



UNIVERSITY OF GHANA
(All rights reserved)

FACULTY OF ENGINEERING SCIENCES
DEPARTMENT OF FOOD PROCESS ENGINEERING
B.Sc FIRST SEMESTER FINAL EXAMINATION, 2013/2014

FPEN 401: FOOD PLANT DESIGN AND ECONOMICS

ATTEMPT ANY THREE QUESTIONS

TIME ALLOWED TWO HOURS

1. (a) List the different stages involved in the design of a food plant design from the beginning to completion
- b) What are the assumptions made in the design of a heat exchanger
- c) An existing plate heat exchanger in a factory is used to heat orange juice. The orange juice stream which flows at a rate of F (kg/s) enters the heat exchanger at a temperature of T_1 ($^{\circ}\text{C}$) and is heated up to a temperature of T_2 ($^{\circ}\text{C}$) before exiting. The hot water stream which provides the heat enters and leaves the plate heat exchanger at a temperature of T_{w1} ($^{\circ}\text{C}$) and T_{w2} ($^{\circ}\text{C}$) respectively. The hot water flows at a rate of F_w (kg/s). The hot water stream flows countercurrent to the orange juice stream.

Process Variables

$$F = 8 \text{ kg/s}$$

$$T_1 = 50^{\circ}\text{C}$$

$$T_2 = 90^{\circ}\text{C}$$

$$T_{w2} = 95^{\circ}\text{C}$$

Technical Data

$$\rho = 1000 \text{ kg/m}^3$$

$$C_p = 3.86 \text{ KJ/Kg K}$$

$$\rho_w = 960 \text{ kg/m}^3$$

$$C_{p_w} = 4.18 \text{ KJ/kg K}$$

$$U = 4230 \text{ W/m}^2\text{k}$$

$$f = 0.006$$

Design Variables

$U = 2.6 \text{ m/s}$

$b = 1 \text{ mm}$

$n = 5$

$L = 0.3 \text{ m}$

Determine the flowrate of the hot water stream, the inlet temperature of the hot water stream (T_{w1} °C) and the pressure drop on the juice stream side.

2. a) Define corporate social responsibility (CSR).

b) How long would it take to triple an amount of money deposited at a bank if the interest rate is 4.55% per quarter compounded continuously. What is the effective annual interest rate?

c) A rotary dryer is used to dry gari. Using the given process specification, process data and design variables below:

Process Specifications

F	=	250 kg/h db feed flow
X_o	=	0.8 kg/kg db moisture content
X	=	0.10 kg/kg db final moisture content
d	=	0. material characteristic size
T_o	=	25°C Ambient temperature
Y_o	=	0.02 Ambient humidity
T_s	=	160°C Heating stream temperature
P	=	1.00 bar

Process Data

Specific heat (kJ/kg K)

C_{pL}	=	4.2 water
C_{pV}	=	1.90 water vapour
C_{pA}	=	1.00 air
C_{pS}	=	2.0 Dry material 3.73

Latent Heat (MJ/kg)

ΔH_o	=	2.50 Steam condensation at 0°C
--------------	---	--------------------------------

Heat transfer coefficient

Heat transfer coefficients (KW/m²K)

U_s	=	0.1 air heater
-------	---	----------------

Design variables

Y	=	0.66 kg/kg db Drying air humidity
T	=	85°C Drying air temperature

$$\begin{aligned} V &= 1.5 \text{ m/s drying air velocity} \\ D &= 2.0 \text{ m Dryer diameter} \end{aligned}$$

Calculate

- (i) the air flow rate ,
- (ii) thermal energy efficiency; and
- (iii) the air heating area required

3. Mr. Greg Greedy deposits GHC56,000 into his savings account at Fairview Bank which attracts an interest of 18.4% per year compounded quarterly, He then goes for a GHC X 20-year loan from Faithful bank at an effective annual interest rate of 2.4% compounded continuously.

If after 14 years of monthly payment of the loan he borrowed from Faithful bank the remaining amount yet to be paid is equal to the total interest gained on the money he deposited at Fairview Bank at the end of 12 years calculate the total amount borrowed (GHC X).

b) Mrs. Sally Selfish's company is considering a project that has a 10 year life and cost GHC 5000. It would save GHC 1,000 per year in operating cost and increase revenue by GHC 600 per year. It would be financed with a 10 year loan with an interest of 8% per year. The salvage value for the newly purchased equipment is zero. If the minimum annual rate of return (MARR) or hurdle rate is 14% and the tax rate is 25%, what is the net present value (NPV) of the project. Use the straight line method to calculate the depreciation.

4. a) Explain why the net present value method is considered the best method for calculating profitability.

b) A project proposal for a new baby food product developed by level 400 food process engineering students has the following information:

Total capital investment (C_T)	18,000,000 GHC
Working capital (C_w)	17% Total Capital Investment (C_T)
Production rate	120,000,000 kg/year
Raw materials	0.08GHC/kg
Utilities	1.20 GHC
Labour	1.50 GHC/kg
Salvage value	0
Maintenance Cost	6.5% C_F /year
Supplies	18% of maintenance cost
Administration cost	9% of sales
Sales cost	10% of sales
Insurance	3% C_F /year
Useful life	12 years
Tax rate	25%

Use the straight line method to determine depreciation.

- (i) Using the net present value (NPV) method, determine the minimum acceptable price the baby food product should be sold per kg if the hurdle rate (or market rate) is 15% per year using the net present value method
- (ii) How would your answer in (i) change if the return on initial investment method is used?