UNIVERSITY OF GHANA

BSC. ENGINEERING FIRST SEMESTER EXAMINATIONS: 2017/2018

DEPARTMENT OF FOOD PROCESS ENGINEERING

FPEN 401: FOOD PLANT DESIGN AND ECONOMICS (3 Credits)

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS

TIME ALLOWED: THREE (3) HOURS

1.

a. Using the process data, design variables, and process specifications given in the table below for a conveyor belt dryer, determine

i. The evaporating capacity (W)
ii. The drying air humidity (Y)
iii. The thermal efficiency
iv. Length of dryer
v. The specific rate of evaporation
vi. The recycle air flow rate

Process Data	Design variables	Process Specification
Specific heat (kJ/kg K)		Process Specifications
C_{pL} = 4.2 water	V = 2.5 m/s drying air velocity	F = . 750 kg/kg db Feed flow rate
C_{pV} = 1.90 water vapour	D = 2.0 m Dryer diameter	X_o = 0.85 kg/kg db initial moisture content
C_{PA} = 1.00 air		X = 0.10 kg/kg db final moisture content
C_{PS} = 2.0 solid material		d = 0.05m material characteristic size
Dry material= 3.73		T_o = 26°C Ambient temperature
Latent Heat (MJ/kg)		T = 95 °C drying air temperature
H_o = 2.50 Steam condensation at O°C		Y_o = 0.02 Ambient humidity
Heat transfer Coefficient (KW/m²K)		T_s = 165°C Heating steam temperature
U_s = 0.1 air heater		P = 1.00 bar
Density (kg/m³)		F = 1.3 F_a
ρ_w = 1000		
ρ_a = 1		
ρ_s = 1750		

b. Compare a rotary dryer to a conveyor belt dryer in terms of their cost and usage.
c. Briefly discuss how the following parameters affect the equipment cost and operating cost for a conveyor belt dryer:
   i. high temperature
   ii. low humidity
   iii. high air velocity

2.

a. An existing plate heat exchanger in a factory is used to heat mixed fruit juice. The mixed fruit juice stream which flows at a rate of F (kg/s) enters the heat exchanger at a temperature of T_1 (°C) and is heated up to a temperature of T_2 (°C) before exiting. The hot water stream which provides the heat enters and leaves the plate heat exchanger at a temperature of T_{w1} (°C) and T_{w2} (°C) respectively. The hot water flows at a rate of F_w (kg/s). The hot water stream flows countercurrent to the mixed fruit juice stream (process stream). Determine
   i. The thermal load (Q)
   ii. The heating water inlet temperature (T_{w1})
   iii. The friction pressure loss on the hot water stream side.

Process Specifications	Technical Data	Design Variables
F = 28,800 kg/h, process stream flowrate	ρ = 1000 kg/m^3	b = 5 mm
T_1 = 60°C, Feed Temperature	ρ_w = 960 kg/m^3	n = 5
T_2 = 90°C, Target Temperature	Cp_w = 4.18 KJ/kg K	u = 1.6 u_w
Tw_2 = 95°C, Heating water outlet Temperature	Cp = 3.86 KJ/Kg K	
f = 0.00124, Fanning friction coefficient of process stream side	η = 0.40 mPas	
	η_w = 0.25 mPas	
	λ = 0.65 W/mK	
	λ_w = 0.65 W/mK	

b.
   i. State the assumption made in the design of a plate heat exchanger.
   ii. How does the spacing of the plate heat exchanger influence the capital cost and operating cost?
   iii. Why is it important to consider the number of groups in series (n) in the design of a plate heat exchanger?

3.

a.

i. What is the difference between simple interest and compound interest?

ii. What is annuity?

b. How long would it take an amount of GH¢ 4,000 invested at an interest rate of 21% per year, compounded quarterly to reach GH¢ 16,000?

c. Excellent bank has offered you GH¢ 40,000 30 – year loan to purchase an equipment in your Factory. The loan payments are to be made on monthly basis. If the total payment at the end of the thirty-year period is GH¢ 134964.00. Determine the effective annual interest rate if the interest is compounded monthly.

d. Suppose your parents have decided that after your graduation at the end of the year they would start to save money to help pay for your younger sister to attend University to study Food Process Engineering. They plan to save money for 5 years before she starts college and to save during her university years. They plan to contribute GH¢4,000 per year at the start of each of her 4 university years. Your parents would thus make monthly payments for 8 years; 5 year prior to and 3 during your sister's university education. The monthly interest rate earned on their savings is 0.45%. How much must the monthly savings be under this condition?

4.

a. Define corporate social responsibility (CSR) and briefly discuss the benefits and concerns of CSR.

b. If you were the Chief Executive Officer of a Food Factory state **FIVE** CSR activities you would promote in your company. Give reasons for your choices.

c. Mr. Greg Greedy deposits GH¢5,000 into an investment account at Trustworthy Bank. He deposits GH¢X yearly into the same account at the beginning of the 4^{th}, 5^{th}, 6^{th}, and 7^{th} year. At the end of the 10^{th} year he has GH¢65,000 in his account. If the interest rate is 9% per year determine GH¢X.

d. Suppose you are paying GH¢31.73 per week for 10 years to repay a GH¢10,000 loan. What is the effective annual rate? Assume the interest rate is compounded continuously.

5.

a. Given the following information

• Sales/Revenue	= GH¢5.00/kg
• Production rate @ 100%	= 375,000kg/yr
• Total Initial Fixed Capital Investment (C_T)	= GH¢850,000
• Working Capital (Cw)	= 15% of Total Initial fixed Capital Investment (C_T)
• Manufacturing Cost at 100% Production	
- Raw Materials	= GH¢40,000
- Labour	= GH¢30,000
- Electricity	= GH¢15,000
- Water	= GH¢ 3,000
- Maintenance & Repair	= GH¢ 5,000
• General Expenses at 100% Production	
- Administration	= GH¢16,000
- Advertising Distribution	= GH¢40,000
- Salvage Value	= 5% of Initial Fixed Capital Investment (C_F)
- Service Life	= 12 year
- Hurdle rate	= 12%
- Tax Rate	= 25%

Assume the production rate is 60% the first two years, 80% the next four years and 100% the remaining years, likewise the manufacturing cost and the general expenses.

Determine:

i. Payback Period (PBP)
ii. Return on Investment (ROI)

iii. Net Present Value (NPV)
iv. Equivalent Uniform Annual Worth
v. Profitability Index

State all assumptions made.

b. Determine the new NPV if the Manufacturing Cost and General Expenses are both increased by10% and the sales price is reduced to 3.5 GH¢/kg.

Comment on your results.