

THE OPEN UNIVERSITY OF SRI LANKA
 BACHELOR OF SCIENCE DEGREE PROGRAMME – LEVEL 05
 FINAL EXAMINATION 2011/2012
 MEDICAL PHYSICS –PYU 3167/PHU 3158/PHE5158



Duration: TWO HOURS (2 hrs)

Date 16th Nov. 2012

Time 1.30 pm – 3.30 pm

Answer Any Four (4) questions only

1. (a) What is the *piezoelectric effect* and name one usage in Medical Physics? (6 marks)
 - (b) Explain why it is not possible to detect lung disease by ultrasound imaging? (6 marks)
 - (c) The acoustic impedance of the abdomen wall adjacent to the muscle is $1.56 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$. If muscle tissue has a density of $1.04 \times 10^3 \text{ kg m}^{-3}$ and an acoustic velocity of 1580 m s^{-1} , calculate the percentage of the incident ultrasound pulse that is reflected at boundary. (6 marks)
 - (d) During a blood flow determination, ultrasound of frequency 3 MHz is transmitted at an angle of 30° to the blood vessel. If the velocity of ultrasound is taken to be 1.55 km s^{-1} and the diameter of the vessel to be 1.2 mm, estimate the blood volume flow rate if a Doppler shift in frequency of 1500 Hz is recorded. (7 marks)
2. (a) What is the function of the cladding in an optical fibre? State the necessary condition of the refractive index of the cladding for the function of an optical fibre. (6 marks)
 - (b) An optical fibre has core glass and cladding glass with refractive indices of 1.68 and 1.5. Calculate the numerical aperture. (7 marks)
Find the critical angle of light, if the fibre is placed in air.
 - (c) List three main Characteristics and properties of *Lasers*. (6 marks)
 - (d) Lasers are classified mainly into three groups according to their laser active medium. What are these groups and give one example for each of these groups. (6 marks)
3. (a) Using text and a labeled diagram, explain how X-rays are produced. (6 marks)
 - (b) An X-ray tube operates at a voltage of 80 kV and a tube current of 50 mA. As the X-rays leave the tube the area of the beam is 10 mm^2 . The efficiency of the tube at producing X rays is 1%. What is the input power of the X-ray tube and the intensity of the X-rays leaving the tube? (6 marks)
 - (c) Assume that the intensity you calculated in Question 3(b) is at 0.01 m away from the anode. What is the intensity of X-rays at 1.5 m away from the X-ray tube? [Hint: it's in air]. (6 marks)

(d). What is the intensity of the beam behind a sheet of aluminium 5 mm thick placed 1.5 m away from the tube? (The average linear attenuation coefficient of aluminium is 217 m^{-1} .)

(7 marks)

4. (a) Why radioisotopes are useful as medical diagnostic tools, give two reasons. (6 marks)

(b) The half-life of ^{99m}Tc is 6.0 hours. How much time t must elapse before a 20 GBq sample of ^{99m}Tc and a 100 GBq sample of ^{113m}In which has a half life of 1.7 hours possess equal activities? (6 marks)

(c) Explain briefly why α and β emitters are much less suitable than γ emitters for radionuclide imaging. (6 marks)

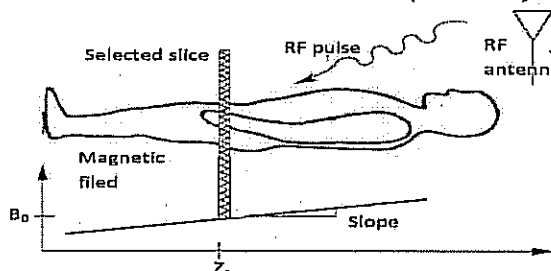
(d) If 12% of ^{99m}Tc -labeled diisopropylimino diacetic acid (DISIDA) is eliminated via renal excretion, 34.5 % by fecal excretion and 3.4% by perspiration in 4 hours, from the human body, what is the effective half life of the radio pharmaceutical ? (Physical half life of ^{99m}Tc is 6 hours) (7 marks)

5. (a) Give a brief account on spin-lattice relaxation time (T_1) and spin-spin relaxation time (T_2) in nuclear magnetic resonance (NMR). (6 marks)

(b) Explain why MRI is an effective tool for diagnosing cancerous tissues. (6 marks)

(c) State and explain two advantages of using an MRI scanner to scan a patient's brain compared with a CT scanner. (6 marks)

(d) In MRI imaging, a patient is placed in a uniform magnetic field of flux density (B_0) 1.5 T directed from his feet to his head as shown in the figure. A longitudinal gradient field of strength 10 mT m^{-1} is introduced in to a slice with 2 mm thickness perpendicular to the Z-axis at position $Z_s = 0.1 \text{ m}$ is excited with a radio frequency pulse at frequency f in such a way that the field strength remains 1.5 T at the sample centre. Assume if gyromagnetic ratio (γ) 267.8 MHz T^{-1} , estimate the frequency f of the radio frequency pulse required to produce proton resonance in this slice. (7 marks)



6. (a) State three reasons why ^{99m}Tc is one of the most widely used radioisotope in nuclear medicine. (6 marks)

(b) A gamma camera has four major components. List these components and indicate their functions. (6 marks)

(c) The effects of radiation on the human population can be classified as either somatic or genetic effects. In no more than a few sentences, briefly explain these effects. (6 marks)

(d) What is a Medical Linear Accelerator? List two advantages of it in nuclear medicine. (7 marks)