RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Third Year – Semester II Examination – April / May 2015

PHY 3212 – MEDICAL PHYSICS

Answer **Four** Questions Only | Time allowed: Two hours

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1. Answers should be written in the **space given**.
2. Only the calculators provided by the university are allowed to be used.

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{ms}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Plank constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
mass of electron	$\mathrm{m}_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
mass of proton	$\mathrm{m}_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
acceleration of free fall on the Earth's surface	$\mathrm{g} = 9.81\ \mathrm{m\,s}^{-1}$
electron volt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$
Rydberg constant	$R_H = 1.097 \times 10^{7}\ \mathrm{m}^{-1}$

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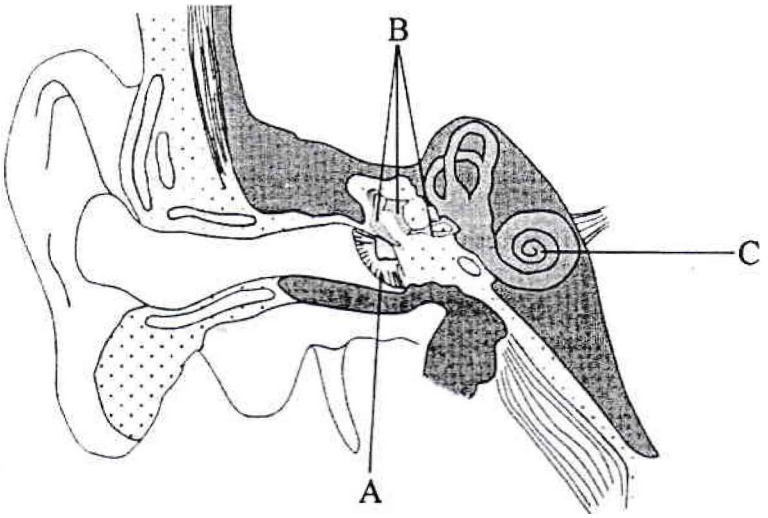
1. The diagram shows a vertical section through a human ear.



(a) Name and state the functions of the parts labeled A, B and C in the diagram.

A name .....

function .....

B name .....

function .....

C name .....

function .....

(6 marks)

(b) Describe how the vibrations of a sound wave are received by the outer ear and transmitted to the inner ear.

(3 marks)

(c) Explain how the pressure changes due to the sound wave, are amplified by the ear.

(2 marks)

(d) At the site of a machine in a factory, a sound meter was used to measure the sound level. The relative intensity level with the machine operating was 86 dB. The sound intensity reaching the meter when the machine was not operating was $7.0 \times 10^{-5}\ \text{Wm}^{-2}$. ($I_0 = 1.0 \times 10^{-12}\ \text{Wm}^{-2}$)

(i) Show that with the machine operating, the sound intensity reaching the meter was about $4.0 \times 10^{-4}\ \text{Wm}^{-2}$.

(2 marks)

(ii) Calculate the relative intensity level due to the machine alone.

(2 marks)

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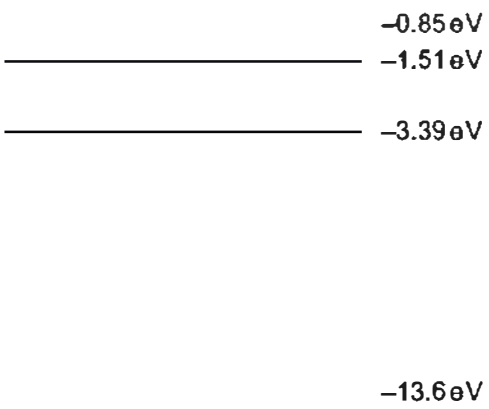
The emission spectra of atoms provide evidence that electrons e
energy levels in atoms.
Explain briefly what is meant by this statement.

(3 marks)

(b) The following figure shows some of the energy levels in the hydrogen atom.



Calculate the **lowest frequency of radiation** emitted when an electron makes an appropriate transition between two of the levels shown.

(5 marks)

(c) Outline the basic principle of magnetic resonance (MR) scanner used to scan a patient's brain.

(3 marks)

(d) State and explain **two** advantages of using MR scanner to scan a patient's brain with a CT scanner.

(4 marks)

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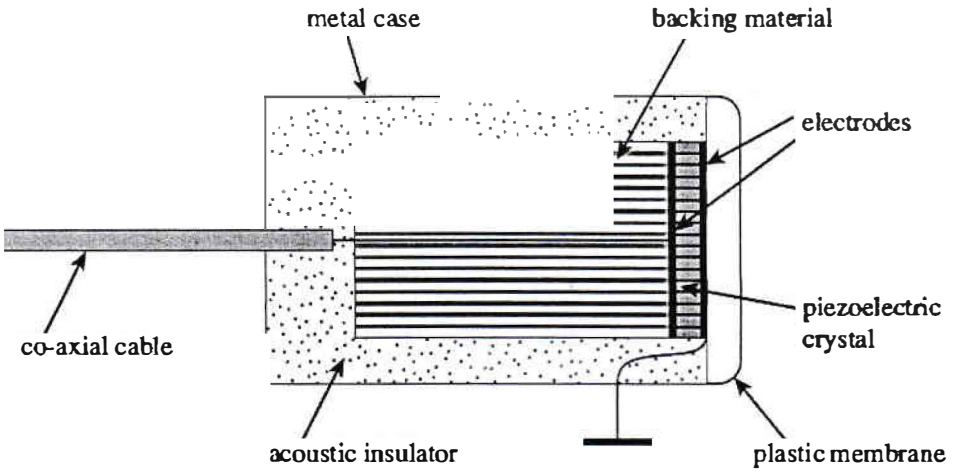
3. (a) The following figure shows an ultrasound transducer used in a A-scan.



Outline, **with reference to the diagram**, the **process** by which the transducer produces a short pulse of ultrasound.

(4 marks)

(b) When an incident sound wave in fluid 1 encounters the boundary with fluid 2, the reflection coefficient, R, is defined as the **fraction of the incident intensity that is reflected**. Derive an expression for R in terms of the acoustic impedances of fluids, Z_1 and Z_2.

(3 marks)

(c) Calculate the **fraction of the incident intensity** reflected at the **boundaries going from muscle to fat** and **fat to muscle** using the data in the following table.

Tissue	Z *(Pa s m^{-1})*	c *(m s^{-1})*
Fat	1.38×10^6	1475
Brain	1.55×10^6	1560
Blood	1.61×10^6	1570
Muscle	1.65×10^6	1580
Bone	6.10×10^6	3360

(6 marks)

(d) When obtaining the ultrasound image of an unborn fetus, a **coupling gel** is used. Explain why a coupling gel is needed and state the **property of the gel** that ensures a good quality image.

(2 marks)

4. Both ultrasound and lasers can be used to treat gallstones.

(a) Calculate the frequency of a sound wave that has a wavelength of 0.2 m when travelling through air. (Speed of sound waves in air is 330 ms^{-1}).

(2 marks)

(b) Explain why this sound wave **cannot** be described as 'ultrasound'.

(1 mark)

(c) When lasers are used to treat gallstones, the laser light is sent along optical fibres.

(i) Explain why these optical fibres must be made using glass that has a **high refractive index**.

.....

(3 marks)

(ii) One type of glass used to make optical fibres has a refractive index of 1.3. Calculate the critical angle for this type of glass.

(2 marks)

(iii) Explain what would happen to a ray of light, when travelling from this **glass into the air**, hits the glass/air boundary at an angle of incidence of 25°.

(3 marks)

(d) A patient has been given the choice of having his gallstones treated either by using ultrasound or a laser.
Critically evaluate the **advantages and disadvantages** of **each of these methods** in order to help the patient make his choice.

(4 marks)

5 (a) Write short descriptions of

(i) **Laser action** in terms of population emission and stimulated emission.

.....

(5 marks)

(ii) CO_2 laser

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(5 marks)

(b) Show that when a source of sound waves is moving away from the receiver, the frequency of the source, f, and the frequency of the receiver, f', are related by $f' = f/(1 + v_s/c)$.

(5 marks)