explain why underdosing can be considered a radiation incident. (1 mark)

d) What steps should be taken before releasing an upgraded version of the radiotherapy treatment planning (RTP) system for clinical use? (3 marks)

(paper continued on next page)

Question 3

Define and write brief notes on the following terms, including the units of measurement where appropriate: (1 mark each)

a) Exposure

b) Absorbed dose

c) Equivalent dose

d) Tissue compensation

e) Wedge factors

f) Stopping power ratio

g) Inverse square law

h) Photon dose build-up

i) Anisotropy factor

j) Field size

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Question 4

a) Consider a 6MV photon beam incident on a water phantom at 100cm FSD. The field size on the phantom surface is 10cm x 10cm. Draw labelled diagrams showing representative isodose curves for this beam where: (3 marks)

   i) the field edges are symmetric about the central axis.

   ii) an independent jaw has been used to block the beam to the central axis in one dimension.

b) Explain the differences between the dose distributions observed in part (a). (2 marks)

c) Consider a 6MV photon beam incident on a water phantom at 100cm FSD. The field size on the phantom surface is a 10cm diameter circle. Draw labelled diagrams showing Beam's Eye View representation of the beam aperture defined using: (2 marks)

   i) a cerrobend block.

   ii) multi-leaf collimators.

d) Describe and explain the differences between the dose distributions generated by the beams in part (c). (2 marks)

e) What differences, if any, will be observed in the monitor unit calculation equations used for the beams in part (c)? (1 mark)

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Question 5

a) Consider an electron beam traversing a material. Define IONISATION and EXCITATION within that material. (1 mark)

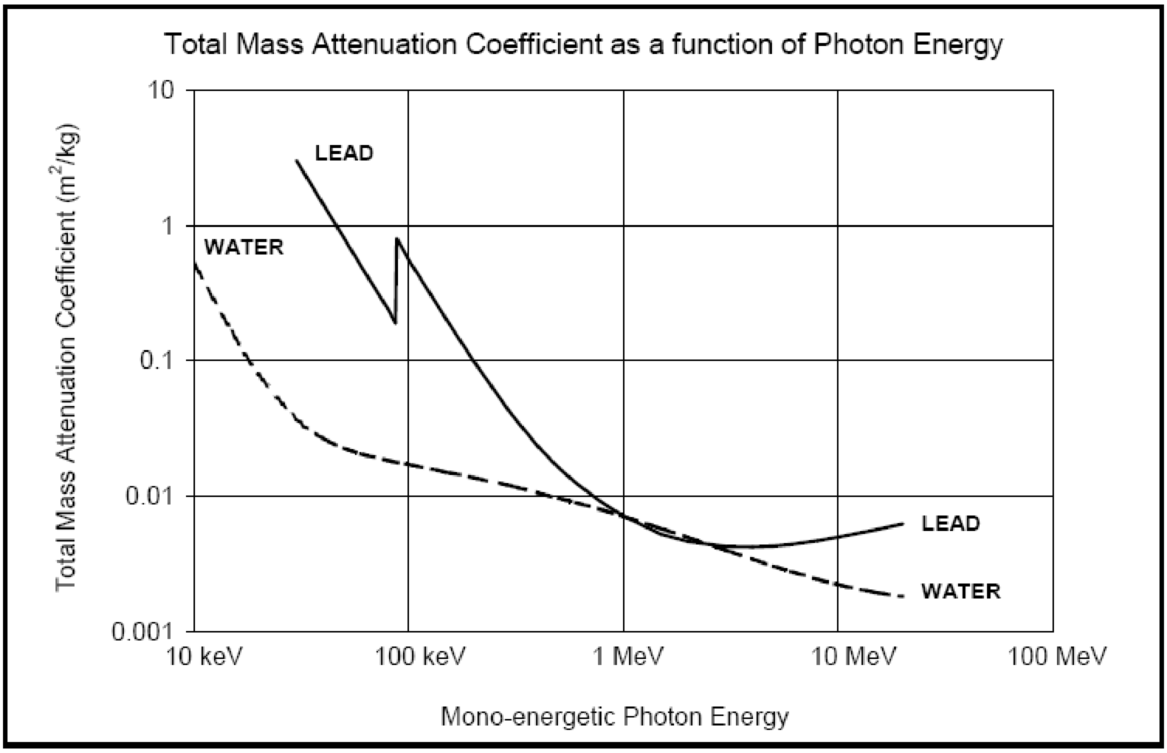
b) Consider an electron beam traversing a material. Explain BREMSSTRAHLUNG production within that material. (1 mark)

c) Provide two examples of how multiple scattering affects the shape of the electron beam dose distribution in soft tissue. (2 marks)

d) Describe the physical conditions required to produce EXPONENTIAL PHOTON ATTENUATION. Provide the equation which describes this attenuation and define each component of the equation. (1 mark)

e) Consider a photon beam traversing a material. Define the ENERGY TRANSFER COEFFICIENT. Describe its relationship to the ENERGY ABSORPTION COEFFICIENT. (1 mark)

f) Use your knowledge of the attenuation coefficients for the PHOTOELECTRIC EFFECT, COMPTON EFFECT and PAIR PRODUCTION to explain the shape of the TOTAL ATTENUATION COEFFICIENT CURVES for WATER and LEAD as shown in the accompanying diagram. (4 marks)



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Question 6

a) Intensity modulated radiation therapy (IMRT) can be delivered in two ways. Describe the process of IMRT delivery based on: (2 marks)

i) multi-leaf collimators (MLCs)

ii) compensators

b) Describe benefits and potential problems of each method. (2 marks)

c) A superficial tumour with skin involvement is located just below the eye. The oncologist describes the PTV which is 1.0cm wide, 1.5cm long, 1.0cm deep. The superior border of the PTV lies 0.5cm inferior to the centre of the bony orbital rim.

Give a brief description of suitable techniques, their limitations and potential usefulness in treating this tumour with the following beam modalities: (6 marks)

i) kV photons.

ii) MV electrons.