NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE (MAJOR AND MINOR)	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 7
COURSE NAME: BIOMEDICAL PHYSICS	**COURSE CODE:** BPH702S
SESSION: JANUARY 2020	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

SUPPLEMENTARY/SECOND OPPORTUNITY EXAMINATION PAPER	
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MODERATOR:	DR ROSWITA HAMUNYELA

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

Scientific Calculator

ATTACHMENTS

None

THIS EXAMINATION PAPER CONSISTS OF 5 PAGES

(INCLUDING THIS FRONT PAGE)

QUESTION 1 [20]

1.1 Identify and discuss the principles of any two (2) imaging techniques used in diagnostic nuclear medicine. (6)

1.2 A concentration of blood passing through a vein within a human body has a diffusion constant, D = 1.4 x 10^{-2} m^2/s. The radius and length of the vein are given as 0.08 m and 0.15 m respectively. Hint: (K_B = 1.3806 × 10^{-23} $m^2.kg.s^{-2}.K^{-1}$, T = 343 K).

(a) Compute the gradient of concentration given that C_2 = 20 kg/m^3 and C_1 = 70 kg/m^3. (4)

(b) Estimate the coefficient of viscosity of blood. (4)

1.3 In medical physics profession, scientists apply physics concepts, theories and methods to healthcare. State four (4) physical applications applied to life sciences in **medical imaging techniques**. (4)

1.4 What are the two applications of biomechanics? (2)

QUESTION 2 [20]

2.1 Estimate the specific ionization resulting from the passage of a 0.20-MeV beta particle through standard air, given that the mean ionization for air is 34 eV/ip. The equation $\frac{dE}{dx} = \frac{2\pi q^4 NZ\,(3\,x\,10^9)^4}{E_m\beta^2(1.6\,x\,10^{-6})^2}\left\{\ln\left[\frac{E_m E_k \beta^2}{I^2(1-\beta^2)}\right] - \beta^2\right\}\frac{MeV}{cm}$ is used to compute the linear energy loss of a particle, where q is the charge on the electron, $1.6\,x\,10^{-19}C$, N is the number of absorber atoms per cm^3, NZ is of absorber electrons per $cm^3 = 3.88\,x\,10^{20}$ for air at 0^o and $76\ cm\ Hg$, E_m is the energy equivalent of the electron mass, 0.51 MeV, E_k is the kinetic energy of the beta particle in MeV, β is the speed of the ionization particle/speed of light, $\beta = {}^{v}/_{c}$, I is the mean ionization and excitation potential of absorbing atoms (MeV), $I = 8.6\,x\,10^{-5}$ for air, and $I = 1.35\,x\,10^{-5}Z$ for the substance. (14)

2.2 State and discuss how the two types of x-rays are generated in the x-ray tube. (6)

QUESTION 3 [20]

3.1 Derive Bernoulli's equation. (6)

3.2 A pipe has one end/side positioned on level (h_1) and the other is tilted upward at a height h_2. The pressure values of fluid within this pipe, both on level and up, are measured as P_1 and P_2, respectively. If the fluid flow is kept at steady flow, show that the height of the fluid on the tilted end of pipe is given by $h_2 = \frac{P_1 - P_2}{\rho g}$. Which pressure is greater? (8)

3.3 Study the diagram below (figure 1). The liquid in a container behaves like the ideal fluid. The pressure of still fluid inside the container and pressure of flowing fluid are the same as atmospheric pressure. A small hole is at level (2) at height y_2 and the water level at (1) drops slowly from height y_1 ($v_1 = 0$). Prove that $v_2 = \sqrt{2gh}$. (6)

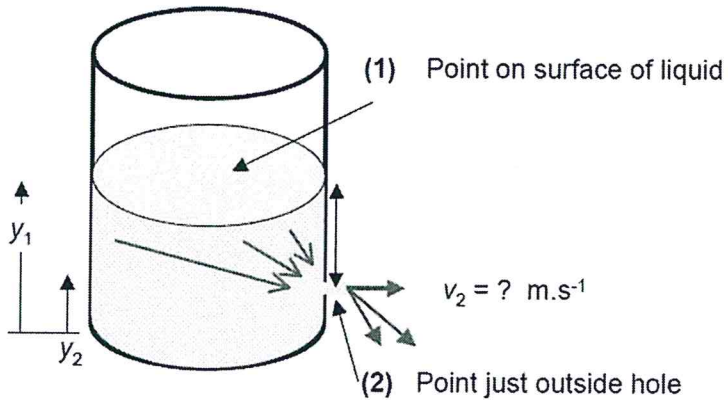

Figure 1

QUESTION 4 [20]

4.1 State any two applications of medical ultrasound. (2)

4.2 The average velocity of ultrasound in soft tissue is **1540 m/s**. Is the value higher, smaller or similar to velocity values in bone and in lung or air? Justify your answers. (4)

4.3 A continuous pulse of ultrasound beam with frequency of 20 MHz was used on the patient to measure the size of a fetus. Assumption is that the patient's organ (fetus) is a soft tissue ($\rho = 1.000\ {}^{g}/_{cm^3}$).

(i) Estimate the wavelength (λ) of the beam and acoustic impedance (Z) (4)

(ii) The distance from the ultrasound probe and the fetus is 5 cm. Compute the pulse-echo time. (4)

4.4 State the two sources of attenuation on the ultrasound beam. (2)

4.5 Provide reasons for applying the **gel** in ultrasound medical imaging. (2)

4.6 Define the term **piezoelectric** effect and state the function of the **piezoelectric transducer**? (2)

QUESTION 5 **[20]**

5.1 Define the following terms:

(i) Effective dose (2)

(ii) Linear Energy Transfer (2)

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

5.3 Many magnetic resonance imagers operate at a magnetic field strength of 1.5 Tesla. What is the resonance frequency of a deuterium nucleus in a magnetic field? (1)

Note that for ^{1}H: $\gamma = 42.58\ MHz/T$, and ^{2}H: $\gamma = 6.54\ MHz/T$.

5.4 A sample has a T_2 of 70 ms. The net magnetization is rotated into the xy-plane and allowed to decay to 50%. Estimate the time elapsed to reach transverse magnetization. (5)

5.5 A sample has a T_1 of 0.9 seconds. The net magnetization from the sample set equal to zero and then allowed to recover towards its equilibrium value. After 1.5 seconds, what fraction of the equilibrium magnetization value will be present? (5)

END OF EXAMINATION QUESTIONS