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: NOVEMBER 2019	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION PAPER	
EXAMINER(S)	MR VAINO INDONGO
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 Define the following terms:

(i) tumour (2)

(ii) radiotherapy (2)

1.2 Differentiate between **malignant** and **benign** tumours. (6)

1.3 The compressive strength of a bone is $1.8\ x\ 10^{10}\ N/m^2$. Estimate the compressive strain and Young Modulus of the bone which is 32 cm long, when compressed by 1.6 mm. (6)

1.4 (i) State Wolf's Law. (2)

(ii) Why is **lubrication** essential on mechanical or human machines? (2)

QUESTION 2 [20]

2.1 The following equation is used to compute a ***linear rate of energy loss,*** of radiation particle, due to excitation and ionization when electrons interact with a medium with atomic number Z.

$$\frac{dE}{dx} = \frac{2\pi q^4\ NZ\ (3\ x\ 10^9)^4}{E_m\beta^2(1.6\ x\ 10^{-6})^2}\{\ln\left[\frac{E_m E_k \beta^2}{I^2(1-\beta^2)}\right] - \beta^2\}\frac{MeV}{cm}$$

(i) Define the terms *q, E_m and E_k* in the equation. (3)

(ii) Calculate the speed of the ionization particle/speed of light, $\beta = {}^{v}/_{c}$, given that E_k = 0.1 MeV? (7)

2.2 Calculate the relative mass stopping power of graphite (to air), density = 2.26 g/cm^3, when a linear rate of energy loss $\frac{dE}{dx} = 2.94\ x\ 10^{-3}\ {}^{MeV}/_{cm}$ on a better beta particle. The density of standard air is $1.293\ x\ 10^{-3}\ {}^{g}/_{cm^3}$. (4)

2.3 Figure 1 illustrates the steady (laminar) flow of **incompressible** fluid through an enclosed tube/pipe.. Use the information on the diagram and derive the equation of continuity. (6)

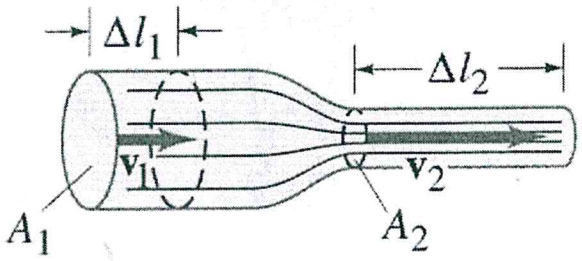

Figure 1

QUESTION 3 **[20]**

3.1 An 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 x 10^3 kg/m^3. (4)

3.2 If the intensity of reflected ultrasound is $R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$, show that the intensity for transmitted ultrasound wave is given by T = $\frac{4Z_1Z_2}{[Z_1+Z_2]^2}$. (6)

3.3 The relative sound intensity is measured on a logarithmic scale. Calculate the relative intensity of a sound beam when;

(i) It is reduced by 45%. (5)

(ii) There is a two-fold increase. (5)

QUESTION 4 **[20]**

4.1 State and discuss the law of radioactive decay. (5)

4.2 Sodium (^{24}Na) has a half-life of 15 hours. Estimate the activity of a 30 MBq source of ^{24}Na after 2.5 days. (5)

4.3 Define the following terms and stipulate there units (4)

(i) Dose rate (D)

(ii) Equivalent dose (D_e)

4.4 A Mo-99m/Tc-99m generator is in transient equilibrium. The radioactivity of Mo-99m/Tc-99m generator at time t_o is 16 GBq. After 156 hours the activity of mo-99m is 3.2 GBq if no milking takes place. Estimate the activity of the daughter nuclide. Note: Mo-99m $T_{1/2}$ = 67 hours and Tc-99m $T_{1/2}$ = 6 hours. (6)

QUESTION 5 **[20]**

5.1 Scintillation counters consist of a scintillation detector, mechanical parts and a lead collimator. Discuss how the scintillation counters work during imaging of patients in nuclear medicine. (6)

5.2 A magnetic field of 1.5 Tesla was passed through a nucleus of a hydrogen atom, ^{1}H. Also a x-ray photon ($f = 2 \times 10^{19}$ *Hz*) was passed through the same atom. **Hint:** Planck's constant $h = 6.626 \times 10^{-34}$ *Js*

(i) Compute the energy of a 2×10^{19} *Hz* x-ray photon? (4)

(ii) Calculate the energy of the photon that will be absorbed by a ^{1}H nucleus in a 1.5 Tesla magnetic field? (4)

(iii) Stipulate how the two energies compare, E_X/E_H? (2)

5.3 The net magnetization of magnetic resonance imaging (MRI) is set equal to zero, how long will it take for the net magnetization to recover to 92% of its equilibrium value on a sample which a T_1 of 1.0 seconds? (4)

END OF EXAMINATION QUESTIONS