The Royal Australian and New Zealand College of Radiologists®

The Faculty of Radiation Oncology

Candidate Number: _____

FRANZCR Examination

Phase 1 Radiation Oncology

Paper 1

16 October 2020

9:30am

Time Allowed: 2.5 Hours

INSTRUCTIONS

- There are a total of SIX questions numbered 1 – 6.
- Each question relates to one Oncology Science subject. The paper indicates which subject is being assessed in each question. The following abbreviations will be used:

  ANA = Anatomy
  PHY = Radiation Oncology Physics
  RCB = Radiation and Cancer Biology

- All questions are worth 15 marks each. **The marks allocated to each sub-part of the questions are indicated in brackets.**
- Write your answers in the book provided, or on the answer sheets provided as directed in the questions.
- Start each question on a new page.
- Only use a black or blue pen.
- All questions are to be attempted.
- You may use diagrams, tables or lists in your answers.
- Write your candidate number on each page used in the answer booklet.
- Hand **all** papers to the invigilator. No papers are allowed to be taken from the exam room. THIS INCLUDES THE EXAMINATION QUESTION PAPERS.

Question 1

ANA

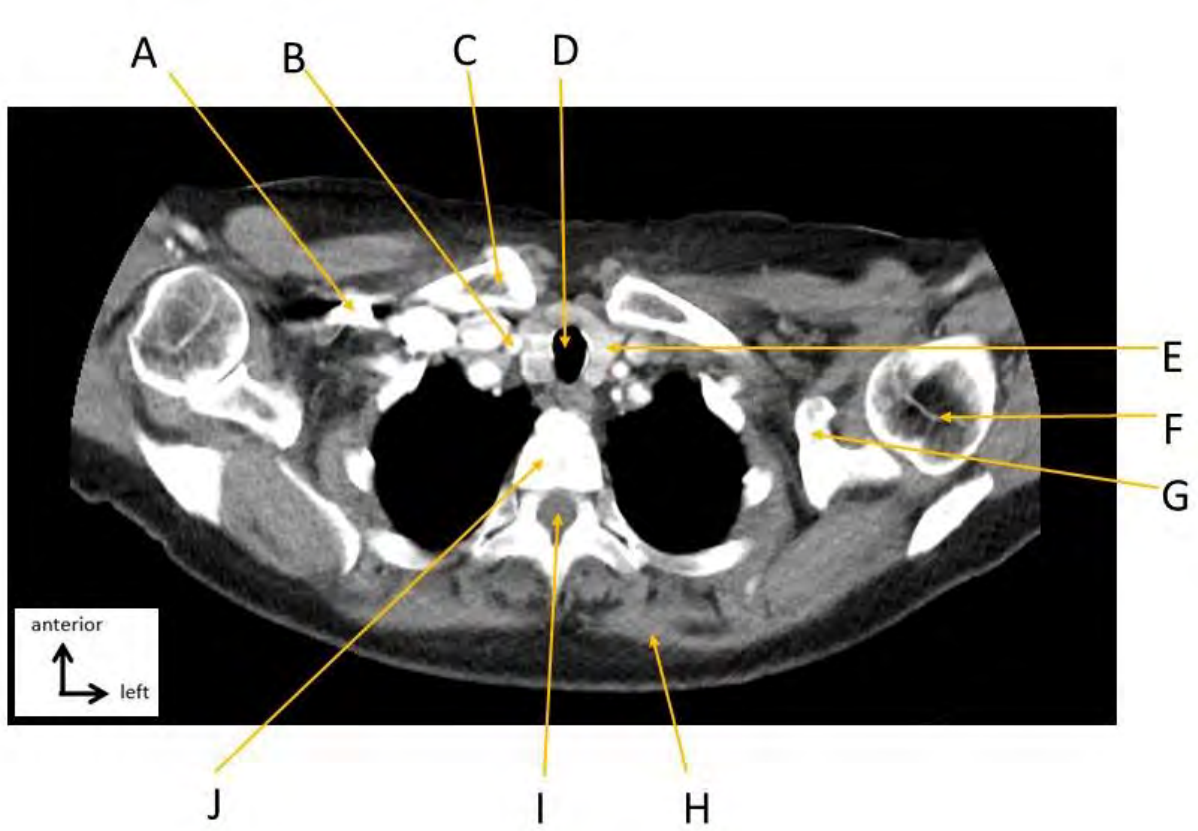
a. Describe the anatomical boundaries of the left breast. **(2 marks)**

b. Describe the lymphatic drainage of the left breast. **(2 marks)**

c. Describe the anatomical boundaries and list the contents of the left supraclavicular fossa. **(3 marks)**

d. Describe the structure and course of the right brachial plexus from roots to the five terminal branches. **(4 marks)**

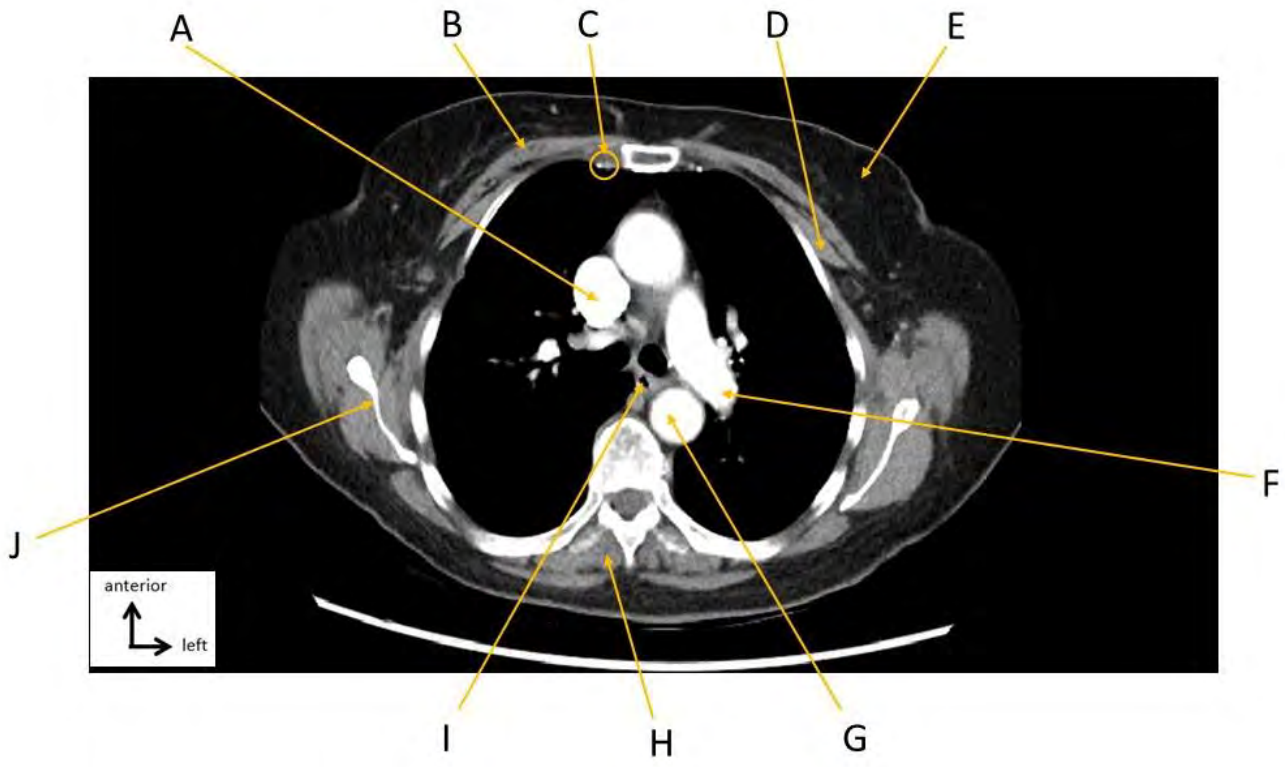
e. Name the structures labelled A to J on the axial CT slice below through the upper thorax. Indicate laterality where applicable. **(2 marks)**



Question 1 (Continued)

ANA

f. Name the structures labelled A to J on the axial CT slice below through the mid thorax. Indicate laterality where applicable. **(2 marks)**
Note: C has two structures.



Question 2

PHY

a. List at least six key components in the treatment head of a linear accelerator used to deliver a clinical photon beam. **(2 marks)**

b.

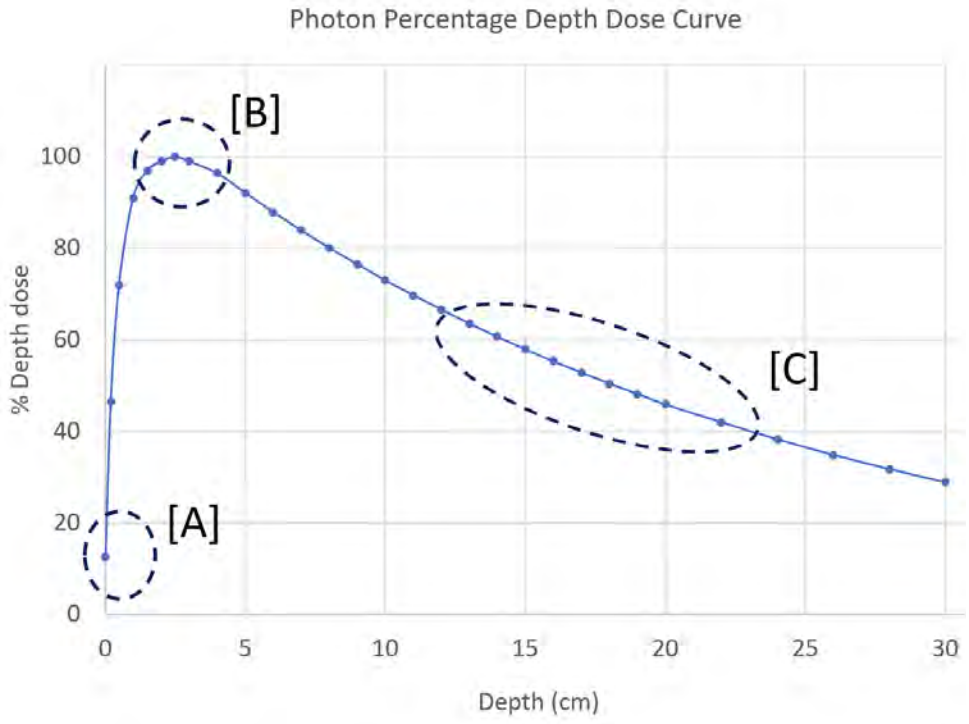
i. List four types of interactions between charged particles and an absorbing medium. **(2 marks)**

ii. Describe physical differences between an electron and a proton. **(1 mark)**

iii. For electrons and protons, explain how their interactions with matter can differ. **(1 mark)**

c. Describe the basic principles of bremsstrahlung interactions in x-ray production. **(1 mark)**

d. The graph below shows a percentage depth dose curve (PDD) for a photon beam in water producing a 10 x 10 cm field and 100 cm source skin distance (SSD).



i. State and describe the physical principles that account for the features of the PDD seen at points [A], [B] and [C]. **(3 marks)**

Question 2 (Continued)

PHY

d.

ii. Suggest an appropriate energy for this photon beam. **(0.5 marks)**

iii. For each of the following five changes, outline the differences that would be observed in the dose at point [A]: **(2.5 marks)**

- 2.5 cm tissue-equivalent bolus is placed in front of the beam.
- 20 x 20 cm field size is used instead.
- The beam is delivered from extended SSD.
- A higher beam energy is used instead.
- An orthovoltage beam energy is used instead.

iv. A segment of lung is placed in the path of the beam at 10 cm. Relative to the previous PDD, state and explain the difference that would be observed along the path of the beam at the following points: **(2 marks)**

- The dose just proximal to the water-lung interface.
- The dose within the lung.

Question 3

RCB

a. Describe the steps involved in the activation of a “signal transduction pathway” and provide the name of a recognised pathway as an example. **(2 marks)**

b. Briefly describe the structure of the epidermal growth factor receptor (EGFR), how it is activated and its normal function. **(3 marks)**

c. Describe three differences between a somatic and germline mutation. Is EGFR mutation somatic or germline? **(2 marks)**

d. The DNA sequence of a gene can be altered in a number of ways. Describe five types of genetic mutations. **(3 marks)**

e. Name six hallmarks of cancer. Which of these concepts apply to the role of EGFR mutation in the development of human cancer? **(5 marks)**

Question 4

ANA

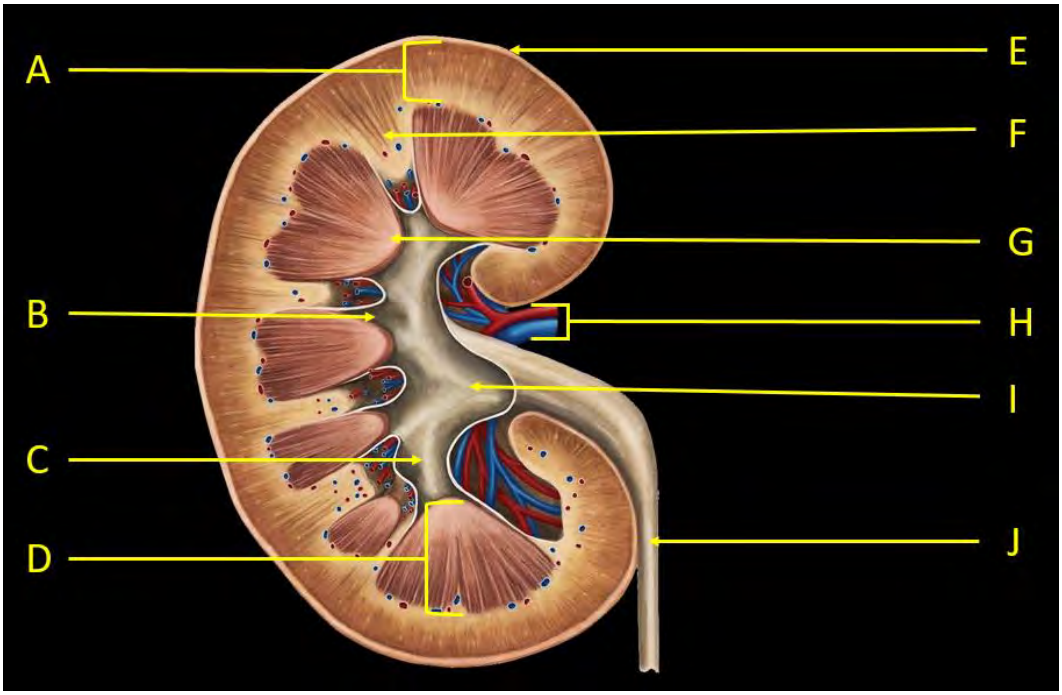
a.

i. Describe the gross anatomy of the duodenum. In your answer, include the duodenal segments and their corresponding vertebral levels. **(2 marks)**

ii. Describe the arterial supply of each segment of the duodenum. **(2 marks)**

b.

i. Name the structures A to J on the diagram of the left kidney below. **(2 marks)**



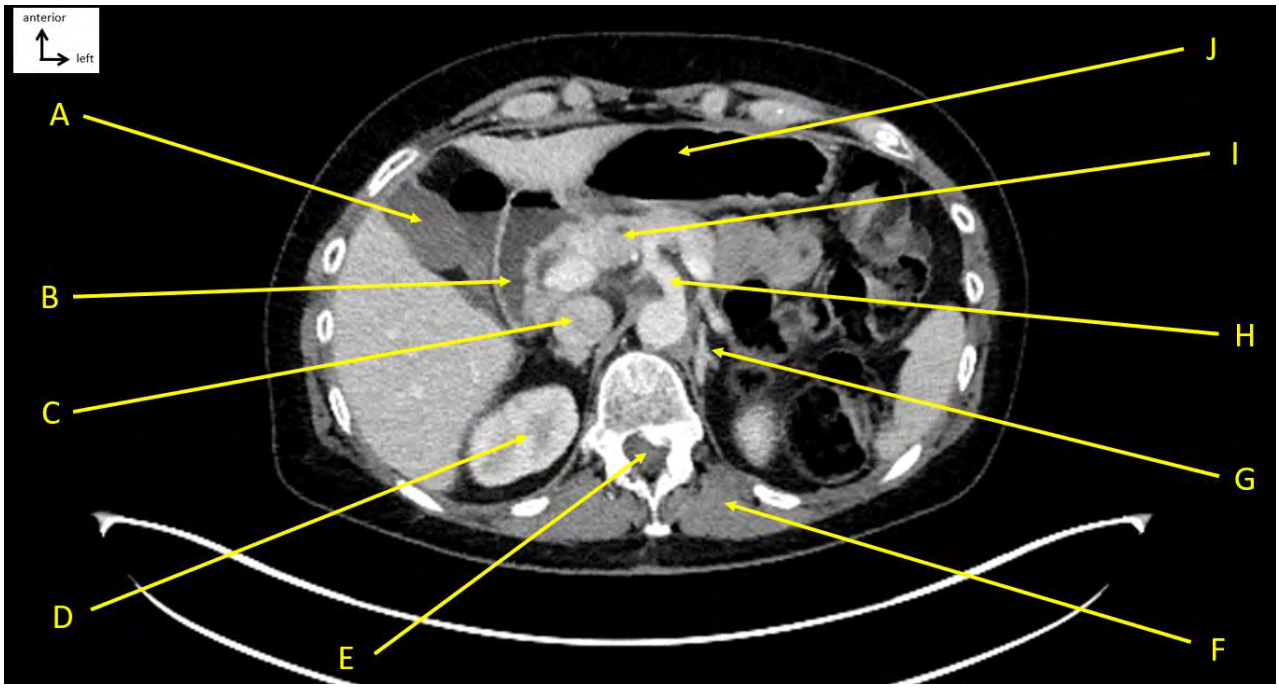
ii. List the four layers of fascia and fat encasing the kidney. **(1 mark)**

c. Describe the efferent nerve supply of the bladder, including function and the nerve roots from which they arise. **(3 marks)**

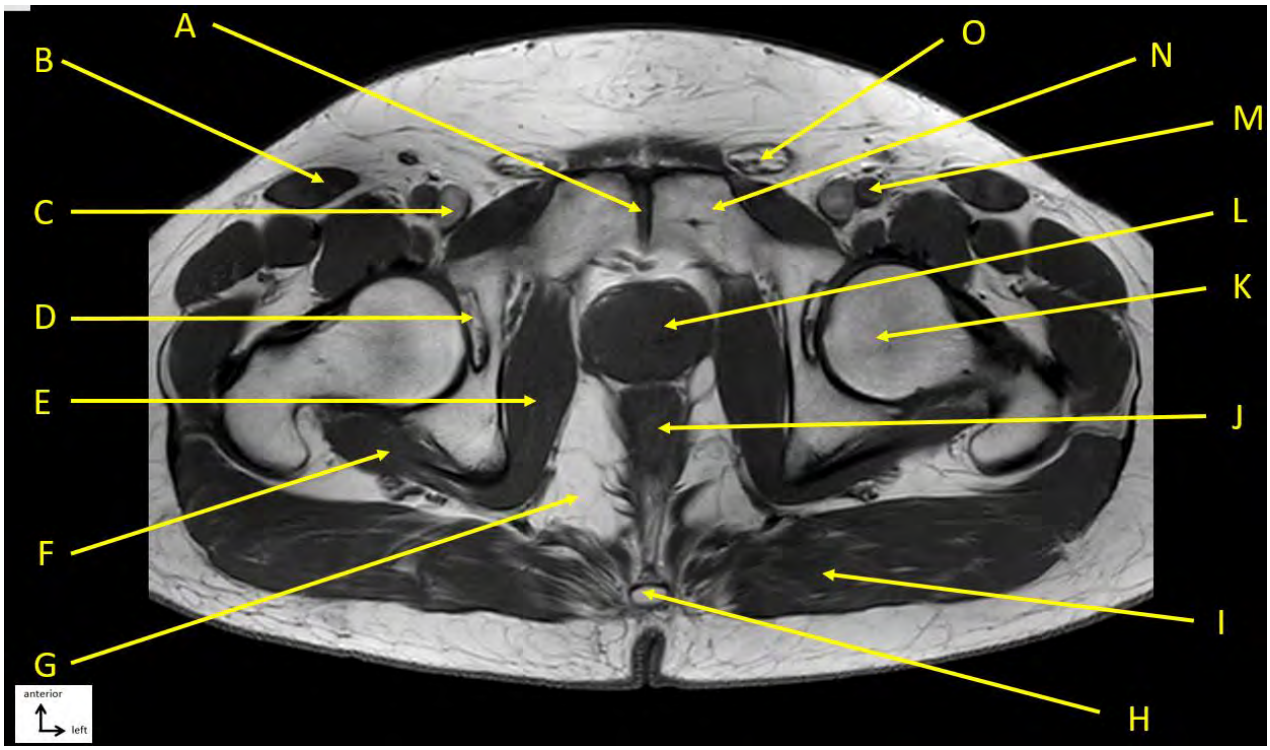
Question 4 (Continued)

ANA

d. Name the structures labelled A to J on the axial CT image of the abdomen below. Indicate laterality where applicable. **(2 marks)**



e. Name the structures labelled A to O on the axial MRI of a male pelvis below. Indicate laterality where applicable. **(3 marks)**



Question 5

PHY

a. List all of the radioactive decay processes. **(2 marks)**

b. Consider the following five radionuclides: **(5 marks)**

- Caesium-137
- Iridium-192
- Iodine-125
- Palladium-103
- Strontium-90

i. For <u>each</u> radionuclide, name a clinical application.

ii. For <u>each</u> radionuclide, define any two of the following physical properties: physical half-life, type of decay, decay energy.

c. Name and describe three brachytherapy delivery techniques employed in the management of cancer, providing a clinical example for each technique. **(3 marks)**

d. Describe the afterloading technique and list two advantages of the *remote* afterloading method. **(3 marks)**

e. Define source ‘dose rate’ and provide four different dose rates (including range) used in clinical practice. **(2 marks)**

Question 6

RCB

A 56 year old man was diagnosed with a T3N2 squamous cell carcinoma of the right middle lobe of the lung. The primary tumour was located in close proximity to the mediastinum and vertebrae. He received primary radiation treatment to a dose of 60 Gy in 30 fractions using daily fractionation Monday to Friday over 6 weeks, concurrent with cisplatin and vinorelbine chemotherapy.

a. Define the term “tolerance dose”. **(1 mark)**

b. List six factors that may not be accounted for when determining the tolerance dose of an organ according to the QUANTEC papers. **(2 marks)**

c. **(2 marks)**

i. Explain the concept of tissue architecture as described by Withers and how it is structured in a serial and parallel organ.

ii. When considering the maximum tolerance dose of an organ at risk, how would this differ if you were irradiating a parallel organ as compared to a serial organ?

d. How does the “volume effect” impact on clinical tolerance when irradiating a skin cancer and why does this happen? **(2 marks)**

Two years later the patient presents with severe back pain. Imaging with CT and MRI confirms the presence of vertebral metastases with impending cord compression at T6. Reviewing the patient’s previous radiation field, the spinal cord within the T3 – T8 vertebrae received a maximum dose of 30 Gy in 30 fractions.

e. What is the EQD2 that the spinal cord received? (Assume the α/β value of spinal cord is 2 Gy). **(1 mark)**

f. Briefly discuss at least six factors that need to be considered when considering retreatment to an organ. **(3 marks)**

g. Outline the concept of “forgotten dose” in relation to the tolerance dose of organs at risk. **(1 mark)**

Question 6 (Continued)

RCB

h. If retreatment is to be considered to the spinal cord using a standard external beam plan (stereotactic treatment is not possible), discuss what "safe" dose would be considered for this treatment and your reasoning behind this. Include any relevant workings on your calculations in your answer. **(3 marks)**

Remember the patient has received 30 Gy in 30 fractions to spinal cord 2 years previously.

The Royal Australian and New Zealand College of Radiologists®

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Candidate Number: _____

FRANZCR Examination

Phase 1 Radiation Oncology

Paper 2

16 October 2020

2.00pm

Time Allowed: 2.5 Hours

INSTRUCTIONS

- There are a total of SIX questions numbered 7 – 12.
- Each question relates to one Oncology Science subject. The paper indicates which subject is being assessed in each question. The following abbreviations will be used:

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Question 7

ANA

a.

i. Name the arterial supply and sensory innervation of the anterior (oral) tongue. **(1 mark)**

ii. Name the major draining nodal station(s) and sensory innervation of the posterior tongue (base of tongue). **(1 mark)**

iii. List four extrinsic muscles of the tongue. **(1 mark)**

b. Describe the boundaries of the anterior triangle of the neck. **(2 marks)**

c.

i. List the hormone output(s) of the pituitary gland, indicating whether they are of the anterior or posterior pituitary. **(1 mark)**

ii. Describe the venous drainage of the pituitary gland. **(1.5 marks)**

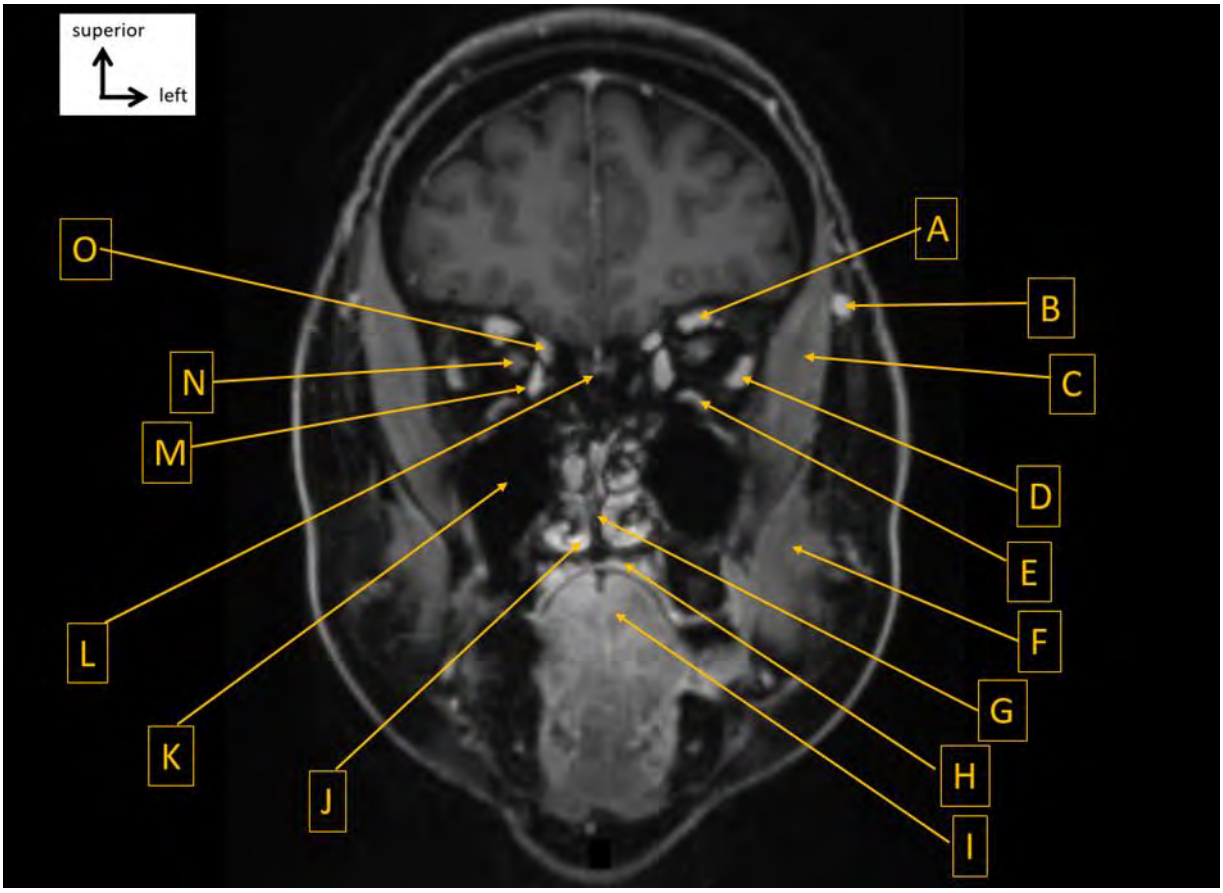
iii. Name the anatomical relations of the pituitary gland. **(1.5 marks)**

iv. List the six contents of the cavernous sinus. **(1 mark)**

Question 7 (Continued)

ANA

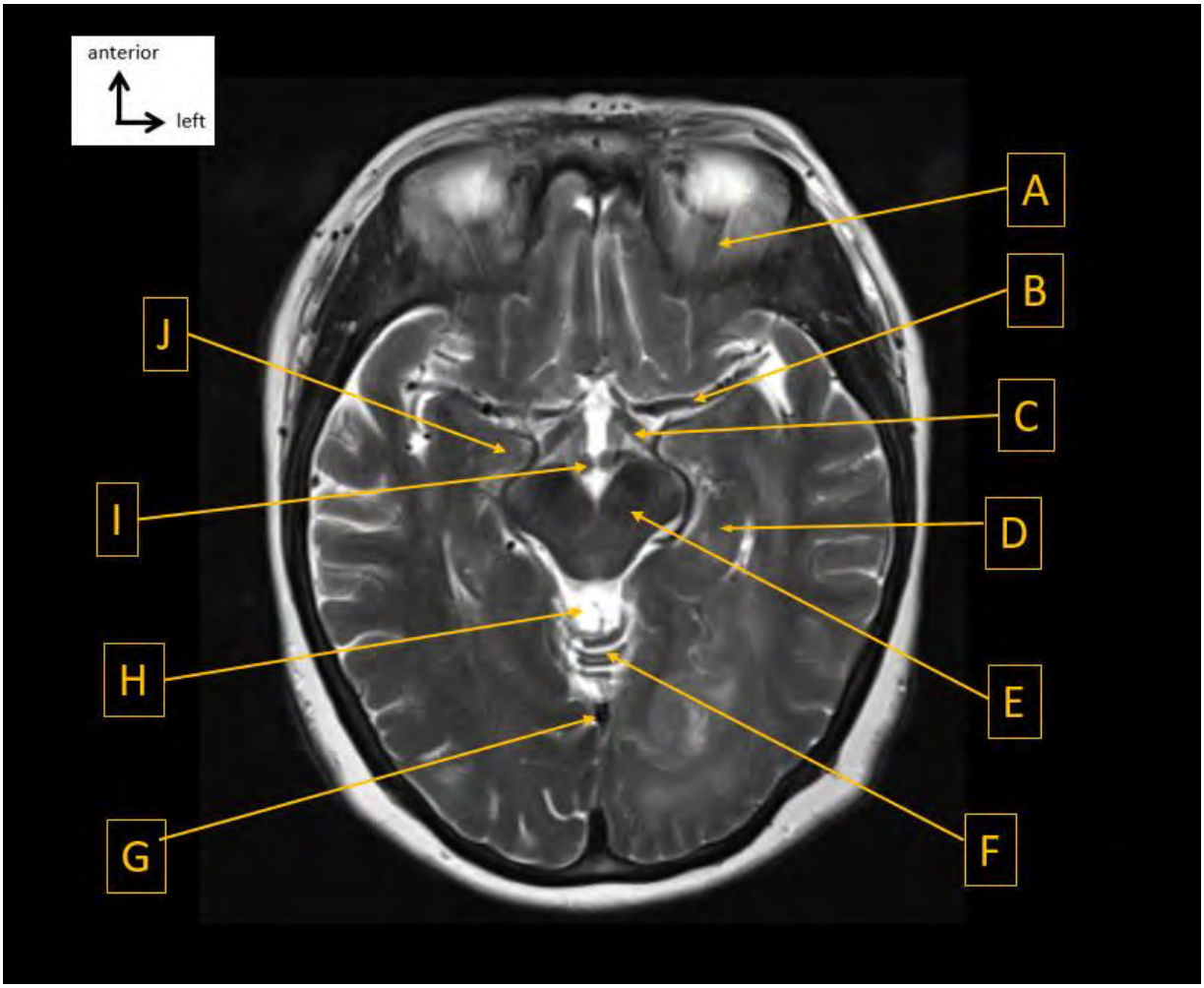
d. Name the structures labelled A to O on the coronal MRI slice of the head. Indicate laterality where applicable. **(3 marks)**



Question 7 (Continued)

ANA

e. Name the structures labelled A to J on the axial MRI slice of the head. Indicate laterality where applicable. **(2 marks)**



Question 8

PHY

a. Respiratory motion is a potential source of radiation therapy error as it can alter the position of target volumes and organs at risk. **(6 marks)**

Describe three motion management strategies used to minimise the impact of respiratory motion and provide the rationale for each.

b. List eight patient positioning and immobilisation tools or accessories that may be used to set up a patient during CT simulation and treatment. **(2 marks)**

c. MRI imaging is increasingly used in radiation therapy.

i. Describe two potential advantages of an MRI simulator. **(1 mark)**

ii. Describe three potential problems of fusing diagnostic MRI images to CT simulator images for planning. **(3 marks)**

d.

i. Explain the physical principles of thermoluminescent dosimetry (TLD). **(2 marks)**

ii. Describe one advantage and one disadvantage of TLDs. **(1 mark)**

Question 9

RCB

a.

i. List at least 4 types of DNA damage that can be induced by ionising radiation. **(1 mark)**

ii. Define the terms *sublethal damage* and *potentially lethal damage*. **(1 mark)**

b. Use a table to compare and contrast the two double-strand break DNA repair pathways in relation to: **(8 marks)**

i. repair mechanism

ii. need for a template

iii. repair accuracy

iv. time required for repair

v. predominance in phases of a cell cycle

vi. tissue type predominance

vii. used proteins / protein complexes

viii. associated genetic conditions

c.

i. Outline the purpose of pulsed-field gel electrophoresis (PFGE) in regards to DNA damage and the key steps in this assay. **(2 marks)**

ii. Identify the main advantage of comet assay versus PFGE? **(1 mark)**

d.

i. List at least two lethal and two non-lethal chromosome aberrations. **(1 mark)**

ii. Which chromosome aberration assay is used to assess total body irradiation dose, and what is the lowest dose it can detect? **(1 mark)**

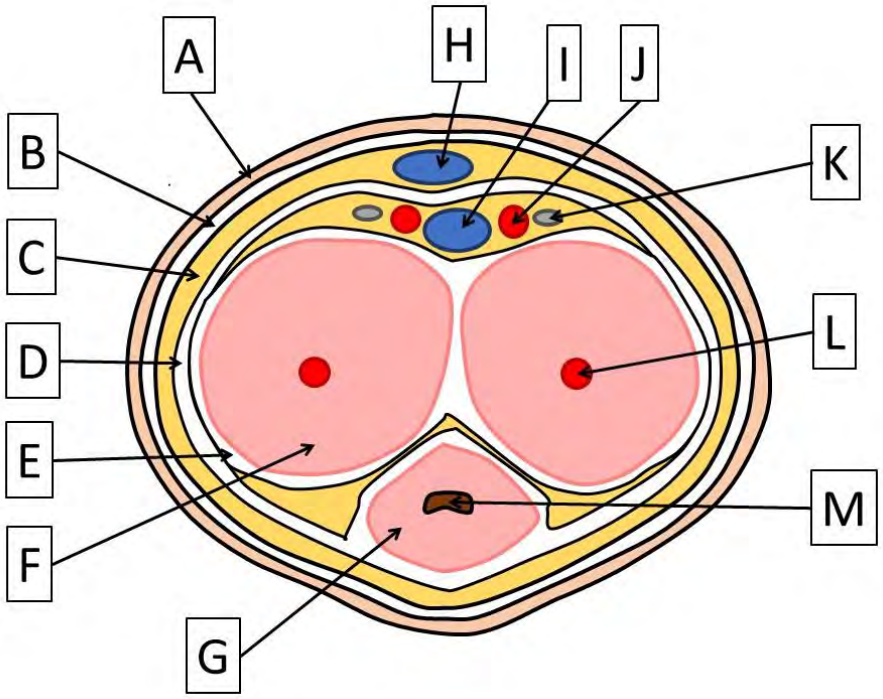
Question 10

ANA

a. List the microscopic layers and sublayers of the skin, from superficial to deep. **(1.5 marks)**

b.

i. Name the structures labelled A to M on the transverse cross-sectional diagram of the body of the penis. **(2.5 marks)**



ii. Describe the lymphatic drainage of the penis. **(2 marks)**

c. Describe the boundaries and the contents of the left femoral triangle. **(2 marks)**

d.

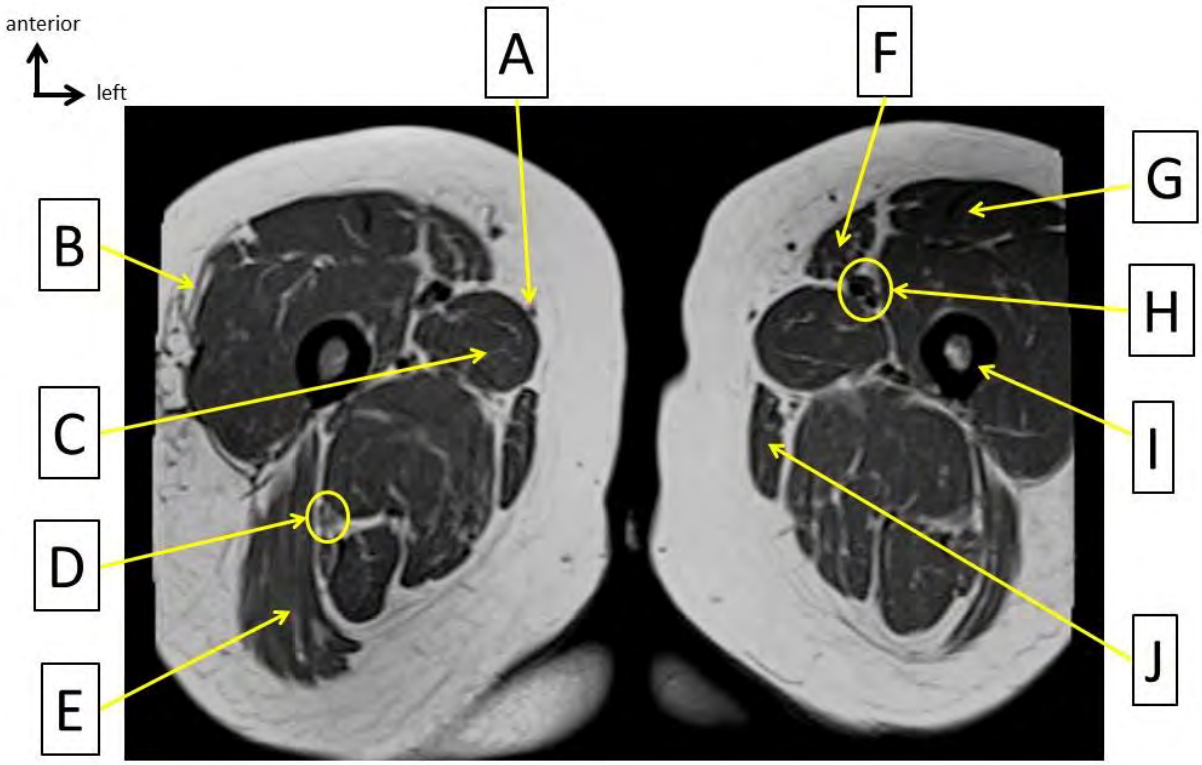
i. Describe the origin nerve roots, course and terminal branches of the sciatic nerve. **(2 marks)**

ii. Name the other four major branches of the sacral plexus and their main motor and/or sensory distribution. **(3 marks)**

Question 10 (Continued)

ANA

e. Name the structures labelled A to J on the axial MRI slice of the superior thighs below. Indicate laterality. Note: H has two structures. **(2 marks)**



Question 11

PHY

a. Define the following terms: **(1.5 marks)**

i. ALARA

ii. Occupational exposure

iii. Sievert

b. A patient is undergoing HDR brachytherapy. **(3 marks)**

Describe the three main principles used to minimise radiation exposure to staff and outline how each of these can be applied to sealed source brachytherapy delivery.

c. A patient undergoing radical head and neck radiation therapy at 2 Gy per fraction is mistaken for a patient with the same name and accidentally receives a single 4 Gy fraction to the brain.

i. Describe the management of the above incident (including the required documentation and reporting), and describe methods to reduce the risk of this happening in the future. **(4.5 marks)**

ii. List four examples of radiation incidents that must be reported. **(1.5 marks)**

d.

i. What is the rationale for the difference in radiation dose limits between the general public and radiation workers? **(0.5 marks)**

ii. Using a table, compare the annual dose limits for radiation exposure for the general public versus radiation workers according to the International Commission for Radiation Protection (ICRP) guidelines for: **(3 marks)**

- Effective dose (whole body)
- Equivalent dose (eye, lens)
- Equivalent dose (hands, feet, skin).

Question 11 (Continued)

PHY

e. **(1 mark)**

i. What is the recommended radiation dose limit to the foetus in a patient known to be pregnant?

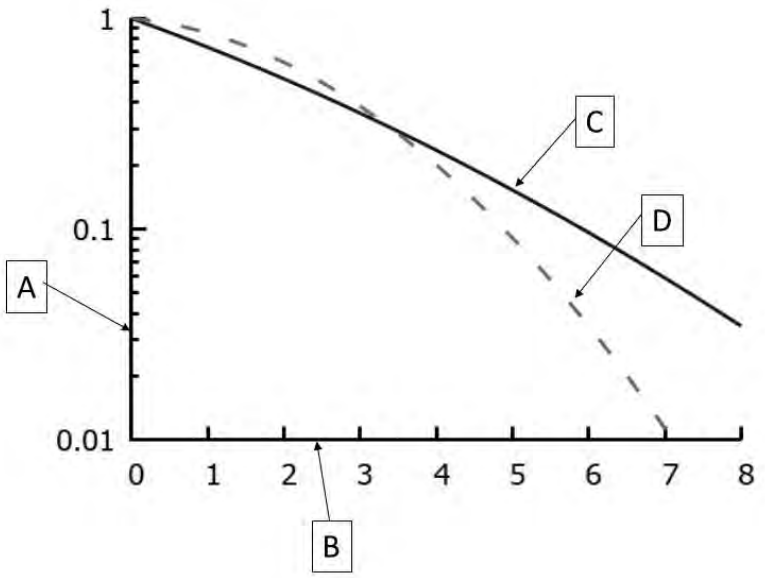
ii. List one method to limit foetal dose in a pregnant patient receiving radiation therapy.

Question 12

RCB

a. State the formula for the linear quadratic model of cell kill and individually define each of the terms of the equation. **(3 marks)**

b. Below are cell survival curves for low and high α/β ratio cell lines.



i. Label the axes (A, B) and curves (C, D). **(1 mark)**

ii. Define the term α/β value and describe how it can be found from a cell survival curve. **(1 mark)**

c. State two limitations of the linear quadratic model. **(1 mark)**

d.

i. For <u>both</u> acute and late responding normal tissues, provide α/β value ranges. **(1 mark)**

ii. For <u>both</u> acute and late responding normal tissues, state the relative effects on normal tissue complication probability for the following four scenarios: **(4 marks)**

- increasing total dose
- hyperfractionation
- hypofractionation
- reducing overall treatment time (keeping total dose constant)

Question 12 (Continued)

RCB

e.

i. Define the term hyperfractionation. **(0.5 marks)**

ii. Discuss the impact of hyperfractionated treatment schedules on tumour control and normal tissue effects. **(3.5 marks)**