



UNIVERSITY OF GHANA
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SCHOOL OF ENGINEERING SCIENCES
DEPARTMENT OF FOOD PROCESS ENGINEERING
B.Sc FIRST SEMESTER FINAL EXAMINATION, 2014/2015

FPEN 401: FOOD PLANT DESIGN AND ECONOMICS

ANSWER THREE (3) QUESTIONS

TIME: ONE & HALF HOURS (1½)

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

b) 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

$$F/F_w = 0.8$$

$$T_1 = 40^{\circ}\text{C}$$

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

Technical Data

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

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

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

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

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

$$\Lambda = 0.65 \text{ W/mK}$$

$$\lambda_w = 0.65 \text{ W/mK}$$

$$\eta = 0.40 \text{ mPa.s}$$

$$\eta_w = 0.25 \text{ mPa.s}$$

Design Variables

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

$$b = 1 \text{ mm}$$

$$n = 5$$

$$L = 0.4 \text{ m}$$

$$A = 4 \text{ m}^2$$

Determine the flowrate of the hot water stream (F_{w1}) and the inlet temperature (T_{w1} °C) and outlet temperature of the hot water stream (T_{w1} °C).

(c) What are the assumptions made in the design of a heat plate exchanger and why is the choice of the process stream velocity (u) and the plate spacing in the design of a plate heat exchanger very important?

2. a) Briefly discuss the different stages involved in the design of a food plant from the beginning to completion

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

Process Specifications

$$F = 400 \text{ kg/h db feed flow}$$

$$X_o = 0.7 \text{ kg/kg db moisture content}$$

$$X = 0.10 \text{ kg/kg db final moisture content}$$

$$d = 0.01 \text{ m material characteristic size}$$

$$T_o = 25^\circ\text{C Ambient temperature}$$

$$Y_o = 0.02 \text{ Ambient humidity}$$

$$T_s = 160^\circ\text{C Heating stream temperature}$$

$$P = 1.00 \text{ bar}$$

Process Data

$$\text{Specific heat (kJ/kg K)}$$

$$C_{pL} = 4.2 \text{ water}$$

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

Latent Heat (MJ/kg)
 $H_o = 2.50$ Steam condensation at 0°C

Heat transfer coefficient
Heat transfer coefficient (KW/m^2K)
 $U_s = 0.1$ air heater

Design variables
 $Y = 0.66$ kg/kg db Drying air humidity
 $T = 85^\circ C$ Drying air temperature
 $V = 1.5$ m/s drying air velocity
 $D = 2.0$ m Dryer diameter

Calculate

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

3. a) Suppose you expect to receive GH¢ 1500 per year for each of the next 16 years except you would not receive any payment in years 3, 7 and 11. What is the present value of this amount if the interest rate is 13% per year compounded daily?
- b) Determine the amount of loan taken from the Bank if the remaining amount due is GH¢ 1500 after paying for twenty months. The effective annual interest rate is 32% compounded monthly and the total loan period is 5 years
- c) A businessman is considering buying a new food process equipment worth GH¢ 75,000. He can either finance the equipment by either withdrawing cash from his savings account which earns 16.5% interest per year or borrow GH¢ 75,000 from the dealer to pay monthly for a period of 10 years at 6% per quarter compounded monthly. His financial advisor advised that he should borrow the money from the dealer leaving his money in bank. Do you agree with this advised? Show numerically.
4. a) (i) What is profitability?
(ii) 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:

Fixed Capital Investment (C_F)	24,000,000 GH¢
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Working capital (C_w)	10% Fixed Capital Investment (C_F)
Selling price of food product	5.00 GH¢/kg
Raw materials	0.08GH¢/kg
Utilities	1.20 GH¢
Labour	1.50 GH¢/kg
Salvage value	0
Maintenance Cost	6.5% C_T /year
Supplies	18% of maintenance cost
Administration cost	9% of sales
Sales cost	10% of sales
Insurance	1% C_T /year
Useful life	12 years
Depreciation	2,000,000 GH¢
Tax	25%

- (i) Using the net present value (NPV) method, determine the minimum acceptable production rate if the hurdle rate (or market rate) is 19% per year.
- (ii) How would your answer in (i) change if the return on initial investment method (ROI) is used.
- (iii) Determine the payback period.