NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE (MAJOR AND MINOR)	
QUALIFICATION CODE: 7BOSC	**LEVEL:** 7
COURSE CODE: BPH702S	**COURSE NAME:** BIOMEDICAL PHYSICS
SESSION: JANUARY 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

SECOND OPPORTUNITY/SUPPLEMENTARY EXAMINATION PAPER	
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MODERATOR:	DR. NDESHIHAFELA VERA UUSHONA

INSTRUCTIONS	
1.	Write all your answers in the answer booklet provided.
2.	Read the whole question before answering.
3.	Begin each question on a new page.

PERMISSIBLE MATERIALS

Non-programmable Scientific Calculator

THIS MEMORANDUM CONSISTS OF 5 PAGES

(INCLUDING THIS FRONT PAGE)

QUESTION 1 **[20]**

1.1 Define the following terms: (i) tomography, (ii) radio-sensitivity, and (iii) nuclear magnetic resonance. (6)

1.2 State two medical imaging modalities whose performances are based on detections of gamma rays ejected from the patient's body where the inner structures are obtained as a result of spontaneous decays of radioisotopes. (2)

1.3 Explain, in short, why is **lubrication** essential on mechanical or human machines? (2)

1.4 A collagen of cross-sectional of $1.2 \times 10^{-2}\ m^2$ and mass ***m*** kg has a tensile strength of $2.3 \times 10^{4}\ Nm^{-2}$. Calculate the;

(i) breaking force of the collagen, and (3)

(ii) value of its mass, $g = 9.8\ m/s^2$. (2)

1.5 State two physical uses of bones in the skeleton. (2)

1.6 The application of physics is an important phenomenon in observing electrical activities of a biological material. Discuss in short the uses of the following instruments:

(i) Electroculography (1)

(ii) Electroencephalography (EEG) (1)

iii) Sphygmanometer (1)

QUESTION 2 **[30]**

2.1 Define flow rate and show that it is a product of cross-sectional area of a channel and velocity of fluid under consideration. (3)

2.2 Consider an incompressible fluid flowing at a steady rate through an enclosed pipe of cross-section. Use the information in Figure 1 to derive the equation of continuity. (5)

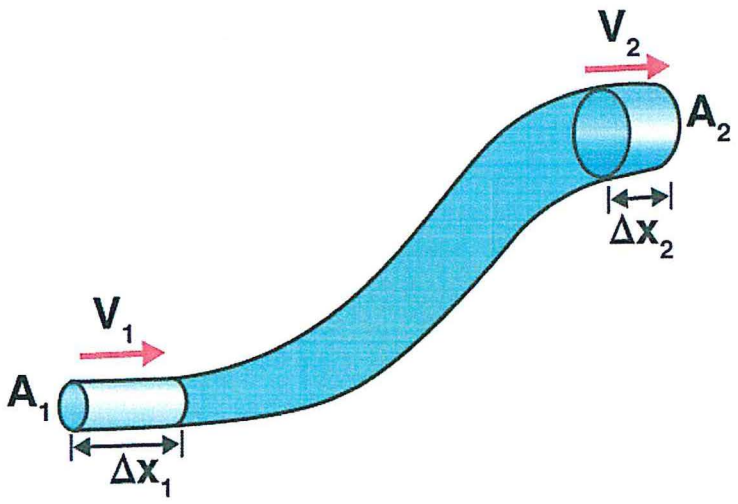

Figure 1

2.3 (i) State Bernoulli's principle in simple words. (2)

(ii) State and discuss any two entrainment devices that work on Bernoulli's principle by increasing fluid speed to create low pressures. (4)

2.4 Define a transducer. (1)

2.5 Elaborate on **refraction** of ultrasound, when an incident beam traverses through a body of the patient. (4)

2.6 Given that the ultrasound frequency of 2 MHz and wavelengths of 6.5 nm was used to take an image of a bone. Calculate the acoustic impedance of a bone if the density of a bone is 2.2×10^3 kg/m^3. (3)

2.7. Calculate the amplitude reflection coefficient for a fat–liver interface.

Z (fat) = 1.65×10^6 ; Z (liver) = 1.34×10^6. (4)

2.8. The relative sound intensity is measured on a logarithmic scale. Calculate the relative intensity of a sound beam when it is:

(i) reduced to a quarter. (2)

(ii) a six-fold increase. (2)

QUESTION 3 **[30]**

3.1 The human body is composed of 63% of hydrogen atoms. If we zoom into one of the hydrogens past the electron cloud we see a nucleus comprised of a single proton. The proton possesses a property called spin. State the properties of a spin. (4)

3.2 Many magnetic resonance imagers operate at a magnetic field strength of 1.5 Tesla. A few research units operate at 4.7 Tesla. What is the resonance frequency of the hydrogen nuclei in both magnetic fields? γ= 42.58 MHz/T (2)

3.3 A group of spins was placed into a magnetic field with the number of spins in the lower energy level of 5 and that in the upper level as 25. Calculate the energy difference ΔE between the spin states; k is Boltzmann's constant, 1.3805×10^{-23} J.K^{-1}; and the temperature is 27°C. (7)

3.4 A sample has a T_2 of 50 ms. The net magnetization of 100 T is rotated into the xy-plane and allowed to decay. How much transverse magnetization will be present 17 ms after being placed in the plane? (3)

3.5 An x-ray machine mounted in Khomas Medical Centre has tungsten ($^{184}_{74}W$) as a target material. One male patient with a fracture on the arm had to undergo radiographic procedure to determine the severity of a fracture. The radiologist has decided on the voltage of 90 keV and the radiographer recommended for 100 keV for settings during the procedure. These two medical personnel mutually agreed for an average potential difference to be set on the instrument. Calculate the energy of x-ray produced during this imaging procedure. (5)

3.6 An x-ray beam intensity of 170 mW/m^2 was focused to pass through aluminium material of half-value thickness $t_{1/2}$ = 1.4 cm. Estimate the strength of intensity after passing through a thickness of 2.0 cm for aluminium. (5)

3.7 Explain the attenuation by means of **absorption** and **scattering** of x-rays when passed through a human body for imaging purposes. (4)

QUESTION 4 **[20]**

4.1 State and discuss the law of radioactive decay. (4)

4.2 Explain in short the term biological half-life. (2)

4.3 Sodium-24 (^{24}Na) has a half-life of 15 hours.

(i) Estimate is its decay constant (s^{-1}). (2)

(ii) Calculate the activity of ^{24}Na radionuclide after 24 hours, when its activity A = 500 Bq at t = 0. (3)

4.4 Given that the activity of a radionuclide is $A = -dN/dt = \lambda N$ and decay constant is $\lambda = ln2/T_{1/2}$, prove that the mean life, $\tau = \frac{1}{\lambda}$. Show all steps. (5)

4.5 During radiotherapy, either radioactive or non-radioactive sources are used for efficient treatment of cancer. Give two reasons why collimators are crucial in the gantry of a radiotherapy equipment. (4)

END