GWANDA STATE UNIVERSITY

Faculty of Engineering and the Environment

Department Of Mining Engineering

OPERATIONS RESEARCH

EMN 3106

Examination Paper

NOVEMBER 2023

This examination paper consists of 4 printed pages

Time Allowed: **3 hours**

Total Marks: 100

Examiner's Name: Mr. E. Utete

INSTRUCTIONS

Answer **ALL** questions in Section A and **ANY THREE** questions in Section B

ADDITIONAL REQUIREMENTS

Scientific calculator

Graph papers

Statistical Tables

SECTION A : Answer ALL Questions : 25 marks

A1 Define the following terms as used in operation research.

(a) Objective function [3]

(b) Feasible solution [3]

(c) Optimal solution [3]

A2 The Shepco Mining Company is introducing two new mineral lines: gold and platinum. The expected profit is \$5 per gram on gold and \$2 per gram on platinum. Management wishes to establish sales quotas for the new product lines to maximize total expected profit. The work requirements are as follows:

Department	**Work-Hours per gram**		Work-Hours Available
	Gold	Platinum	
Mining	3	2	2400
Administration	0	1	800
Transport	2	0	1200

(a) Formulate a linear programming model for this problem. [7]

(b) Use the graphical method to find the optimal quantity of new products that maximize profit. [9]

SECTION B : Answer THREE QUESTIONS only : 75 marks

B3 The Metalco Company desires to blend a new alloy of 40 percent tin, 35 percent zinc, and 25 percent lead from several available alloys having the following properties.

	Alloy				
Property	1	2	3	4	5
Percentage of tin	60	25	45	20	50
Percentage of zinc	10	15	45	50	40
Percentage of lead	30	60	10	30	10
Cost (\$/lb)	22	20	25	24	27

The objective is to determine the proportions of these alloys that should be blended to produce the new alloy at a minimum cost.

(a) Formulate a linear programming model for this problem. [10]

(b) Solve this model by the simplex method. [15]

B4 A coal processing company, Trino Energy Pvt Ltd, has to haul coal ore to three factory sites. They can purchase as much as 18 tons at a coal mine in the north of the city and 14 tons at one in the south. They need 10, 5, and 10 tons at factory sites 1, 2, and 3, respectively. The purchase price per ton of each coal ore at mine and the hauling

Mine	**Hauling Cost per Ton at Site**			Price per Ton
	1	2	3	
North	\$30	\$60	\$50	\$100
South	\$60	\$30	\$40	\$120

cost per ton are given in the table above. Trino Energy Pvt Ltd management wishes to determine how much to haul from each mine to each factory site to minimize the total cost for purchasing and hauling coal ore.

(a) Now formulate a transportation problem by constructing the appropriate parameter table. [10]

(b) Solve the transportation problem using the simplex method to obtain an optimal solution. [15]

B5 Epoch Mining Company is planning to start a new mining project. Management identified six activities which need to be done before commencement of operations. You are given the following information about the project consisting of six activities.

Activity	**Immediate Predecessors**	**Estimated Duration**
A	—	5 months
B	—	1 months
C	B	2 months
D	A, C	4 months
E	A	6 months
F	D, E	3 months

(a) Construct the project network for this mining project. [5]

(b) Find the earliest times, latest times, and slack for each activity. [11]

(c) Which of the paths is a critical path? [4]

(d) If all other activities take the estimated amount of time, what is the maximum duration of activity D without delaying the completion of the whole project? [5]

B6 (a) State the Karush–Kuhn–Tucker (KKT) conditions of optimality. [5]

(b) Use the Karush–Kuhn–Tucker (KKT) conditions to derive an optimal solution for the following problem.

$$Maximize \quad f(x) = x_1 + 2x_2 - x_2^3$$

Subject to

$$x_1 + x_2 \leq 1$$

$$and \qquad x_1 \geq 0 \;\; ; \;\; x_2 \geq 0$$

[20]

B7 Management at Rinto Mine is considering taking one of the two mining projects. You are given the following payoff table in thousands of dollars for a decision analysis problem.

Alternative	**State of Nature**		
	S_1	S_2	S_3
A_1	220	170	110
A_2	200	180	150
Prior Probability	0.6	0.3	0.1

(a) Which alternative should be chosen under the maximum pay-off criterion? [5]

(b) Which alternative should be chosen under the maximum likelihood criterion? [10]

(c) Which alternative should be chosen under the Baye's decision rule? [10]

B8 (a) Trucks from an open cast mine make a queueing system waiting for ore offloading. Offloading is done at three servers with expected service times of 20 minutes, 15 minutes, and 10 minutes. The service times have an exponential distribution. Each offloading server has been busy with a current truck for 5 minutes. Determine the expected remaining time until the next service completion.

(b) In a mineral extraction, a maintenance person has the job of keeping two machines in working order. The amount of time that a machine works before breaking down has an exponential distribution with a mean of 10 hours. The time then spent by the maintenance person to repair the machine has an exponential distribution with a mean of 8 hours. [5]

i. Show that this process fits the birth-and-death process by defining the states, specifying the values of the μ_n and λ_n , and then constructing the rate diagram. [4]

ii. Calculate the P_n. [4]

iii. Calculate L, L_q, W, and W_q. [4]

iv. Determine the proportion of time that the maintenance person is busy. [4]

v. Determine the proportion of time that any given machine is working. [4]