

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

THIR YEAR EXAMINATIONS FOR THE AWARD OF DEGREE OF BACHELOR OF  
SCIENCE (GENERAL)  
PHYS 392: BIOPHYSICS

STREAMS: B.Sc (GENERAL)

TIME: 2 HOURS

DAY/DATE: WEDNESDAY 5/12/2018

2.30 P.M - 4.30 P.M.

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**INSTRUCTIONS:**

- Answer Question One in Section A and any other Two Questions in Section B
- Do not write anything on the question paper
- This is a closed book exam, No reference materials are allowed in the examination room
- There will be No use of mobile phones or any other unauthorized materials
- Write your answers legibly and use your time wisely

**Useful Constants**

Density of blood  $\rho_{blood} = 1.04 \times 10^3 \text{ kg/m}^3$

Viscosity of blood  $\eta_{blood} = 4 \times 10^{-3} \text{ Pa.s}$

Gravitational acceleration  $g = 9.8 \text{ m/s}^2$

**SECTION A**

**QUESTION ONE: [30 MARKS]**

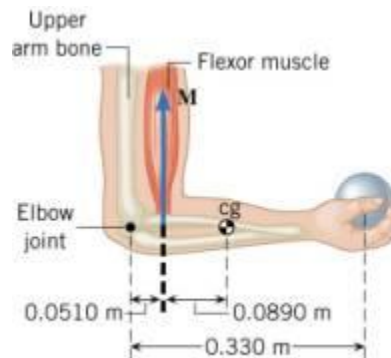
- a. Define the terms;
- i. Radioactivity [1 Marks]
  - ii. Electroinjection [1 Marks]
- b. Calculate the additional cardiovascular pressure in the following conditions due to gravity,
- i. At the feet due to the height column of about 125 cm [2 Marks]
  - ii. In the brain, for a man standing on his head. Use approximate length of 50 cm from the heart to the top of the head. [2 Marks]
- c. Calculate the total flow resistance of the cardiovascular system modelled such that the tubes are parallel to each other as shown in the figure 1.

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[2 Marks]

- d. Using the Boltzmann definition of entropy, show that second law of thermodynamics holds for naturally and spontaneous occurring biological processes. [2 Marks]
- e. Provide three examples of how weak and strong Extracellular Electric fields are used by cells and organisms. [3 Marks]
- f. Why are the electric properties of animal tissues frequency dependent? [2 Marks]
- g. What do you understand by passive Electrical properties of tissues. [1 Mark]
- h. A man holds a 178-N ball in his hand, with the fore arm horizontal. He can support the ball in this position because of the flexor muscle force,  $\mathbf{M}$ , which is applied perpendicular to the forearm. The forearm weighs 22.0 N and has a center of gravity as indicated. Find;
- i. the magnitude of  $\mathbf{M}$  and [3 Marks]
- ii. the magnitude and direction of the force applied by the upper arm bone to the forearm at the elbow joint. [2 Marks]



- i. Why are some isotopes radioactive and others not? [3 Marks]
- j. The half-life of Technetium 99m is 6.0 h. 12 mg of Technetium 99m is injected into a patient and starts to decay into Technetium 99. Calculate the amount of Technetium 99 present in the patient after 24 hours. [3 Marks]
- k. Explain why human blood relative viscosity shows a pseudo plastic thixotropic behavior. [3 Marks]

**SECTION B**

**QUESTION TWO :[20 MARKS]**

Consider the person lifting a heavy box with his back, shown in figure 2.

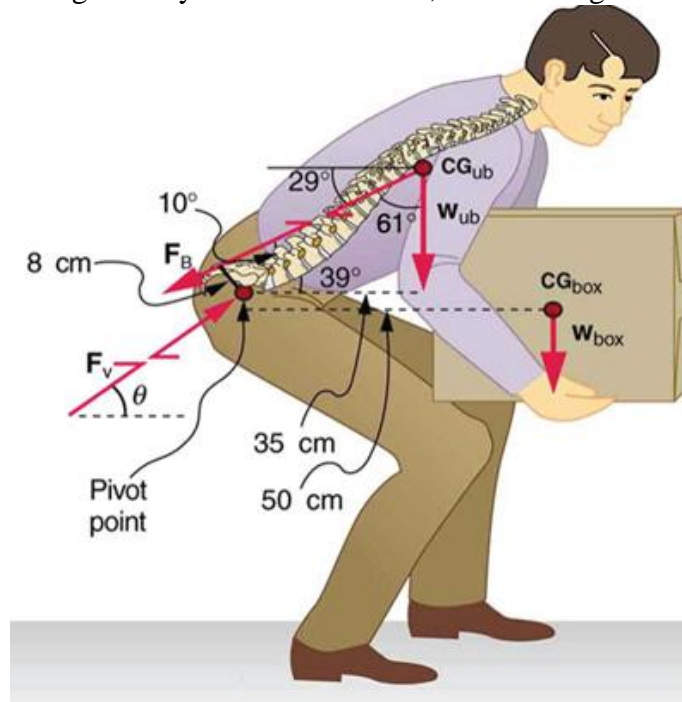


figure 2

- i. Calculate the magnitude of the force  $F_B$  in the back muscles that is needed to support the upper body plus the box and compare this with his weight. The mass of the upper body is 55.0 kg and the mass of the box is 30.0 kg. [4 Marks]
- ii. Compare the force calculate in (i) above with the force  $F_B$  in the back muscles that is needed to support the upper body alone. [3 Marks]
- iii. Calculate the magnitude and direction of the force  $F_V$  exerted by the vertebrae on the spine at the indicated pivot point. Again, data in the figure may be taken to be accurate to three significant figures. [10 Marks]
- iv. Discuss why it's safer to lift with the back erect. [3 Marks]

**QUESTION THREE: [20 MARKS]**

- a. What do you understand by laminar flow [2 Marks]
- b. The resistance  $R$  of flow  $Q$  of a liquid, determined by the pressure difference  $\Delta p$  between two points in a tube is given as  $R = \frac{8\eta L}{\pi r^4}$  where  $\eta$  is the viscosity,  $L$  is the tube of length, radius  $r$ .
  - i. Derive the equation by first deriving Hagen-Poiseulli equation assuming laminar flow. [10 Marks]

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- ii. What two quantities in the equation above represent the two sources of resistance to fluid flow? [2 Marks]
- iii. State two ways you would employ to increase the rate of flow of water in a tube of fixed length (assume viscosity is constant) [2 Marks]
- c. Calculate the resistance of the Aorta and use the following quantities,  $L_{aorta} = 30 \text{ cm}$ ,  $r_{aorta} = 1.3 \text{ cm}$ ,  $\eta$  of blood =  $4 \times 10^{-3} \text{ Pa.s}$  [4 Marks]

### QUESTION FOUR: [20 MARKS]

- a. Differentiate between electropermeabilization and electrofusion. [2 Marks]
- b. List and explain three origins of extracellular Electric fields [6 Marks]
- c. Draw a simplified analog circuit of a simple spherical cell suspended in a medium demonstrating current through and around the cell. Depict in your diagram the resistance of the external medium, resistance of the cytoplasm and resistance of the membrane, capacity of the membrane and the reference potentials. [5 Marks]
- d. By reducing your circuit in b above, discuss the behavior of a low frequency current in the extracellular space. [3 Marks]
- e. Using sketches explain the behavior of external electric fields of low and high frequency currents through a cell. [4 Marks]

### QUESTION FIVE: [20 MARKS]

- a. In radioactive decay the number  $N$  of nuclei present at time  $t$  is described by the equation,  $N = N_0 e^{-\lambda t}$ , where  $N_0$  is the number originally there and  $\lambda$  is a constant.
- i. Define  $\lambda$  and give its units if  $t$  is in hours [2 Marks]
- ii. Obtain an expression for  $\lambda$  in terms of half-life of the radiative material [2 Marks]
- b. A freshly prepared sample of a radioactive isotope contains  $1 \times 10^{14}$  nuclei. If the half-life of the isotope is 12 hours, determine the following,
- i. The initial activity of the sample [3 Marks]
- ii. The number of radioactive nuclei remaining after one hour [3 Marks]

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c. The number of radioactive isotopes in a sample decayed as follows:

|                               |    |     |     |     |     |     |
|-------------------------------|----|-----|-----|-----|-----|-----|
| Number N of atoms x $10^{14}$ | 12 | 7.8 | 5.6 | 4.2 | 3.4 | 2.6 |
| Time t in hours               | 0  | 1   | 2   | 3   | 4   | 5   |

- i. Draw N versus t graph [3 Marks]
- ii. From the graph determine the half-life of the material [3 Marks]

d. Why is Tc-99m suitable for medical imaging? Give four reasons. [4 Marks]

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