CIVENG 3C03 Assignment 2

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Question 1

If the number of bronze, silver, and gold passes issued are X_1, X_2, and X_3, then the profit margins for the park can be represented as:

$$\text{Max: } Z = X_1 + 3X_2 + 10X_3$$

The passes are also subject to the following constraints:
$X_1 + X_2 + 3.5X_3 \leq 22000$ (administrative working units constraint)
$X_1 \leq 10000$ (maximum units per type)
$X_2 \leq 10000$ (maximum units per type)
$X_3 \leq 10000$ (maximum units per type)
$X_1 \geq 1200$ (minimum number of bronze tickets)
X_1, X_2, $X_3 \geq 0$ (non-negativity constraint)

From the objective function and the constraints, we can represent the problem in canonical form:

Minimize:

$$Z^* = -X_1 - 3X_2 - 10X_3 + MA_1$$

Subject to: Subject to:

$$\begin{gathered} X_1 + X_2 + 3.5X_3 + S_1 = 22000 \\ X_1 + S_2 = 10000 \\ X_2 + S_3 = 10000 \\ X_3 + S_4 = 10000 \\ X_1 - E_1 + A_1 = 1200 \\ X_1, X_2, X_3, S_1, S_2, S_3, S_4, E_1, A_1 \geq 0 \end{gathered}$$

The Simplex Tableau for this problem can be seen in Table 1. The solution was found in three iterations of the Simplex method. The optimal number of each pass type the park should issue to maximize its profit is $[X_1 = 1200, X_2 = 10000, X_3 = 3085.71]$. The corresponding total profit margin cost of the optimal pass policy is $Z = 1200 + (3 \cdot 10000) + (10 \cdot 3085.71) =$ \$62057.1.

Since $S_1, S_3, E_1, A_1 = 0$, the binding constraints are:

$$\begin{gathered} X_1 + X_2 + 3.5X_3 \leq 22000 \\ X_2 \leq 10000 \\ X_1 \geq 1200 \end{gathered}$$

The non-binding constraints are:

$$\begin{gathered} X_1 \leq 10000 \\ X_3 \leq 10000 \end{gathered}$$

Table 1: Question 1: Simplex Tableau

C_i	Baisc Variables	C_j	-1	-3	-10	0	0	0	0	0	0	b_i/a_{ij}
		b_i	X_1	X_2	X_3	S_1	S_2	S_3	S_4	E_1	A_1	
0	S_1	22000	1	1	3.5	1	0	0	0	0	0	22000
0	S_2	10000	1	0	0	0	1	0	0	0	0	10000
0	S_3	10000	0	1	0	0	0	1	0	0	0	∞
0	S_4	10000	0	0	1	0	0	0	1	0	0	∞
M	A_1	1200	1	0	0	0	0	0	0	-1	1	1200
		ΔZ_j	-1-M	-3	-10					-M		
0	S_1	20800	0	1	3.5	1	0	0	0	1	-1	5942.86
0	S_2	8800	0	0	0	0	1	0	0	1	-1	∞
0	S_3	10000	0	1	0	0	0	1	0	0	0	∞
0	S_4	10000	0	0	1	0	0	0	1	0	0	10000
-1	X_1	1200	1	0	0	0	0	0	0	-1	1	∞
		ΔZ_j		-3	-10					-1	M-1	
-10	X_3	5942.86	0	0.29	1	0.29	0	0	0	0.29	-0.29	20800
0	S_2	8800	0	0	0	0	1	0	0	1	-1	∞
0	S_3	10000	0	1	0	0	0	1	0	0	0	10000
0	S_4	4057.14	0	-0.29	0	-0.29	0	0	1	-0.29	0.29	-14200
-1	X_1	1200	1	0	0	0	0	0	0	-1	1	∞
		ΔZ_j		-0.14		2.86				1.86	M-1.86	
-10	X_3	3085.71	0	0	1	0.29	0	-0.29	0	0.29	-0.29	
0	S_2	8800	0	0	0	0	1	0	0	1	-1	
-3	X_2	10000	0	1	0	0	0	1	0	0	0	
0	S_4	6914.29	0	0	0	-0.29	0	0.29	1	-0.29	0.29	
-1	X_1	1200	1	0	0	0	0	0	0	-1	1	
		ΔZ_j				2.86		0.14		1.86	M-1.86	

Question 2

The solution to Question 1 was redone using Excel solver, producing the same solution as the Simplex method using in question 1 as seen in Figure 1. The solution is $X_1 = 1200$, $X_2 = 10000$, and $X_3 = 3085.71$ for a total profit margin of \$62067.1. The Excel spreadsheet is included with the assignment submission as `question2.xlsx`.

	A	B	C	D	E	F	G	H	I	J	K
1											
2		Variables		X1	X2	X3					
3		Values		1200	10000	3085.71					
4		Cost Cofficients		-1	-3	-10			-62057.1		
5											
6		Struct Coeff		1	1	3.5		#1	22000	<=	22000
7				1	0	0		#2	1200	<=	10000
8				0	1	0		#3	10000	<=	10000
9				0	0	1		#4	3085.71	<=	10000
10				1	0	0		#5	1200	>=	1200

Figure 1: Excel Solver Solution

Question 3

To determine if the current production policy can be continued, we check the sensitivity of the optimal solution due to the changes in each of the cost coefficients. However, this is not possible to calculate with the information provided, as the final iteration of the simplex tableau does not provide the C^i values for the final iteration, and this cannot be calculated without the previous iteration.