University of Ruhuna- Faculty of Technology

Bachelor of Biosystems Technology Honours Degree
Level 2 (Semester I) Examination, June/July 2026
Academic year 2024/2025

Course Unit: BST2123-Engineering Properties of Biomaterials (Written)

Duration: 2 hours

INSTRUCTIONS:

- Answer any **FOUR (04)** out of the five questions provided.
- Use a separate answer booklet for your answers.
- Each question must begin on a new page
- If more than four questions are answered, only the **first four** will be marked.

1. Beer is an alcoholic beverage derived from grains, fermented by yeast and is the third most popular beverage in the world, following water and tea.

    a. Briefly discuss five (5) quality parameters which are important to maintain the quality of beer. (20 Marks)

    b. "Particle size distribution of grist is an important parameter in beer production." Discuss the statement. (30 Marks)

    c. In the cooling stage of beer production (after wort boiling), the wort enters a heat exchanger at 90 °C and must be cooled to 6 °C before fermentation. A batch of 5,000 kg of wort is processed. Specific heat capacity of wort is $C_p = 3.8$ kJ/kg·K.

        i. Calculate the total heat energy that must be removed from the wort to cool it from 90 °C to 6 °C. (20 Marks)

        ii. Propose one engineering improvement to reduce energy consumption during this cooling step, considering the biomaterial properties of wort. (10 Marks)

        iii. The cooling is achieved using chilled water that enters the heat exchanger at 2 °C and exits at 15 °C. Calculate the mass of chilled water required for this batch cooling process. (20 Marks)

(Total-100 Marks)

2. Ohmic heating, pulsed electric field (PEF) processing, and microwave heating are novel processing techniques that operate based on the electrical properties of biomaterials.

a. State the electrical property involved in each technique. (15 Marks)

b. Discuss the similarities and differences between ohmic heating and PEF processing techniques. (35 Marks)

c. A simplified circuit diagram of an ohmic heating setup used to heat a food sample in cylinder is shown in Figure 01. The length of the cylinder is 5.0 cm, and the cross-sectional area is 0.8 cm^2.

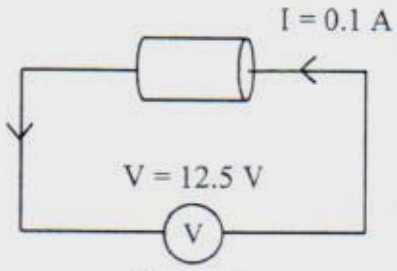


Figure 01

i. Calculate the resistance of the sample. (10 Marks)

ii. Calculate the electrical conductivity of the sample material. (20 Marks)

iii. In a fruit processing unit, apples and strawberries are subjected to ohmic heating until they reach a temperature of 50 ^0C. Predict which fruit will take the least time for the process considering their electrical conductivities. Justify your answer by giving reasons.
(Electrical conductivity of apples and strawberries are 0.067 S/m and 0.186 S/m, respectively). (20 Marks)

(Total-100 Marks)

3. A food packaging company is developing an environmentally friendly edible film made from seaweed polysaccharides. The film is intended to replace conventional single-use plastic wrappers for food packaging.

   a. Explain why toughness is more important than hardness for packaging films made from seaweed polysaccharides. (20 Marks)

   b. A tensile test on a natural fiber-reinforced biopolymer composite gives the following results:

      Original length = 50 mm, original cross-section = 10 mm^2

      Maximum load before fracture = 1200 N

      Total elongation at fracture = 2.5 mm

      Energy absorbed until fracture (from the area under stress-strain curve) = 1.2 J

      i. Calculate the tensile strength (in MPa). (20 Marks)

      ii. Calculate the engineering strain at fracture (in %). (20 Marks)

      iii. Calculate the toughness (in MJ/m^3). (20 Marks)

   c. The edible film's stress-strain curve shows no plastic region and fractures immediately after the proportional limit.

      i. State the type of behavior exhibited by the edible film. (10 Marks)

      ii. Explain whether the edible film is suitable or not for a food wrapper. (10 Marks)

(Total-100 Marks)

4. The post-harvest processing plant handles large quantities of corn kernels and wheat flour for storage and further processing. The plant uses a grain silo to store corn and a screw conveyor to transport flour to the packaging units.

   a. State five (05) factors that affect the friction. (15 Marks)

   b. A triaxial test on a sample of corn kernels resulted in an angle of internal friction (α) of 32°.

      i. Calculate the coefficient of internal friction (μ). (20 Marks)

ii. In a grain silo, the lateral pressure on the wall depends on both internal and wall friction. If the wall friction angle is 20° and the internal friction angle is 32°, which one is more likely to cause grain arching? Explain using the concept of shear resistance. (20 Marks)

iii. If the internal friction angle increases to 40° due to higher moisture, what happens to the ability of the grain to withstand shear stress? (10 Marks)

c. If the screw conveyor is used to transport wet flour instead of dry flour.

i. Explain two factors that alter the friction force. (15 Marks)

ii. State whether the required motor power would increase or decrease compared to handling dry flour, and justify your answer. (20 Marks)

(Total-100 Marks)

5. Ultrasonic pulse velocity (UPV) and differential scanning calorimetry (DSC) are two essential characterization techniques for biomaterials.

a. What is ultrasonic pulse velocity (UPV)? Explain why it is classified as a non-destructive test. (20 Marks)

b. A UPV test is performed on a fracture filled with a bio-composite of concrete column using the direct transmission method. The path length is 0.8 m, and the transit time is 160 μs.

i. Calculate the UPV in m/s. (20 Marks)

ii. If the pulse velocity in a second column of the same length is 4200 m/s, calculate its transit time in μs. (20 Marks)

c. A DSC curve for a polylactic sample shows a melting peak at 130 °C with an enthalpy of fusion (ΔH) of 200 J/g. The known enthalpy of fusion for 100% crystalline polylactic is 290 J/g. Calculate the percent crystallinity. (40 Marks)

(Total-100 marks)

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