THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF SCIENCE DEGREE PROGRAMME–LEVEL 04
FINAL EXAMINATION 2024/2025
BIOPHYSICS–PHU5304
Duration: TWO HOURS (2 hrs)

Date: 28th November 2024 **Time 9.30 am -11.30 am**

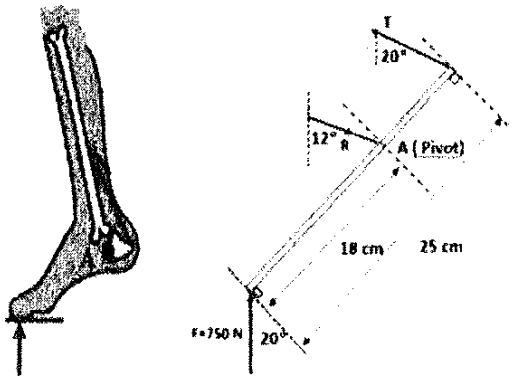
Answer Four (4) questions only

Stefan -Boltzmann constant (σ) = 5.67×10^{-8} W $m^{-2}K^{-4}$, Rydberg constant (R_H)= 1.09737×10^{7} m^{-1}, speed of light (c) = 3.0×10^{8} m s^{-1}, Plank's constant (h) = 6.63×10^{-34} J s, Threshold intensity of hearing (I_O)= 1×10^{-12} W m^{-2} and Gravitational acceleration (g) = 9.8 ms^{-2}.

1.**(a)** A person needs 2500 kcal day^{-1} to maintain his current weight. He reduces his intake to 2000 kcal day^{-1}. If 1 kg of body fat is approximately equal to 7700 kcal, estimate the number of days it would take for this person to lose 1 kg, assuming no change in their activity level.

(30 marks)

(b). When a person stands on his/her toes, his/her weight is supported by the normal force from the floor. A simplified model of the foot in this position is depicted in the figure below, where T represents the tension in the tendon, and R represents the force exerted by the tibia on the foot. Given that the person's weight is 750 N, determine the values of T and R. **(30 marks)**



(c). Describe the differences between myopia and hypermetropia, explaining how each condition affects the eye's ability to focus light on the retina. **(20 marks)**

(d). A person with myopia has a far point at 50 cm. Calculate the power of the lens required to correct the vision and bring the far point to infinity. **(20 marks)**

2. (a). Write down the mathematical formula for sound intensity level in dB. Show that if one sound is twice as intense as another, it has a sound level about 3 dB higher. **(25 marks)**

(b). A sound waves travels from Material A which has a density of 1500 kg m^{-3} and a speed of sound of 3000 m s^{-1} to Material B which has a density of 2000 kg m^{-3} and a speed of sound of 2500 m s^{-1}. Calculate the reflection coefficient of the sound wave at the interface between Material A and Material B. **(30 marks)**

(c). What are the primary mechanisms of regulation of body temperature regulation and the role of the hypothalamus in this process? **(15 marks)**

(d). A human body at 37 °C radiates heat to the environment which is at 27 °C. Assuming the body has a surface area of 1.8 m^2 and an emissivity of 0.97, calculate the rate of heat loss by radiation. **(30 marks)**

3. (a). For which types of particles is the de Broglie wavelength most prominent? Provide reasoning and illustrate your answer with two examples. An electron of mass 9.11×10^{-31} kg is fired from an electron gun and has a de Broglie wavelength of 1.07×10^{-10} m. Determine the anode voltage necessary to produce this specific wavelength **(25 marks)**

(b). Write down the expression for the energy levels of atomic hydrogen in terms of its quantum number. Calculate the wavelength of the first line in the Lyman series, and demonstrate that it falls within the ultraviolet (UV) range of the electromagnetic spectrum. **(25 marks)**

(c). Explain following terms briefly;

(i). Isothermal process

(ii). Isobaric process

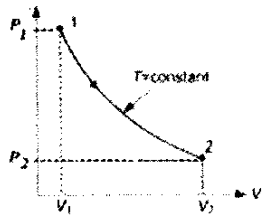
(iii). Isochoric process

(iv). Adiabatic process

(20 marks)

(d). An ideal gas of mass m undergoes a quasi-static isothermal processes at temperature T. The initial and final pressure and volume are P_1, V_1 and P_2, V_2 respectively. Show that the work done by the gas is,

$$W = mR \ln\left(\frac{P_1}{P_2}\right) = mR \ln\left(\frac{V_2}{V_1}\right)$$



(30 marks)

4. (a). What is diffusion of particles or molecules, and how does it occurs at a molecular level?

(20 marks)

(b). If the diffusion coefficient of a molecule is 1.0×10^{-10} m^2 s^{-1} how much time would it take for the molecule to achieve a mean square displacement of 3.0×10^{-6} m^2 in a 3D medium?

(20 marks)

(c). Calculate the terminal velocity of a spherical particle with radius r = 1 x 10^{-6} m and density ρ_P= 2000 kg m^{-3} falling in a fluid with density ρ_L = 1000 kg m^{-3} and viscosity η = 1.0 x 10^{-3} Pa s. **(30 marks)**

(d). In an experiment, large protein molecules with a diameter of 4 nm are settling under gravity in a fluid with a viscosity of 4×10^{-3} N m^{-2}. The densities of the protein molecules and the fluid are 4.5×10^3 kg m^{-3} and 1.5×10^3 kg m^{-3} respectively. Calculate the sedimentation coefficient of the protein molecules. **(30 marks)**

5. (a). What is meant by interference of light? List three conditions required for light waves to interfere? **(20 marks)**

(b). Explain briefly the difference between constructive and destructive interference. **(20 marks)**

(c). In a Young's double-slit experiment setup, the slit separation d is 0.2 mm and the screen is placed 1.5 m away. If the forth bright fringe is observed at a distance 1.8 cm from the central maximum, what is the wavelength of the light used? **(30 marks)**

(d). In a Young's double-slit experiment, a thin transparent film with a thickness of 6.3×10^{-4} cm is introduced into the path of one of the interfering beams. It is observed that the central fringe shifts to the position originally occupied by the sixth bright fringe. Given that the wavelength of the light used is 5460 Å, determine the refractive index of the film **(30 marks)**

6.(a). Briefly define following terms in crystals;
(i). Structure
(ii). Lattice
(iii). Basis
(iv). Unit cell **(20 marks)**

(b). An X-ray diffraction experiment using Cu Kα radiation (λ=1.54 A˚) shows the first-order diffraction peak at a 2θ angle of 28.5° for a crystal with a simple cubic structure. Calculate the interplaner spacing of that crystal. **(30 marks)**

(c). Illustrate the crystal planes represented by (111), (100), (110), and (101). **(20 marks)**

(d). An X-ray beam of wavelength 1.2 Å falls on a protein crystal. Find the possible angles of incidence which provide maxima of the planes with miller indices (121) which are separated by 2.3 Å. **(30 marks)**

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