UNIVERSITY OF JOHANNESBURG

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| **FACULTY:** | Faculty of Engineering and Built Environment. |
| **DEPARTMENT:** | Quality and Operations Management. |
| **CAMPUS:** | DFC |
| **MODULE:** | BPI33A3/ OPT33A3<br>OPERATIONS MANAGEMENT TECHNIQUES. |
| **SEMESTER:** | FIRST |
| **EXAM:** | 25 MAY 2019 |

**DATE:** **25 MAY 2019** **SESSION:** 12:30- 15:30

**ASSESSOR(S):** Ms. N.E NWOBODO-ANYADIEGWU

**MODERATOR:** PROF. O. M. SAMUEL

**DURATION:** 3 Hours **MARKS:** 100

**NUMBER OF PAGES**: 4 PAGES (Graph paper is required)

**INSTRUCTIONS TO CANDIDATES:**

- Answer ALL questions.
- This is a closed book assessment.
- Leave margins and spaces between the questions.
- Show **all** your calculations.
- Unless otherwise indicated, express your answers correct to **two (2) decimal** places.
- Where appropriate, indicate the units of your answer. (e.g. Hour, R )
- Number your answers clearly.
- Write your surname and student number on the graph paper used.
- Write neatly and legibly
- NOTE: Marks will be awarded for theoretical knowledge, application of the theory and use of relevant examples.

The general University of Johannesburg policies, procedures and rules pertaining to written assessments apply to this assessment.

**QUESTION 1** **[15]**

1.1 (11)

Ms Jantjies Palesa is the dietitian for the University of Johannesburg football team, and she is attempting to determine a nutritious lunch menu for the team. She has set the following nutritional guidelines for each lunch serving:

- Between 1,500 and 2,000 calories
- At least 5 mg of iron
- At least 20 but no more than 60 g of fat
- At least 30 g of protein
- At least 40 g of carbohydrates
- No more than 30 mg of cholesterol

She selects the menu from seven basic food items, as follows, with the nutritional contribution per pound and the cost as given:

| | Calories (per lb.) | Iron (mg/lb.) | Protein (g/lb.) | Carbohydrates (g/lb.) | Fat(g/lb.) | Cholesterol(mg/lb.) | R/lb. |
|---|---|---|---|---|---|---|---|
| Chicken | 520 | 4.4 | 17 | 0 | 30 | 180 | 0.80 |
| Fish | 500 | 3.3 | 85 | 0 | 5 | 90 | 3.70 |
| Ground beef | 860 | 0.3 | 82 | 0 | 75 | 350 | 2.30 |
| Dried beans | 600 | 3.4 | 10 | 30 | 3 | 0 | 0.90 |
| Lettuce | 50 | 0.5 | 6 | 0 | 0 | 0 | 0.75 |
| Potatoes | 460 | 2.2 | 10 | 70 | 0 | 0 | 0.40 |
| Milk (2%) | 240 | 0.2 | 16 | 22 | 10 | 20 | 0.83 |

The dietitian wants to select a menu to meet the nutritional guidelines while minimizing the total cost per serving.

**Formulate a linear programming model for this problem.**

1.2 List and explain four common components and characteristics of linear programming model (4)

**QUESTION 2** **[25]**

The Nzanzi Fertilizer Company makes fertilizer products from two raw materials that comprise of granules of nitrous oxide, phosphorous and potash. A kg of raw material 1 contributes 10 grams of nitrous oxide and 6 grams of phosphorous; a kg of raw material 2 contributes 2 grams of nitrous oxide and 6 grams of phosphorous and 1 gram of potash. Raw material 1 cost R3 per kg, raw material 2 cost R5 per kg. The company wants to know how many kg of each raw material to put in a bag of fertilizer to meet minimum requirement of 20grams of nitrogen, 36 grams of phosphate, and 2 grams of potash while minimizing cost.

2.1 Formulate a Linear Programming model for this problem. (9)

2.2 Solve this problem using graphical – corner point method. (11)

Graphically illustrate the feasible region and the corner points. Evaluate the objective function at each corner point using a table titled: **[ corner point; coordinates; Cost / Profit (R)]**

2.3 Discus five assumptions of this model (5)

**QUESTION 3** **[30]**

A linear program has been formulated and solved. The optimal simplex tableau follows:

| $C_J$ | Solution Mix | $X_1$ | $X_2$ | $X_3$ | $S_1$ | $S_2$ | $S_3$ | Quantity |
|---|---|---|---|---|---|---|---|---|
| | $C_J$ → | **80** | **120** | **90** | **0** | **0** | **0** | |
| 120 | $X_2$ | −1.5 | 1 | 0 | 0.125 | −0.75 | 0 | 37.5 |
| 90 | $X_3$ | 3.5 | 0 | 1 | −0.125 | 1.25 | 0 | 12.5 |
| 0 | $S_3$ | −1.0 | 0 | 0 | 0 | −0.5 | 1 | 10.0 |
| | $Z_j$ | 135 | 120 | 90 | 3.75 | 22.5 | 0 | 5,625 |
| | $C_j - Z_j$ | −55 | 0 | 0 | −3.75 | −22.5 | 0 | |

3.1 What are the shadow prices for the three constraints? What does a zero shadow price mean? How can this occur? (5)

3.2 How much could the right-hand side of the first constraint be changed without changing the solution mix i.e. **$Q_1$**, (perform RHS ranging for this constraint)? (5)

3.3 How much could the right-hand side of the second **$Q_2$** ;and third (**$Q_3$**) constraint be changed without changing the solution mix? (10)

3.4 Determine the sensitivity range for **$C_2$** (8)

3.5 What can you say about the first product? Should the company produce it? Why? Justify your answer. (2)

**QUESTION 4** **[30]**

BONS ELECTRIC COMPANY

| Resources | Products | | Production Capacity (Hrs) |
|---|---|---|---|
| | Standing Fan | Ceiling Fan | |
| 1. Wiring (hours) | 2 | 3 | 12 |
| 2. Assembly (hours) | 6 | 5 | 30 |
| Contribution per Unit | R 7 | R 6 | |

Solving graphically

The relaxed Linear Programming optimal solution: $x_1 = 3\ \frac{3}{4}$, $X_2 = 1\ \frac{1}{2}$ Profit = R35.25

$x_1$ = 3.75 standing fans

$x_2$ = 1.5 ceiling fans

- Solve the problem to arrive at an optimal all integer solution using the Branch and Bound method.
- Determine the upper and lower bound for each node

NOTE:

1. ***Summarise the solution in the branch and bound diagram. Indicate the values of $X_1$ and $X_2$; and the upper bound and lower bound for each node.***
2. ***Write your surname and student number on the graph paper used.***

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**TOTAL MARKS** **[100]**

**END OF ASSESSMENT**