



**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF CHEMICAL ENGINEERING**

**MANAGEMENT, ECONOMICS AND OPTIMISATION**

**T/ECE 5101**

**Final Examination Paper**

**December 2024**

This examination paper consists of **five** pages

**Time Allowed: 3 hours**

**Special Requirements: None**

**INSTRUCTIONS**

1. Answer **A1** and **any other three (3)** questions
2. Each question carries 25 marks
3. Use of calculators is permissible

**MARK ALLOCATION**

<b>QUESTION</b>	<b>MARKS</b>
1	25
2	25
3	25
4	25
5	25
<b>TOTAL ATTAINABLE MARK</b>	<b>100</b>

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## **Section A**

### **QUESTION A1**

- a) On any project, you will have a number of project constraints that are competing for your attention. List such constraints [4]
- b) The project life cycle refers to a logical sequence of activities to accomplish the project's goals or objectives. Regardless of the scope or complexity, any project goes through a series of stages 4 stages during its life. Using a suitable diagram describe the FOUR phases. [4]
- c) State the key differences between a fixed and a flexible budget. [6]
- d) Define the word 'Budget' and describe its characteristics. [3]
- e) There exists various methods of network analysis. Examples include the PERT and CPM. What are the key differences between PERT and CPM [8]

## **Section B**

### **QUESTION B1**

- a) Budgetary control is a sound technique of control but is not a perfect tool. Despite many good points, it suffers from a number of limitations. Briefly describe the limitations. [5]
- b) Find the extrema of  $f(x,y,z) = 2x+6y + 10z$  using the lagrangian multipliers subject to  $[x^2+y^2+z^2 = 35]$  [5]
- c) The owner of the Sokusile shopping centre is planning to modernize and expand the current 32-business shopping center complex. The project is expected to provide room for 8 to 10 new businesses. Financing has been arranged through a private investor. All that remains is for the owner of the shopping center to plan, schedule, and complete the expansion project. The list of activities for the western hills shopping center project are shown below in Table 1.

Table 1: ACTIVITIES FOR THE SOKUSILE SHOPPING CENTER PROJECT

<b>Activity</b>	<b>Description</b>	<b>Predecessor</b>	<b>Duration</b>
<b>A</b>	<b>Prepare architectural drawings</b>	-	<b>5</b>
<b>B</b>	<b>Identify potential new tenants</b>	-	<b>6</b>
<b>C</b>	<b>Develop prospectus for tenants</b>	<b>A</b>	<b>4</b>
<b>D</b>	<b>Select contractor</b>	<b>A</b>	<b>3</b>

<b>E</b>	<b>Prepare building permits</b>	<b>A</b>	<b>1</b>
<b>F</b>	<b>Obtain approval for building permits</b>	<b>E</b>	<b>4</b>
<b>G</b>	<b>Perform construction</b>	<b>D,F</b>	<b>14</b>
<b>H</b>	<b>Finalize contracts with tenants</b>	<b>B,C</b>	<b>12</b>
<b>I</b>	<b>Tenants move in</b>	<b>G,H</b>	<b>2</b>

- (i) Construct a project network diagram and mark the critical path.

[15]

**QUESTION B2**

- a) Ntokozo is a manager of a gadget factory. Her factory has been quite successful in the past three years. She is wondering whether or not it is a good idea to expand her factory this year. The cost to expand her factory is \$1.5M. If she does nothing and the economy stays good and people continue to buy lots of gadgets she expects \$3M in revenue; while only \$1M if the economy is bad. If she expands the factory, she expects to receive \$6M if economy is good and \$2M if economy is bad. She also assumes that there is a 40% chance of a good economy and a 60% chance of a bad economy.

(i) Draw a Decision Tree showing these choices.

(ii) Is it a good idea to expand the factory?

[15]

- b) You have prepared the following information in the table 2 below for an experiment in which the key resource is a pH meter. The project is contingent on having 3 pH meters available. The chemistry department requests from you in desperation, they are one pH meter short for a teaching practical and would like to borrow one of yours. You tell chemistry department that you'll be willing to loan them one of yours if, and only if, you can complete your experiment in 11 days.

Develop a loading chart and resource schedule in your loading chart

[10]

Table 2: Experiment in which the key resource is a pH meter

Activity ID	Preceding Activity	Duration	Number of pH Meters Required
1	-	1	1
2	-	2	1
3	-	3	1
4	1,2	2	1
5	2,3	4	2
6	4,5	2	2

### QUESTION B3

a) A manufacturer produces three types of plastic fixtures, A, B and C. The time required for moulding, trimming, and packaging is given in Table 3 below. Formulate this as a linear programming problem and maximize using the SIMPLEX method. [15]

Process	Type A	Type B	Type C	Total time available
Moulding	1	2	3/2	12000
Trimming	2/3	2/3	1	4600
Packaging	1/2	1/3	1/2	2400
Profit	11	16	15	-

How many dozen of each type of fixture should be produced to obtain a maximum profit?

b) Two manufacturers are to produce safety shoes A and B. 'X' safety shoes are to be produced at A and 'Y' are produced at factory B. The cost of production is given by  $C(x,y) = 6x^2 + 12y^2$ . If 90 safety shoes are to be produced, what is the number that should be produced at each factory?

[10]

#### **QUESTION B4**

a) A company involved in the assembly and distribution of printers is concerned with two types: laser and inkjet. Assembling of each laser printer takes two hours, while each inkjet printer takes one hour to assemble, and the staff can provide a total of 40 person- hours of assembly time per day. In addition, warehouse space must be available for the assembly and distribution of the printers, 1 m<sup>2</sup> for each laser printer and 3 m<sup>2</sup> for each inkjet printer; the company has a total of 45 m<sup>2</sup> of storage space available for the assembled printers each day. Laser printers can be sold at a profit of \$30 per unit and inkjet printers earn a profit of \$25 each, but the market in which the company is operating can absorb a maximum of 12 laser printers per day. (There is no such limitation on the market for inkjet printers). Formulate this as a linear programming problem and determine, using the SIMPLEX method, the number of each type of printer the company should assemble and distribute in order to maximise daily profit. **[15]**

b) A product manager for a soap manufacturer must decide whether or not to offer a new, biodegradable laundry detergent. The projected profit from a successful detergent is \$2 million, whereas failure of the product would result in a loss of \$1 million. The manager currently thinks there is a 40% chance that the product will be successful. Not offering the product would not change profits. At a cost of \$100,000, the product can be tested. Consumer testing can be favourable, a 50% chance, or unfavourable. Given a favourable test result, the chance of product success is judged to be 80%. However, for an unfavourable test result, the chance of product success is judged to be only 30%.

Construct a decision tree for this problem. What is the optimal decision strategy and its expected value? **[10]**