SEMESTER 2 EXAMINATION 2012-2013

MEDICAL PHYSICS

Duration: 120 MINS (2 hours)

This paper contains 11 questions.

Answer **all** questions in **Section A** and **only two** questions in **Section B**.

Section A carries 1/3 of the total marks for the exam paper and you should aim to spend about 40 mins on it.

Section B carries 2/3 of the total marks for the exam paper and you should aim to spend about 80 mins on it.

An outline marking scheme is shown in brackets to the right of each question.

A Sheet of Physical Constants is provided with this examination paper.

Only university approved calculators may be used.

A foreign language translation dictionary (paper version) is permitted provided it contains no notes, additions or annotations.

Section A

A1. Describe and quantify the main contributions to the average background radiation dose for the public in the UK. [3]

A2. Describe the 3 phases of cell damage which take place during irradiation. List three effects that enhance the radiation damage. [3]

A3. Describe the delivery mechanism used to transmit radiation from a surgical CO_2 laser to a site inside the body. Explain why this is different to the delivery method used with other surgical lasers such as diode or NdYAG lasers [2]

A4. What are the key requirements for radioisotopes for use in nuclear medicine? [3]

A5. Estimate the energy deposited by a 500keV electron passing through a 0.1mm thick beryllium foil (density = 1.8 kg.m^{-3}). What assumptions have you used in your estimate, and how valid are they? [3]

A6. When protons are placed in a magnetic field they precess. Explain why this occurs and describe the resulting phenomena and its importance in MRI. [3]

A7. Estimate the final image resolution for a gamma camera with intrinsic resolution of 3mm, collimator slat separation of 5mm and collimator slat length of 2cm for a source plane 20cm from the front of the collimator. [3]

Section B

B1. Describe the principles and applications of Positron Emission Tomography (PET), using quantitative examples and explanatory diagrams where appropriate. Your answer should include a discussion of the limitations to image quality imposed by both physical processes and the practical implementation of the scanner. You should also include a brief description of the imaging reconstruction methods used in PET. [20]

B2. (a) What phenomenon is exploited to produce and detect ultrasound in an imaging system? Briefly explain how. [4]

(b) Using a labelled diagram, identify the main functional parts of a single element ultrasound transducer. [4]

(c) What property must differ between two media if sound is to be reflected at a boundary between them? Hence explain, with reasons, what is the best backing medium for a B scan imaging transducer and a continuous wave transducer. [5]

(d) Describe the meaning of the term axial resolution. Briefly explain factors considered when deciding on the ultrasound frequency to use. [4]

(e) Explain time-gain compensation and why it is needed. [3]

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B3. (a) Describe, with the aid of a schematic, the principles of operation of the neodymium YAG laser, including in your answer the general principles of laser operation as well as the specifics of the NdYAG laser. [8]

(b) Explain the purpose and principles of Q-switching. [3]

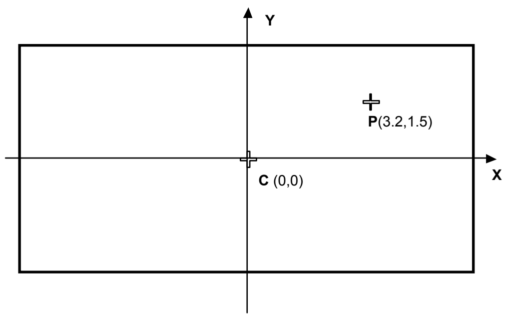
(c) Name 2 other methods of pulsing a laser, and state the typical pulse duration for each. [2]

(d) Calculate the peak power and the peak irradiance of a single pulse of a Q-switched laser of pulse energy 3mJ with spot size 25μm diameter and pulse duration 1 ns. [4]

(e) Name and describe the mechanism of interaction of a Q-switched laser with tissue. [2]

(f) Describe an example of the clinical application of the NdYAG laser in ophthalmology. [1]

B4. A patient requires radiotherapy to the spinal region with a rectangular field of 12cm x 6 cm, with a linac energy of 6 MV. The intended therapeutic dose per fraction is 3 Gy, at a depth of 6.8 cm on the central axis (C), for a total of 10 fractions.



The linac calibration is 1 Gy/100 monitor units (MU) at dmax, and the treatment technique is SSD (fixed at 100 cm). Using *the data on the next page* please calculate:

(a). The number of MU required to deliver the requested dose at the specified depth, on the central axis C. [5]

(b). The maximum dose received by the patient on the central axis (i.e., the dose at dmax). [3]

(c). The clinician would also like to know, for the MU calculated in (a), what would be the dose on a point (P) located off-axis at coordinates x = 3.2, y=1.5 cm, and a depth of 4 cm. [8]

(d). What would be the total dose to be delivered in fractions of 2 Gy having the same radiobiological effect as the above treatment. The spinal cords α/β is 2 Gy. [4]

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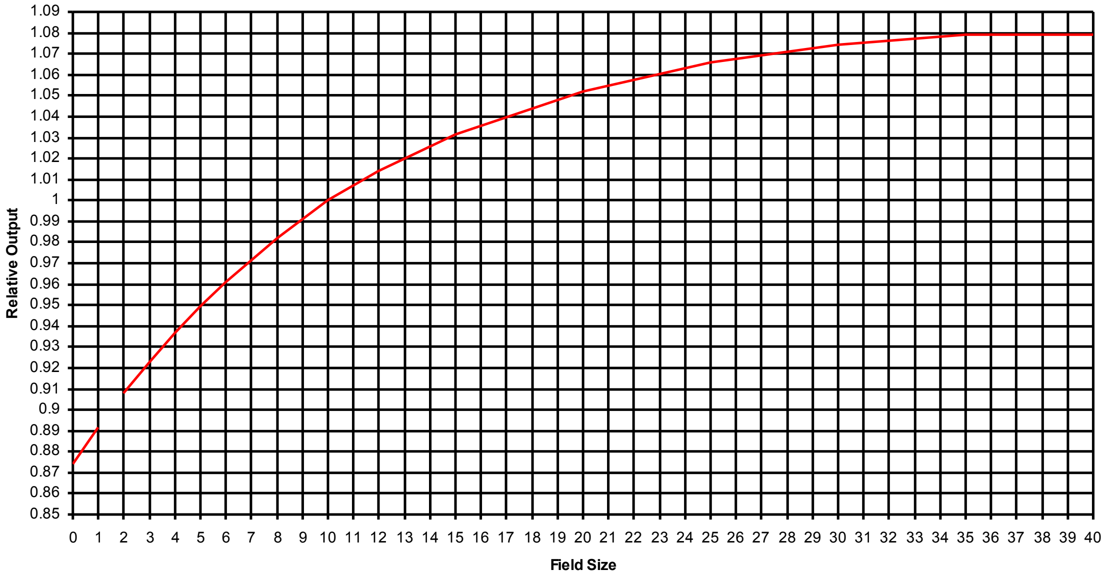
This page contains data for use in Question B4 only.

Relative output factor (ROF) vs field size for Elekta Precise 6MV at 100 SSD at Dmax:

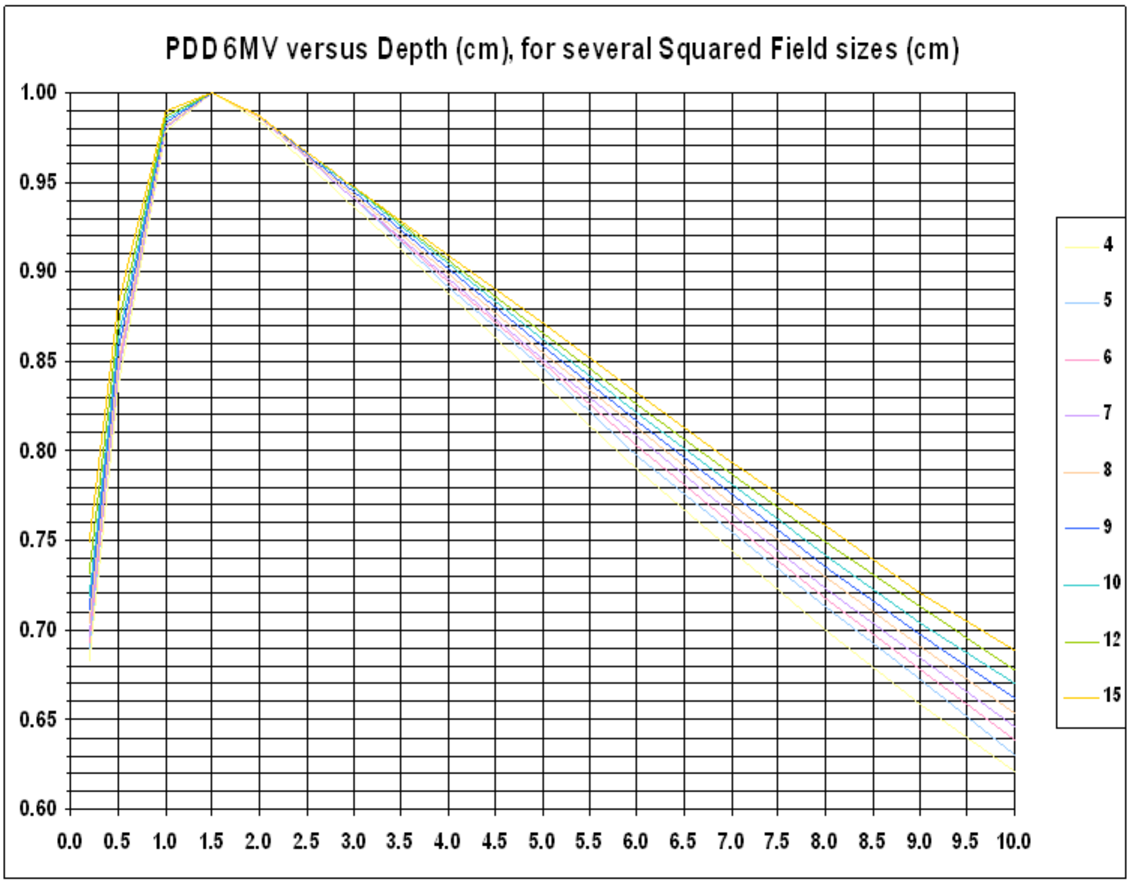


Off-axis ratio vs distance from centre to calculation point:

r (cm)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
OAR	1.000	1.0013	1.003	1.006	1.008	1.0127	1.0157	1.0213	1.0243	1.0273

This page contains data for use in Question B4 only.

PDD 6MV versus depth(cm) for several square field sizes (in cm):



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