UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER

PROGRAM	:	BACHELOR OF SCIENCE IN FOOD SCIENCE, NUTRITION AND TECHNOLOGY YEAR II
COURSE CODE	:	FSNT 205
TITLE OF PAPER	:	PRINCIPLES OF FOOD ENGINEERING
TIME ALLOWED	:	TWO (2) HOURS
INSTRUCTIONS	:	ANSWER QUESTION ONE (1) AND ANY OTHER TWO (2) QUESTIONS. ILLUSTRATE YOUR ANSWERS WITH DIAGRAMS WHERE NEEDED

DO NOT OPEN THIS PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE CHIEF INVIGILATOR

QUESTION 1 [COMPULSORY]

(a) Canned food is thermally treated in a sterilizer whose processing temperature is 135°C. If the initial microbial load is 1000 CFU/container and it is desired to reduce it to 10^{-6} CFU/container, calculate the processing time. The target microorganism for this thermal process has a decimal reduction time of 3 min for a reference temperature of 121°C, and to reduce the process time to the tenth part (reduce by 90%) it is required to increase the temperature by 10°C. (j_h = 2, f_h = 35, Initial product temperature is 25 °C). **(15 Marks)**

(b) Orange juice flowing through a pipe at a rate of 30 kg/min is sweetened by adding concentrated sugar solution (30 % sugar) to the pipe line at constant rate. At what rate would the concentrated sugar solution be added to provide 10% sugar in the product? **(10 Marks)**

(c) The wall of a cold store is made of concrete lined with insulator. The temperature of the inner wall surface is 5°C and that of the outer surface is 25°C. The thickness of the concrete layer is 10 cm and the thickness of the insulation is 8 cm. The thermal conductivity of concrete and the insulator is 1.5 W/m°C and 0.056 W/m°C respectively, Calculate the total resistance of the wall to heat transfer and the heat transfer losses through the wall if the wall area is 16 m^2. **(15 Marks)**

[TOTAL MARKS = 40]

QUESTION 2

(a) Explain the following: **(20 Marks)**
  i. Lethal rate
  ii. Constant rate drying period
  iii. Hysteresis
  iv. Decimal reduction time
  v. Thermal Death Time (TDT) curve

(b) Explain why one has to be concerned about micro-organisms during thermal processing of foods. **(10 Marks)**

[TOTAL MARKS = 30]

QUESTION 3

(a) Outline the advantage of multiple effect evaporation system and show a three-effect backward feed type evaporation system. **(10 Marks)**

(b) For a continuous counter current multi stage (with n – stages) extraction system, write the mass balance equation **(10 Marks)**
   i. for the whole system
   ii. between the first stage and any intermediate stage *"i"*

(c) Outline the advantages of continuous operation. **(10 Marks)**

[TOTAL MARKS = 30]

QUESTION 4

(a) Explain the principle behind separation by filtration and centrifugation. **(10 Marks)**

(b) With the help of sketch, explain the constant rate and constant pressure filtration systems. **(10 Marks)**

(c) Define psychrometry and describe the drying or adiabatic saturation process. **(10 Marks)**

[TOTAL MARKS = 30]

Relationships f_h/U for Values of z = 10 °C

f_h/U	Values of g (°C) when j is:								
	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
0.2	2.27×10^{-5}	2.46×10^{-5}	2.64×10^{-5}	2.83×10^{-5}	3.02×10^{-5}	3.20×10^{-5}	3.39×10^{-5}	3.58×10^{-5}	3.76×10^{-5}
0.4	7.39×10^{-3}	7.94×10^{-3}	8.44×10^{-3}	9.00×10^{-3}	9.50×10^{-3}	1.00×10^{-2}	1.06×10^{-2}	1.11×10^{-2}	1.16×10^{-2}
0.6	4.83×10^{-2}	5.24×10^{-2}	5.66×10^{-2}	6.06×10^{-2}	6.44×10^{-2}	6.83×10^{-2}	7.28×10^{-2}	7.67×10^{-2}	8.06×10^{-2}
0.8	0.126	0.136	0.148	0.159	0.171	0.182	0.194	0.205	0.217
1	0.227	0.248	0.269	0.291	0.312	0.333	0.354	0.376	0.397
2	0.85	0.92	1.00	1.07	1.15	1.23	1.30	1.38	1.45
3	1.46	1.58	1.69	1.81	1.93	2.04	2.16	2.28	2.39
4	2.01	2.15	2.30	2.45	2.60	2.74	2.89	3.04	3.19
5	2.47	2.64	2.82	3.00	3.17	3.35	3.53	3.71	3.88
6	2.86	3.07	3.27	3.47	3.67	3.88	4.08	4.28	4.48
7	3.21	3.43	3.66	3.89	4.12	4.34	4.57	4.80	5.03
8	3.49	3.75	4.00	4.26	4.51	4.76	5.01	5.26	5.52
9	3.76	4.03	4.31	4.58	4.86	5.13	5.41	5.68	5.96
10	3.98	4.28	4.58	4.88	5.18	5.48	5.77	6.07	6.37
20	5.46	5.94	6.42	6.89	7.37	7.84	8.32	8.79	9.27
30	6.39	6.94	7.56	8.11	8.72	9.33	9.89	10.5	11.1
40	7.11	7.72	8.39	9.06	9.72	10.4	11.1	11.7	12.4
50	7.67	8.39	9.11	9.83	10.6	11.3	12.0	12.7	13.4
60	8.22	8.94	9.72	10.5	11.2	12.0	12.7	13.5	14.3
70	8.67	9.38	10.2	11.1	11.8	12.6	13.4	14.2	15.0
80	9.01	9.89	10.7	11.6	12.3	13.2	14.0	14.8	15.6
90	9.44	10.28	11.2	12.0	12.8	13.7	14.5	15.3	16.2
100	9.78	10.7	11.6	12.4	13.3	14.1	15.0	15.8	16.7

UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION PAPER

PROGRAM   :   BACHELOR OF SCIENCE IN FOOD SCIENCE, NUTRITION AND TECHNOLOGY YEAR II

COURSE CODE   :   FSNT 205

TITLE OF PAPER   :   PRINCIPLES OF FOOD ENGINEERING

TIME ALLOWED   :   TWO (2) HOURS

INSTRUCTIONS   :   ANSWER QUESTION ONE (1) AND ANY OTHER TWO (2) QUESTIONS. ILLUSTRATE YOUR ANSWERS WITH DIAGRAMS WHERE NEEDED

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QUESTION 1 [COMPULSORY]

(a) Find two equivalent processes, at 100 °C and 150 °C, which will deliver the same 9 log cycle reduction lethality. Take D_{121} value of 2 minute and z value of 10.5°C.

(10 Marks)

(b) 2000 kg/h of a fruit juice with 10% solids is freeze-concentrated to 30% solids. The dilute juice is fed to a freezer where the ice crystals are formed and then the slush is separated in a centrifugal separator into ice crystals and concentrated juice. If the ice crystals stream is composed of 10% concentrated juice and the balance pure crystal, calculate the amount of ice that is removed in the separator and the amount of concentrated juice produced. Assume steady state. **(15 Marks)**

(c) The wall of a cold store is made of brick lined with insulator. The temperature of the inner wall surface is 5°C and that of the outer surface is 25°C. The thickness of the concrete layer is 10 cm and the thickness of the insulation is 8 cm. The thermal conductivity of concrete and the insulator is 2 W/m°C and 0.04 W/m°C respectively, Calculate the total resistance of the wall to heat transfer and the heat transfer losses through the wall if the wall area is 20 m². **(15 Marks)**

[TOTAL MARKS = 40]

QUESTION 2

(a) Explain the following: **(20 Marks)**
   i. Slowest heating point in can
   ii. Falling rate drying period
   iii. Hysteresis
   iv. Z-value
   v. Survivor curve

(b) Explain why one has to be concerned about micro-organisms during thermal processing of foods.   **(10 Marks)**

[TOTAL MARKS = 30]

QUESTION 3

(a) With the help of sketch, describe a three-effect multiple evaporation system with a parallel feed. **(10 Marks)**

(b) Describe the stages in solid-liquid extraction system. **(10 Marks)**

(c) Outline the advantages of batch operation. **(10 Marks)**

[TOTAL MARKS = 30]

QUESTION 4

(a) Outline the similarities and differences between gravitational settling and centrifugal separation. **(10 Marks)**

(b) With the help of sketch, explain the constant rate and constant pressure filtration systems. **(10 Marks)**

(c) Define psychrometry and list the moist air properties that can be read from a psychrometric chart **(10 Marks)**

[TOTAL MARKS = 30]

Relationships f_h/U_g for Values of $z = 10\,°C$

f_h/U				Values of g (°C) when j is:					
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0.6	4.83×10^{-2}	5.24×10^{-2}	5.66×10^{-2}	6.06×10^{-2}	6.44×10^{-2}	6.83×10^{-2}	7.28×10^{-2}	7.67×10^{-2}	8.06×10^{-2}
0.8	0.125	0.136	0.148	0.159	0.171	0.182	0.194	0.205	0.217
1	0.227	0.248	0.269	0.291	0.312	0.333	0.354	0.376	0.397
2	0.85	0.92	1.00	1.07	1.15	1.23	1.30	1.38	1.45
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40	7.11	7.77	8.39	9.06	9.77	10.4	11.1	11.7	12.4
50	7.67	8.39	9.11	9.83	10.6	11.3	12.0	12.7	13.4
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80	9.01	9.89	10.7	11.6	12.3	13.2	14.0	14.8	15.6
90	9.44	10.28	11.2	12.0	12.8	13.7	14.5	15.3	16.2
100	9.78	10.7	11.6	12.4	13.3	14.1	15.0	15.8	16.7