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| QUALIFICATION : **BACHELOR OF SCIENCE** | |
| QUALIFICATION CODE: **07BOSC** | LEVEL: **7** |
| COURSE: **BIOMEDICAL PHYSICS** | COURSE CODE: **BPH702S** |
| DATE: **JANUARY 2025** | SESSION: **1** |
| DURATION: **3 HOURS** | MARKS: **100** |

## FIRST OPPORTUNITY: EXAMINATION QUESTION PAPER

**EXAMINER:** *Dr Vaino Indongo*

**MODERATOR:** *Dr Vera Uushona-Mikka*

**INSTRUCTIONS:**

1. Answer all questions on the separate answer sheet.
2. Please write neatly and legibly.
3. Do not use the left side margin of the exam paper. This must be allowed for the examiner.
4. No books, notes and other additional aids are allowed.
5. Mark all answers clearly with their respective question numbers.

**PERMISSIBLE MATERIAL:**

Non-Programmable Calculator

**ATTACHEMENT**

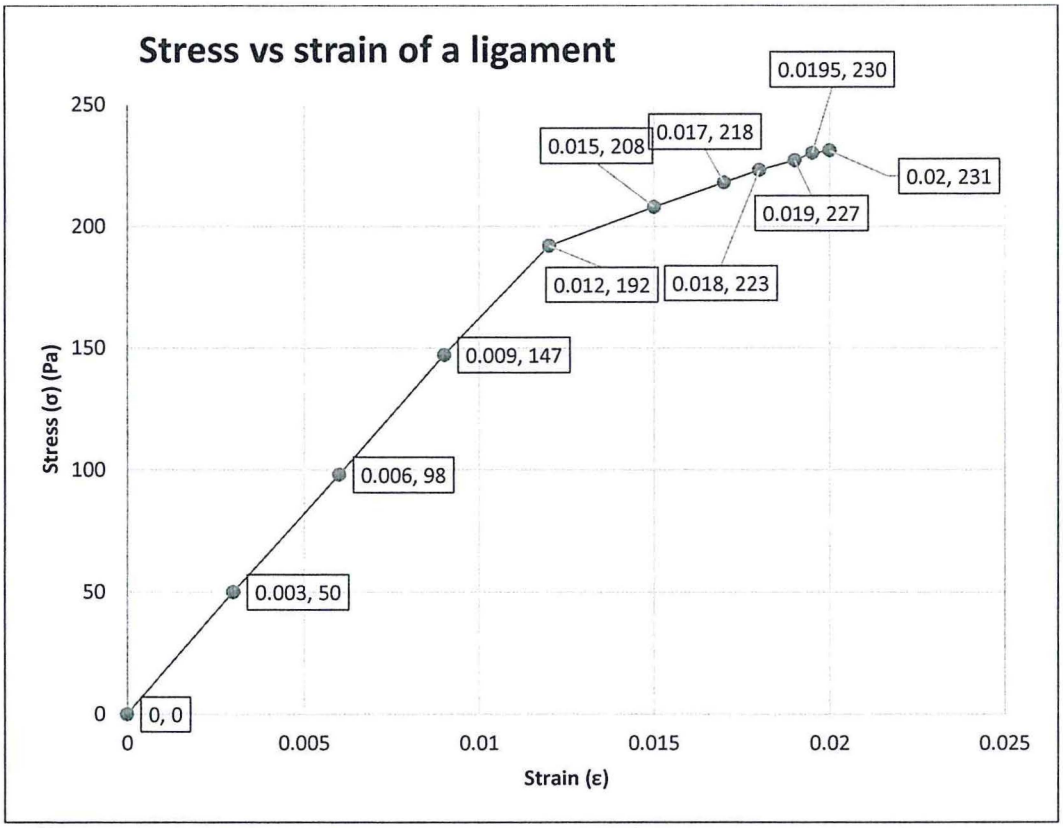
None

**This paper consists of 4 pages including this front page.**

## QUESTION 1 [20]

1.1 Briefly explain the terms: (i) mammography, (ii) radiography (4)

1.2 Study the diagram and answer the questions below.




(i) Define, in short, the term **strain** of a material. (1)
(ii) Estimate the elastic modulus of a ligament on the Stress-Strain curve? (3)
(iii) At what strain does the ligament reach its yield strength? (2)

1.3 List any three types of tissues in the human body. (3)

1.4 (i) State Graham's law of diffusion. (2)
(ii) Suppose that the concentration of blood passing through a vein in a human body has a diffusion constant ($D = 1.4 \times 10^{-3}\ m^2/s$). The radius and length of the vein are given as $2.3 \times 10^{-3}\ m$ and 0.8 m, respectively. Hint: ($K_B = 1.3806 \times 10^{-23}\ m^2.kg.s^{-2}.K^{-1}$, $T = 273\ K$). What would be the gradient of concentration given that $C_1 = 5 \times 10^6\ kg/m^3$ and $C_2 = 1 \times 10^6\ kg/m^3$. (5)

## QUESTION 2 [20]

2.1 A nozzle with a radius, $r_n = 20.00\ mm$ was attached to a garden hose of radius, $r_h = 4r_n$. The flow rate through hose and nozzle is 120.00 *L/s*.

(i) Calculate the speed of the water in the hose. (4)

2.2 Derive Bernoulli's equation. (8)

2.3 Stipulate and discuss the two main essential circuit of the cardiovascular system. (4)

2.4 Write down an expression of hydrostatic pressure ($dp$) with respect to depth or height ($dz$). (4)

## QUESTION 3 [20]

3.1 Calculate the intensity reflection coefficient, $I_R$, for a fat–liver interface.
Z (fat) = 1.65 x $10^6$ *Rayls* ; Z (liver) = 1.34x$10^6$ *Rayls*. (3)

3.2 Which nuclei produces nuclear magnetic resonance signal used to take an image of a human body? (1)

3.3 Determine the total nuclear spins following atoms;

(i) Tritium (2)
(ii) Sodium ($^{23}_{11}Na$) (2)

3.4 Mention the **time constant** which describes the return to equilibrium of the transverse magnetization, $M_{XY}$. (1)

3.5 A phosphorus sample is at equilibrium in a 1.5 *Tesla* magnetic field. A constant $B_1$ field of 2.34x$10^{-4}$ Tesla is applied along the +x'-axis for 17 microseconds. What is the direction of the net magnetization vector after the $B_1$ field is turned off? [$\gamma = 17.25\ MHz/T$] (5)

3.6 A radiation with a frequency of 3.13 x$10^{16}$ *Hz* releases an electron from a copper plate. The kinetic energy of the electron is 2.00 x$10^{-17}$ *J*.

***Note:*** Planck's constant, $h = 6.63 \times 10^{-34}\ Js$, 1 eV = 1.602x$10^{-19}$ *J*.

(i) Calculate the work function (in *eV*) on the copper plate. (4)

(ii) Estimate the energy of a photon (in *eV*) with a frequency of 5.4 x $10^{14}$ *Hz*. (2)

**QUESTION 4** **[20]**

4.1 Discuss the effects of increasing voltage on the x-ray tube? (4)

4.2 Current determines the number of photons the X-ray tube produces and another unit factor in X-ray quantity is the total exposure time, measured in seconds. The relative output (mAs) = current (*mA*) x time (*s*). Draw a relative output (mAs) vs voltage (*keV*) diagram showing peaks of 50, 100 and 150 *mAs*, with maximum voltage of 100 *keV* on the X-ray tube. (6)

4.3 An x-ray tube has a beam current of 15 mA and it is operated at a voltage of 40 kV. *Note that 1 C = 6.25 x $10^{18}$ electrons*, $c = 3.0\ x\ 10^{8} m/s$

(i) Determine the rate at which the machine transforms energy? (3)

(ii) How many electrons reach the target each second? (4)

(iii)Determine the wavelength of the photons at an energy of $5.2\ x\ 10^{-15}\ J$. (3)

**QUESTION 5** **[20]**

5.1 Briefly explain the following terms;

(i) Effective dose (2)

(ii) Half-life of a radionuclide (2)

(iii)Linear Energy Transfer (2)

5.2 Give the equation which expresses the Radioactive Decay Law, and explain the meaning of each of its terms. (4)

5.3 A radioactive substance consisting of 90,000 particles is found to have a decay constant of 0.0109/day.

(i) What is the half-life of a substance? (3)

(ii) Determine the activity of the substance. (3)

5.4 Differentiate malignant and benign tumors (4)

**END !!!!!!**