



**DEPARTMENT OF MEDICAL PHYSICS AND CLINICAL
ENGINEERING**

Spring Semester 2006

2 hours

PHYSICS IN MEDICINE 2

The paper is divided into two sections: A and B.

The student should answer all questions in section A. One sentence answers are sufficient for all questions in this section.

The student should answer two questions from section B.

TURN OVER

Section A (Answer all questions: 2 marks for each question)

- A1. What is the Larmor frequency associated with a hydrogen atom proton precessing in a 1.5T magnetic field?
- A2. Which one of the following most closely represents the magnitude of the gradient field in a clinical MRI scanner?
- i) 0.001 mT/m
 - ii) 0.1 mT/m
 - iii) 10 mT/m
 - iv) 1000 mT/m
- A3. If **M** and **B** refer to magnetization and magnetic field strength respectively, what is the name given to the following equation used in MRI:
 $d\mathbf{M}/dt = \gamma\mathbf{M} \times \mathbf{B}$?
- A4. What do the letters FID stand for in the context of magnetic resonance imaging?
- A5. Which one of the following types of laser beams cannot be transmitted through water?
- i) Nd:YAG;
 - ii) carbon dioxide;
 - iii) argon.
- A6. PDT is a form of laser therapy. What do the initials PDT stand for?
- A7. Why is it not possible to use an optical glass fibre with the carbon dioxide laser?
- A8. A selection of laser sources is presented. Select the ones that will cause damage to the retina at the back of the eye:
- i) carbon dioxide;
 - ii) krypton;
 - iii) neodymium YAG;
 - iv) argon.
- A9. What is the length-dependent resonance condition of a laser cavity if it is to successfully lase at a wavelength λ ?
- A10. Which part of the eye is vulnerable to damage from a Carbon Dioxide laser?
- i) Retina
 - ii) Cornea
 - iii) Optic Nerve
- A11. Give two properties that are characteristic of laser light.

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- A12. The excimer laser gets its name from a concatenation of two terms. Which terms are these?
- A13. Which one of the following is **not** associated with nonlinear ultrasound propagation in soft tissue?
- i) High pressure, transmitted pulse wave;
 - ii) generation of harmonic frequencies;
 - iii) distortion of the sinusoidal wave;
 - iv) uniform acoustic velocity throughout the wave cycle.
- A14. If the absorption of sound in a region of tissue is much greater than that of neighbouring tissue beyond it, what artefact would you expect to see in the image?
- A15. What is the attenuation loss in decibels for an ultrasound wave that penetrates 2 cm of fat? Assume the frequency to be 3 MHz, and the attenuation coefficient $0.6 \text{ dB cm}^{-1} \text{ MHz}^{-1}$.
- A16. What is the spatial pulse length for a 2.5 cycle ultrasound pulse in tissue if the frequency is 5 MHz and the speed of sound is 1540 m s^{-1} ?
- A17. Time gain compensation is a variable amplification technique applied along the ultrasound beam path. Which one of the following does it correct for?
- i) Beam focusing;
 - ii) tissue attenuation;
 - iii) transducer heating;
 - iv) blood flow within the beam.
- A18. How many scan lines compose a real-time ultrasound image from a linear array?
- i) None;
 - ii) one to five;
 - iii) one thousand to two thousand;
 - iv) fifty to two hundred.
- A19. In the context of ultrasound imaging, write down an expression for the frame rate (FR) in terms of the speed of sound (c), scan range (R) and number of scan lines (n).
- A20. The mechanical index (MI) of an ultrasound probe is inversely proportional to which one of the following?
- i) Frequency;
 - ii) square root of frequency;
 - iii) thermal index (TI);
 - iv) transducer gain.

TURN OVER

Section B**B1**

Show from first principles that the magnetic field strength at the centre of a current loop (current I , radius r) is given by $\mu_0 I/2r$. [8]

Describe how this has relevance to the hydrogen atom proton in the classical model of MRI and discuss the steps that lead to induced magnetisation of a sample. [7]

Phase coherence is an important concept in the production of an MRI signal. Relate it to magnetization and describe the techniques used to obtain sufficient phase coherence that a radiofrequency (RF) signal can be detected. [8]

The following list describes discrete events involved in the creation of an MRI image. Arrange them in the correct order to create a flow chart describing the progression of steps required to generate a diagnostic image. [7]

- Switch on resonant RF at Larmor frequency.
- Record emitted RF.
- Apply transverse B-field gradient for frequency encoding.
- Place patient in scanner.
- Generate uniform B-field in bore of scanner.
- Apply transverse B-field gradient for phase encoding.
- Fourier Transform methods used to create image.
- Apply slice select B-field gradient.
- Switch off resonant RF at Larmor frequency.

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B2

Light is known to be an electromagnetic wave. Explain what this means and indicate the energy associated with a wavelength λ . [6]

It is a well known fact that the wavelength of emission of lasers determines their suitability for various applications in the medical field.

Bearing this in mind:

(i) Why is the carbon dioxide laser beam unsuitable for the removal of a 'port wine stain' birthmark on the skin? [4]

(ii) What properties does the Excimer laser beam possess that makes it the preferred laser for treating myopia (short sightedness)? [4]

Health and safety is an important aspect of managing a laser in a clinical environment. What considerations are appropriate for a clinical procedure that requires the use of a therapeutic laser? [9]

PUVA is used to treat which condition? Briefly describe the use of PUVA therapy for the treatment of this ailment. [7]

TURN OVER

B3

- a) A Doppler ultrasound probe can be used to measure velocity. Calculate the velocity of a moving reflector if a Doppler shift of 1 kHz is observed. Assume the transmitting frequency is 5 MHz and the insonation angle is 60° . Briefly explain the influence of Doppler angle uncertainty on the measurement of velocity. During Doppler investigations of the carotid artery it is recommended that an insonation angle of between 30° and 60° is used. Why should insonation angles below 30° be avoided? [5]
- b) Explain what is meant by duplex scanning and state its advantages and disadvantages. [20]
- c) Briefly outline the principles of elastography imaging. When would you employ this technique? [5]

END OF QUESTION PAPER