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I confirm that I understand my coursework needs to be submitted online via Google Classroom under the relevant module page before the deadline in order for my assignment to be accepted and marked. I am fully aware that late submissions will be treated as non-submission and a marks of zero will be awarded.

Acknowledgements

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Table of Contents

Table of Figures

Table of Tables

1. Problem 1

1.1.Introduction to tax calculation.

- The personal income tax in Nepal can feel like a maze of numbers, deduction and the ever-shifting rate of total income. This report introduce the step-by-step procedure designed to take the confusion of every Nepalese taxpayer from the first-time earner and the professional ones.

  At first, we collected an individual income or net salary before tax or any deductions. Deductions like investment in citizen investment trust, life insurance, provident fund etc. subtracting each deduction to the total income became a net taxable income. The total taxable income where the government levies its charges. And the second process gently begins with the Nepal's progressive tax brackets. Starting from 1% for the first 50000 earnings and rising to 39% for the income begin from 3000000 and above by checking each tax rate by using complex formulas.

  Afterall the procedures the tax amount will be calculated and subtracted from the taxable income to get the net income after the tax calculation. The system also check some common error like negative income entry and throw the exception of providing clear and user-friendly messages . The calculation into well-defined stages deductions, tax slab, tax amount, remaining amount, and the net pay .

  This system removes the manual paperwork which may take several time but also create a template for the audit trial that anyone can follow review and trust.

1.2. Screenshot for tax template

The tax template includes Annual Income, Total Taxable Income, and the Total Tax paid for the government. The template include some deduction like insurance, Investment fund, and provident fund. After deducting the total taxable income with total tax, we get Total income. That is the net income of the person. The income range is also given in the template like if we earn 50000 per year then the tax rate should be applied will be 10% and likewise other ranges up to 3000000 and above will be applied 39% tax rate.

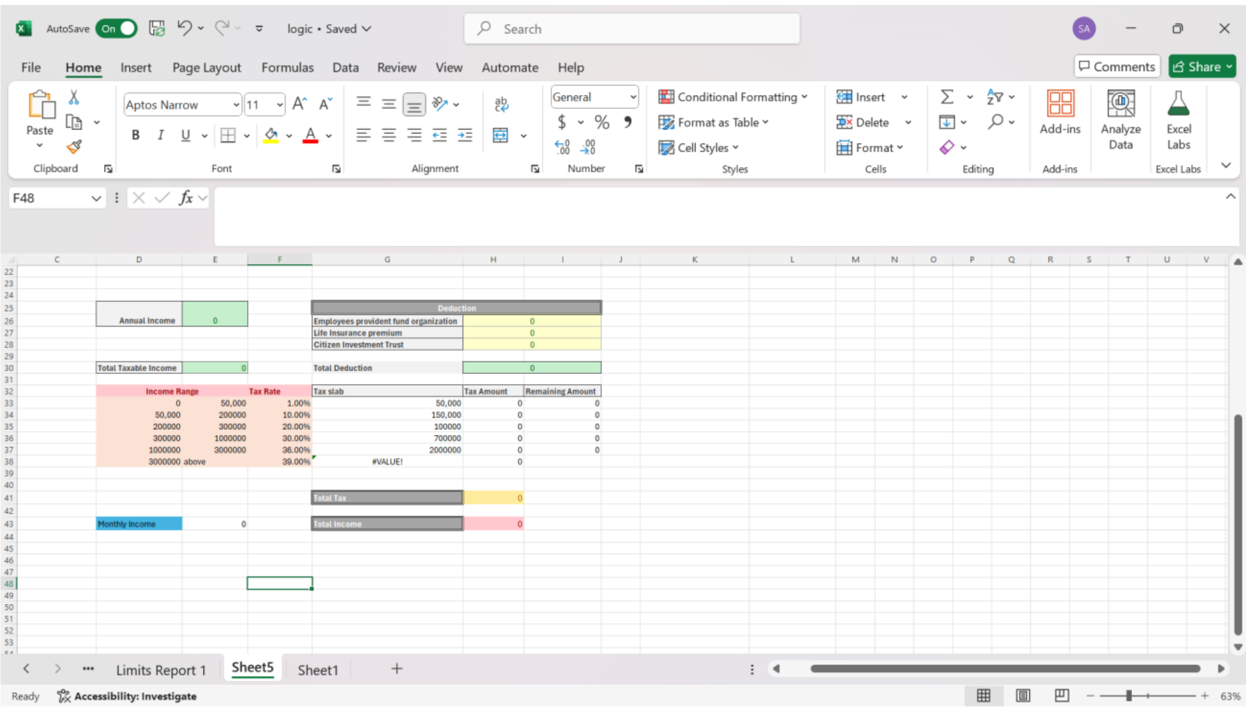


Figure 1: Tax Template

1.3. Screenshot For Formula

The template show the formula for the tax slab ,remaining amount, tax bracket. The formula also calculates the total tax paid to the government ,and we also divided the total income with 12 for calculating the monthly income of the person after all the deductions and tax amount. Little explanation of the terms:

- Annual Income: The income of the person before all the deductions and tax.
- Total Taxable Income: The income of the person after all the deductions.
- Total Deductions: The sum of income after all the deductions.
- Total Tax : The sum of tax amount is total tax per year.
- Total Income: The total income is the net income of the person after all the deductions and taxes.
- Monthly income: The income of the person per months.

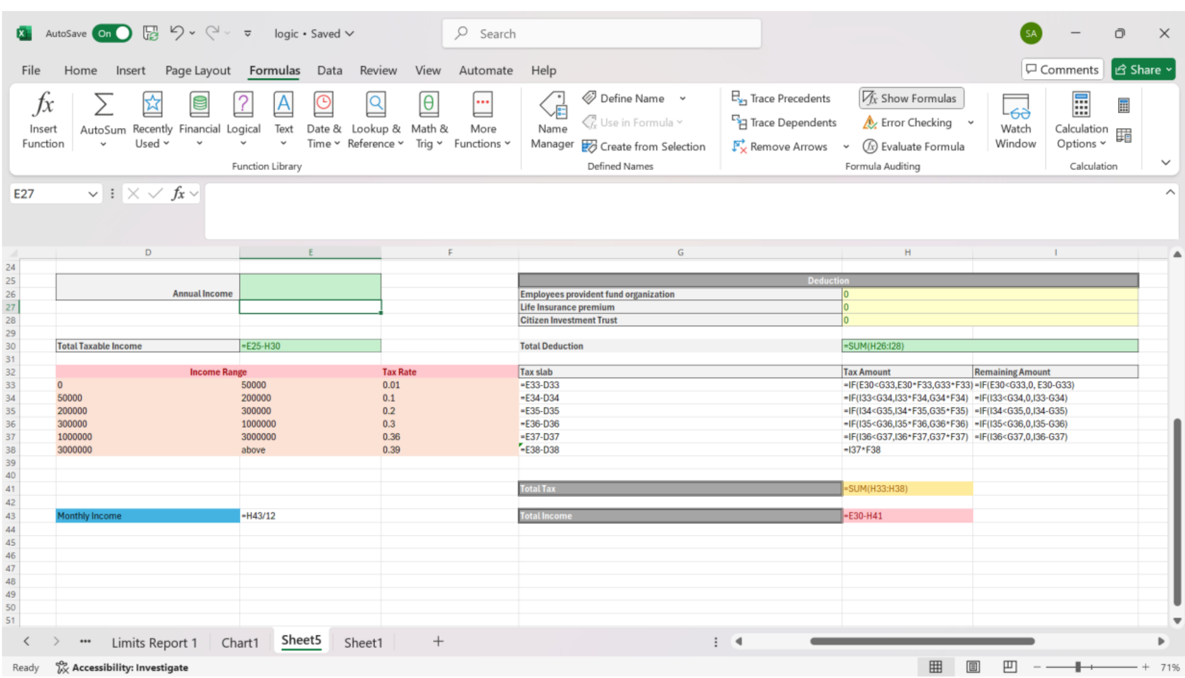


Figure 2: Formula of the template

1.4. Explanation Of Basic Terms

- Tax Slab
  - A tax Slab is a range of taxable income values where income values to which a Specific tax rates applies.
- Taxable Income
  - The remaining income after all the allowable deductions exemptions. The net amount where the government levies income tax.
- Tax Amount
  - The product of taxable income and that tax slab rate is Tax Amount.
- Remaining Amount
  - The amount or portion of your total taxable income that exceeds a given tax slab is the higher limit that remains for the next higher slab.
- Annual Income :
  - The income before the deduction or any expenses is called the annual income. E.g. If the person earns fifty thousand dollars a month then his annual income is fifty thousand dollars.
- Total Income:
  - The income left after all the deductions and taxes to the government is the total income of the person.
- Deductions
  - Employees Provident Fund : The employees provident fund is the main objective of the employees set by the government of any country that defines the retirement saving and pension scheme . The worker will get back the money when he retires from work and get the money as pension monthly. (epf, 2025)

  - Life Insurance Premium: The money where the employee or an individual pay the amount of money to insurance company to maintain coverage under a policy of insurance. The payment of the insurance is monthly, quarterly and yearly. Price is based on the factors such as age,health,lifestyle and term of policy and the chosen death benefits. (bajajfinserv, 2025)
  - Citizen Investment Trust(CIT): The CIT fund is the public financial funding of Nepal; It is established in 1991 under the Citizen Investment Trust. It is the scheme of the government of Nepal. Cit manage the retirement scheme and mutual fund to mobilize the saving frim citizens and promoting investment in capital market of Nepal for the country economic development. (nlk, 2025)

- Total Deductions:
  - The sum of all the deduction like CIT,insurance,provident fund is a Total deductions.
- Tax Range :
  - The tax range is also known as the tax brackets like tax rate with the between the fund given by the appropriate government of country.
- Monthly Income:
  - The income of the person or individual per month after all the deductions and taxes applied.

Test 1:

Total Annual Income: (Rs. 4,05,000)

Deductions:

- Employees provident fund organization: (Rs. 10,000)
- Life Insurance premium: (Rs. 68,000)
- Citizen Investment Trust:(Rs. 0)

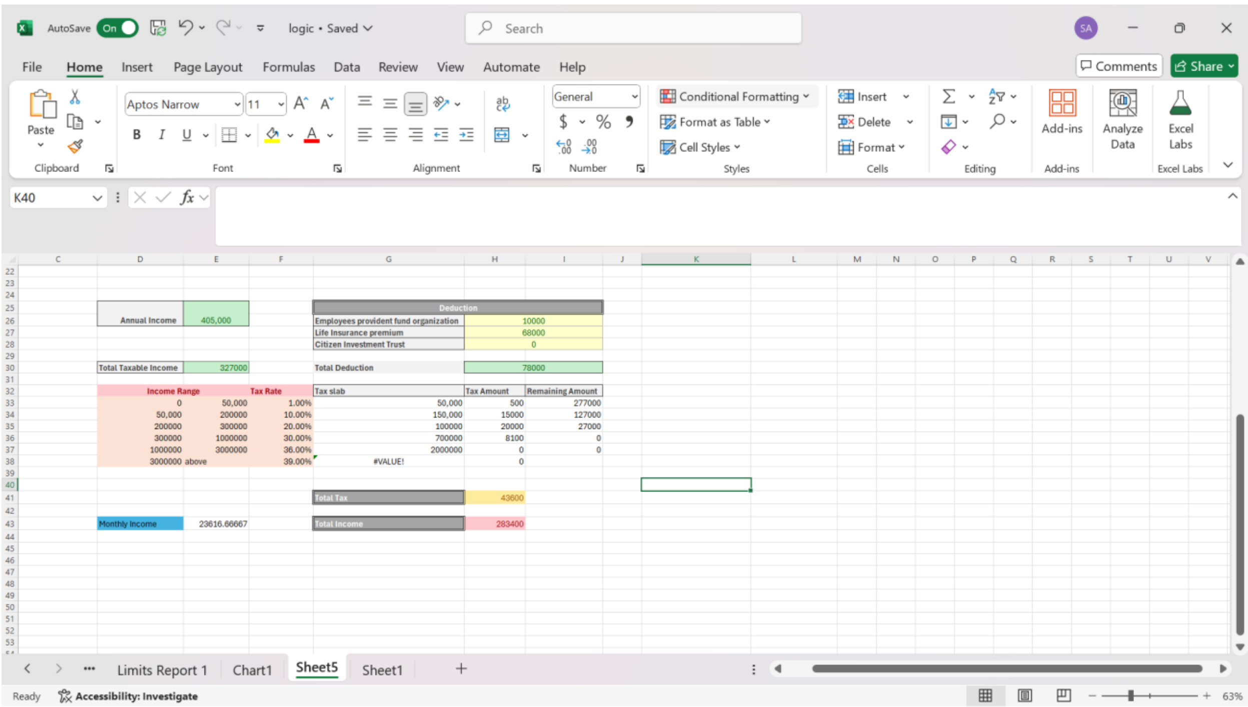


Figure 3: solution of Qs no.1

From the above excel sheet, the person has a salary of Rs.283400 after all the deductions and taxes and the individual earns probably Rs.23616 per month. Individual must pay the government tax Rs.43600 from total earnings after the deduction the net amount of earning before tax is Rs.327000.

Test 2:

Total Annual Income : Rs. 8,09,090

Deductions:

- Employees provident fund organization: (Rs. 15,000)
- Life Insurance premium: (Rs. 20,000)
- Citizen Investment Trust:(Rs.5,000)

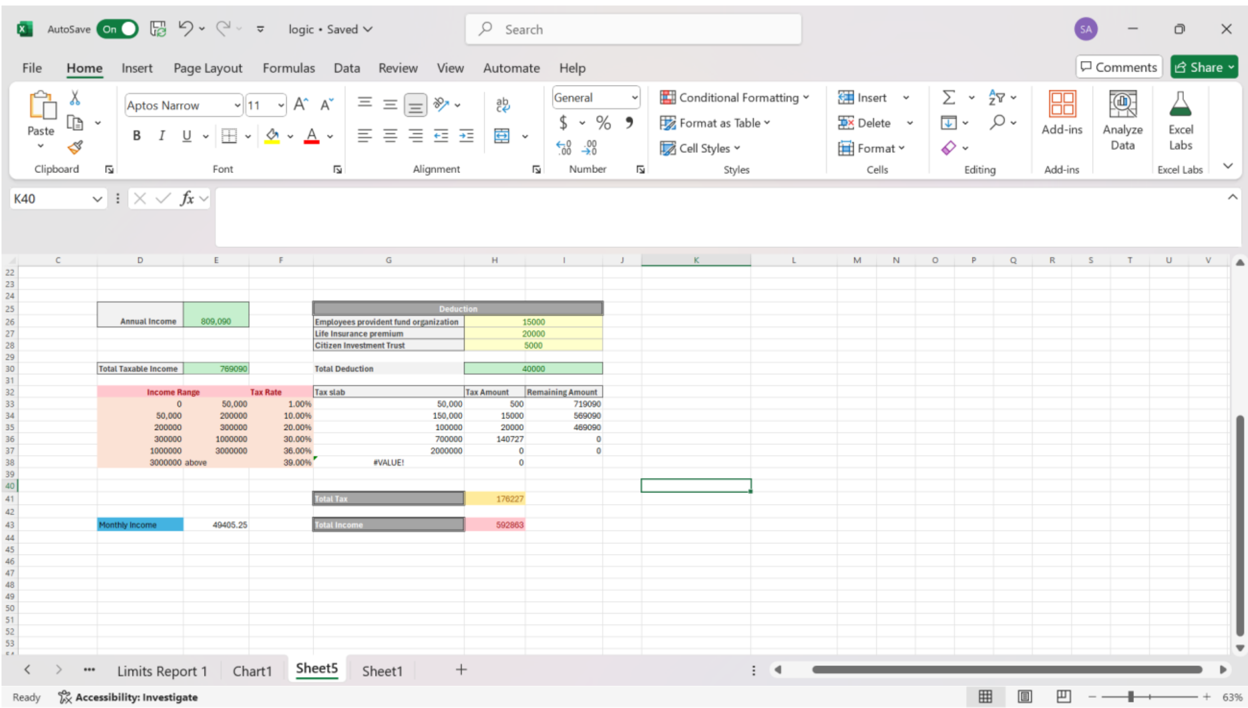


Figure 4: solution of Qs.2

From the above excel sheet, the person has a salary of Rs.592863, after all the deductions and taxes and the individual earns probably Rs.49405.25 per month. Individual must pay the government tax Rs.176227 from total earnings after the deduction the net amount of earning before tax is Rs.769090.

Test 3:

Total Income : Rs. 19,10,000

Deductions:

- Employees provident fund organization: (Rs. 0)
- Life Insurance premium: (Rs. 2,50,000)
- Citizen Investment Trust:(Rs.50,000)

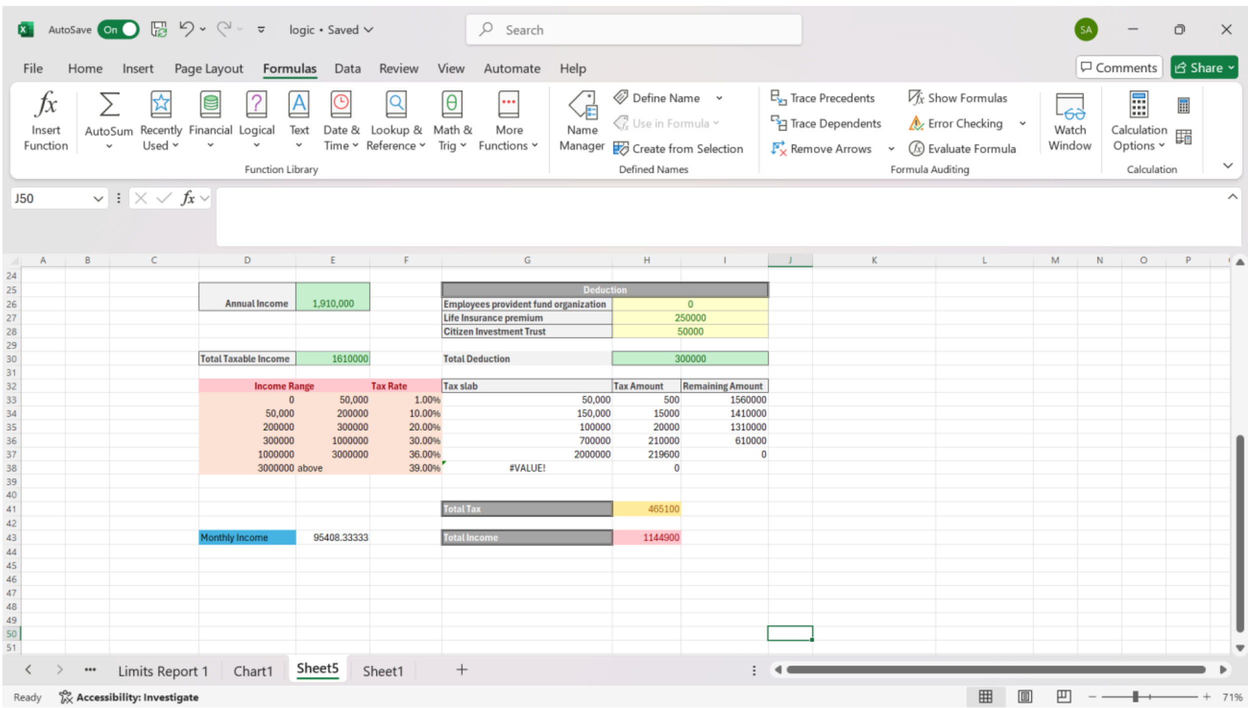


Figure 5:solution of Qs No.3

From the above excel sheet, the person has a salary of Rs.1144900, after all the deductions and taxes and the individual earns probably Rs.95408.333 per month. Individual must pay the government tax Rs.465100 from total earnings after the deduction the net amount of earning before tax is Rs.1610000.

Test 4:

Total Annual Income : Rs. 2,108,790

Deductions:

- Employees provident fund organization: (Rs. 1,50,000)
- Life Insurance premium: (Rs. 30,000)
- Citizen Investment Trust:(Rs.25,000)

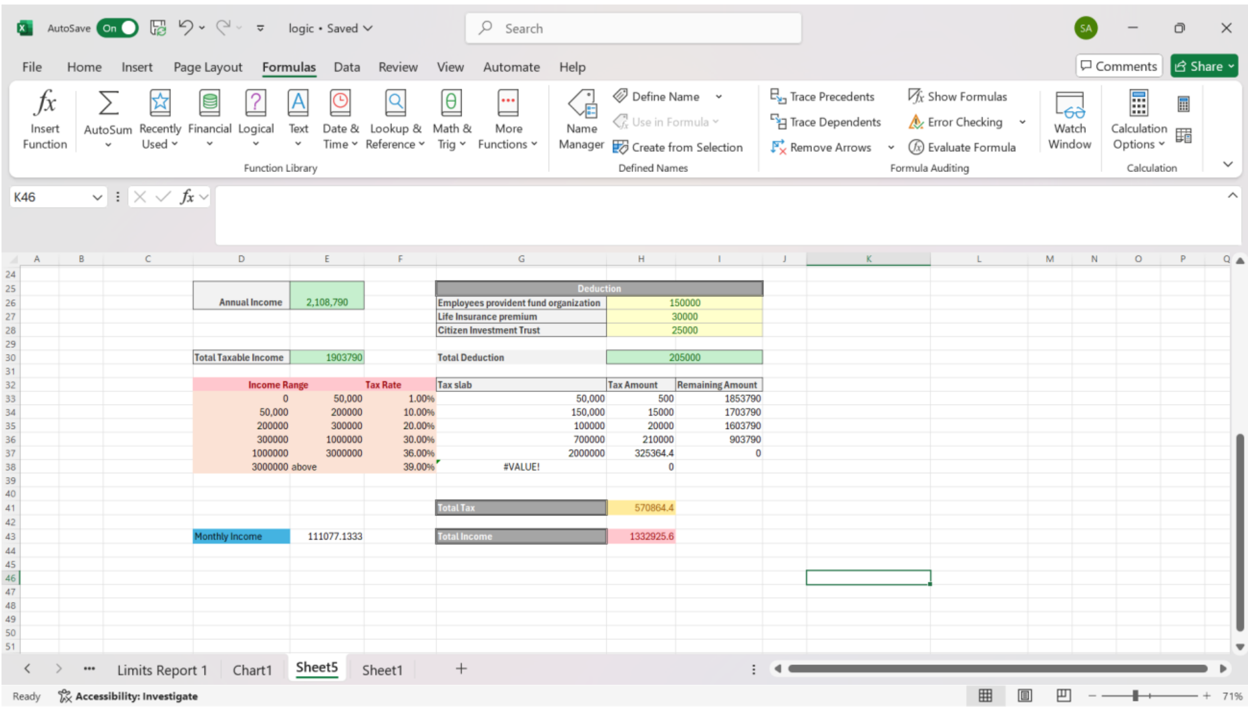


Figure 6:solution of Qs no. 4

From the above excel sheet, the person has a salary of Rs.1332925.6, after all the deductions and taxes and the individual earns probably Rs.111077.1333 per month. Individual must pay the government tax Rs.570864.4 from total earnings after the deduction the net amount of earning before tax is Rs.1903790.

Test 5:

Total Annual Income: Rs. 31,800

Deductions:

- Employees provident fund organization: (Rs.0)
- Life Insurance premium: (Rs. 5,000)
- Citizen Investment Trust:(Rs. 0)

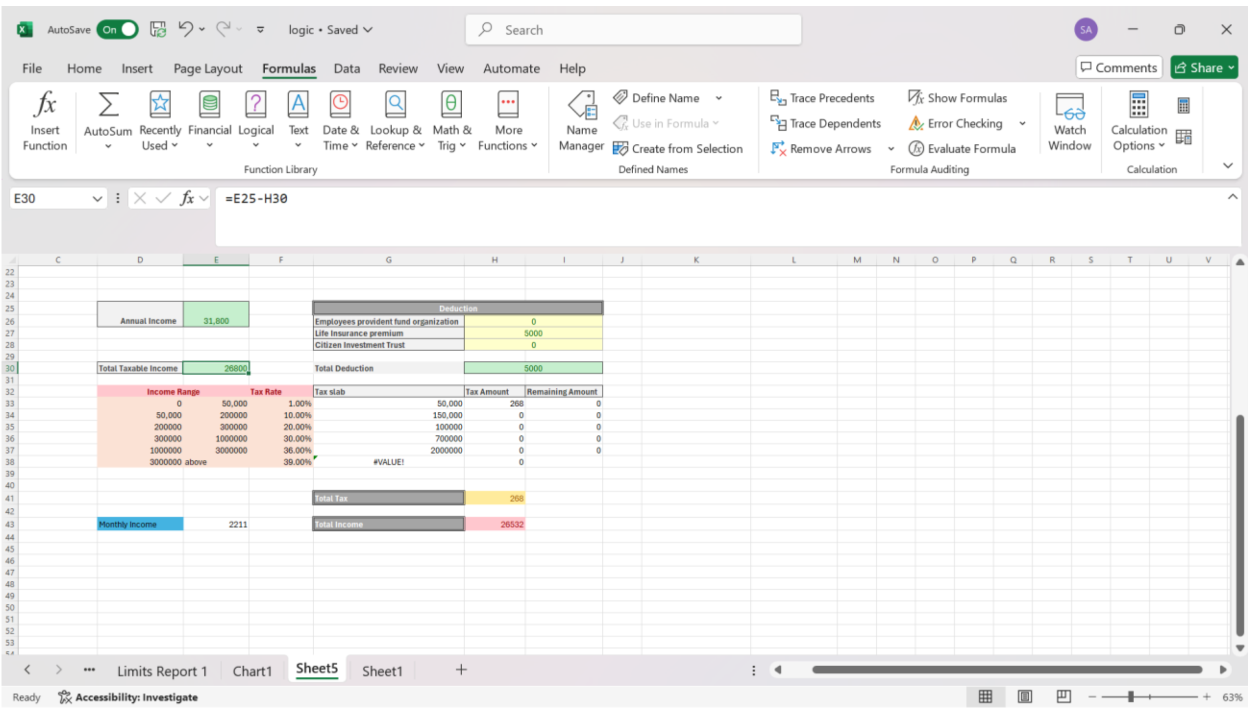


Figure 7: solution of qs no. 5

From the above excel sheet, the person has a salary of Rs.26532, after all the deductions and taxes and the individual earns probably Rs.2211 per month. Individual must pay the government tax Rs.268 from total earnings after the deduction the net amount of earning before tax is Rs.26800.

Test 6:

Total Annual Income : Rs. - 50,000

Deductions:

- Employees provident fund organization: (Rs.0)
- Life Insurance premium: (Rs. 0)
- Citizen Investment Trust:(Rs. 0)

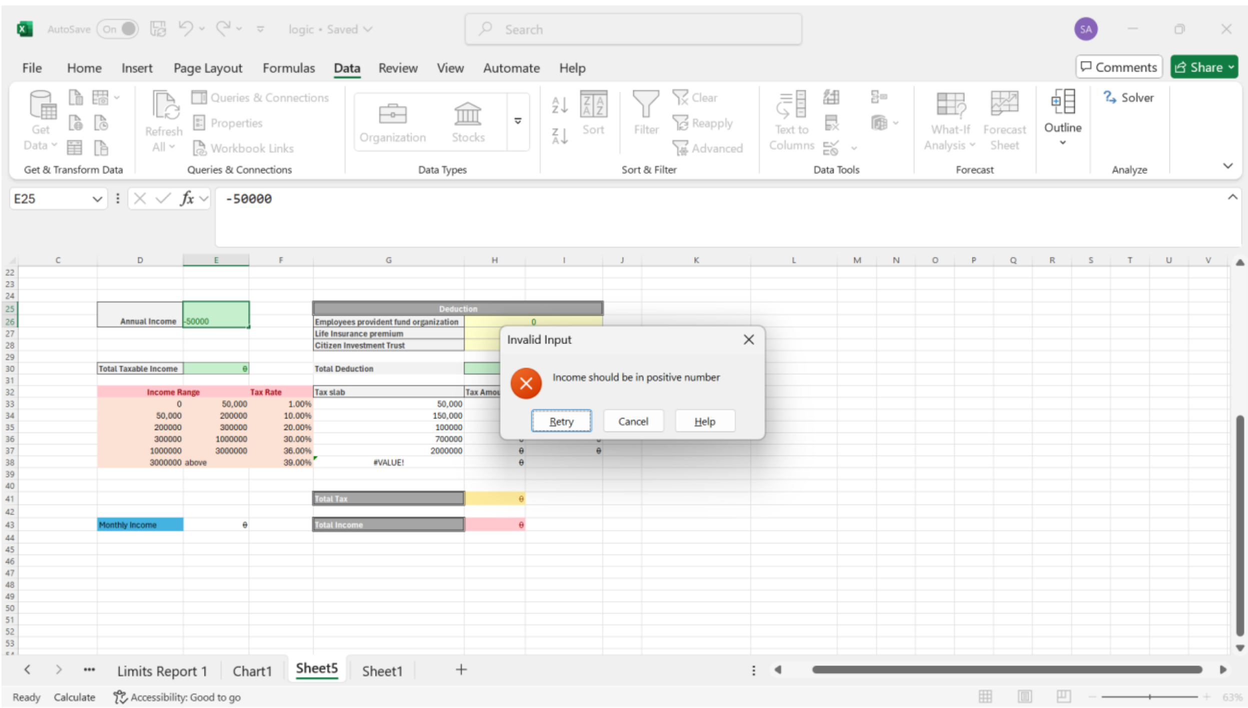


Figure 8:solution of qs no. 6

From the above excel sheet, the individual have a salary of -50000 according to scenario. The salary of the individual has never been of negative value and the validation was set on the Annual income. So, the validation dialog box is popup in the window with appropriate message or feedback.

2. Problem 2

Solution: Part A

2.1.A. Formulate the problem as a linear programming model, clearly defining the variables, the objective function, and the constraints.

Problem Analysis:

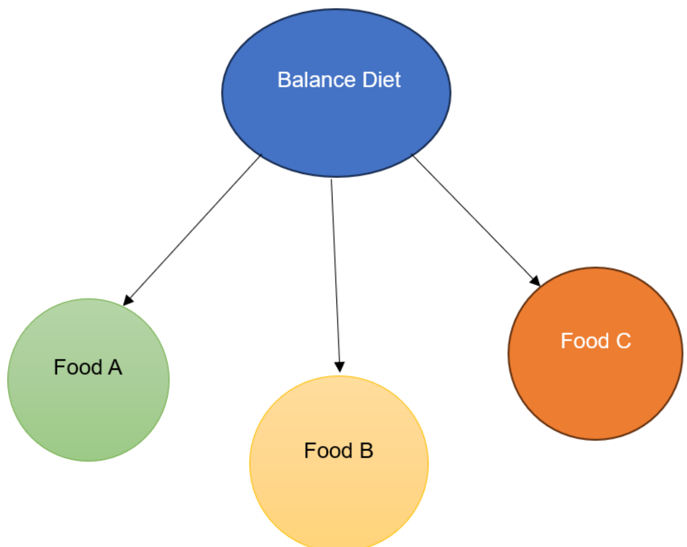


Figure 9:Problem Analysis

Food	Vitamin	Mineral	Carbohydrate	Cost per Unit
A	1	1	2	$3
B	2	1	1	$2
C	2	1	2	$3

Table 1:Food and Cost

a.<u>**Decision Variables:**</u>

Let:

- x = number of units of Food A
- y = number of units of Food B
- z= number of units of Food C

b) <u>**Objective Function (Minimize Cost)**</u>

Each unit costs:

- Food A: $3
- Food B: $2
- Food C: $3

So, the total cost Z' to minimize is:

$$\text{Minimize } Z' = 3x + 2y + 3z$$

c) <u>**Constraints**</u>

1. **Vitamins Constraint:**
    - Food A: 1 unit
    - Food B: 2 units
    - Food C: 2 units
    - Requirement: At least 8 units

$$x + 2y + 2z \geq 8$$

2. Minerals Constraint:

- Each food provides 1 unit
- Requirement: At least 9 units

$$x+y+z \geq 9$$

3. Carbohydrates Constraint:

- Food A: 2 units
- Food B: 1 unit
- Food C: 2 units
- Requirement: At least 10 units

$$2x+y+2z \geq 10$$

4. Non-Negativity Constraints

$$x \geq 0,\ y \geq 0,\ z \geq 0$$

2.2.B. Solve the problem using Simplex method.

Solution:

Let s1, s2, s3 Be the surplus variable and a1,a2,a3 Be the Artificial Variable.

Now,

Changing the inequalities to equalities using surplus and artificial variable,

$x+2y+2z-s1+a1=8$

$x+y+z-s2+a2=9$

$2x+y+2z-s3+a3=10.$

Changing the equation to standard form of equation,

1Z’ – 3x – 2y – 3z + 0S1 +0S2 + 0S3 – 10A1 – 10A2 – 10A3 = 0

0Z’ + x + 2y + 2z – 1S1 – 0S2 – 0S3 + 1A1 + 0A2 + 0A3 = 8

0Z’ + x + y + z – 0S1 – 1S2 – 0S3 + 0A1 + 1A2 + 0A3 = 9

0Z’ + 2x + y + 2z – 0S1 – 0S2 – 1S3 + 0A1 + 0A2 + 1A3 = 10

Simplex Table 1:

Row	Z’	x	Y	z	S1	S2	S3	A1	A2	A3	Constant
R0	1	-3	-2	-3	0	0	0	-10	-10	-10	0
R1	0	1	2	2	-1	0	0	1	0	0	8
R2	0	1	1	1	0	-1	0	0	1	0	9
R3	0	2	1	2	0	0	-1	0	0	1	10

Table 2:Simplex Table 1

For identity matrix,

New R0 = old R0 + 10 (R1 + R2 + R3)

Old R0	+ 10 (R1 + R2 + R3)	New R0
1	0	1
-3	40	37
-2	40	38
-3	50	47
0	-10	-10
0	-10	-10
0	-10	-10
-10	10	0
-10	10	0
-10	10	0
0	270	270

Table 3:Calculation Table for new R0

Simplex Table 2:

Row	Z’	x	Y	Z	S1	S2	S3	A1	A2	A3	Constant	Ratio
R0	1	37	38	47	-10	-10	-10	0	0	0	270	-
R1	0	1	2	2	-1	0	0	1	0	0	8	4
R2	0	1	1	1	0	-1	0	0	1	0	9	9
R3	0	2	1	2	0	0	-1	0	0	1	10	5

Table 4:Simplex Table 2

Here, The highest value if 47 so, z is the key column and 2 is the key element because 4 is the lowest ratio so R1 is the key row.

Updating the table,

New R1 = old R1/2

Old R1	/2	New R1
0	/2	0
1	/2	1/2
2	/2	1
2	/2	1
-1	/2	-1/2
0	/2	0
0	/2	0
1	/2	1/2
0	/2	0
0	/2	0
8	/2	4

Table 5:Calculation for new R1

New R0 = Old R0 – 47 * New R1

Old R0	-47 * New R1	New R0
N	-47 * New R1	1
37	-47 * New R1	27/2
38	-47 * New R1	-9
47	-47 * New R1	0
-10	-47 * New R1	27/2
-10	-47 * New R1	-10
-10	-47 * New R1	-10
0	-47 * New R1	-47/2
0	-47 * New R1	0
0	-47 * New R1	0
270	-47 * New R1	82

Table 6:Calculation for New R2

New R2 = Old R2 – New R1

Old R2	-New R1	New R2
0	-0	0
1	-1/2	1/5
1	-1	0
1	-1	0
0	0.5	1/5
-1	-0	-1
0	-0	0
0	-0.5	-1/5
1	0	1
0	0	0
9	4	5

Table 7:Calculation for New R2

New R3 = Old R3 – 2 * New R1

Old R3	– 2 * New R1	New R3
0	– 2 * New R1	0
2	– 2 * New R1	1
1	– 2 * New R1	-1
2	– 2 * New R1	0
0	– 2 * New R1	1
0	– 2 * New R1	0
-1	– 2 * New R1	-1
0	– 2 * New R1	-1
0	– 2 * New R1	0
1	– 2 * New R1	1
10	– 2 * New R1	2

Table 8:Calculation for new R3

Simplex Table 3:

Row	Z'	x	Y	z	S1	S2	S3	A1	A2	A3	Constant	Ratio
R0	1	27/2	-9	0	27/2	-10	-10	-47/2	0	0	82	-
R1	0	1/2	1	1	-1/2	0	0	1/2	0	0	4	8
R2	0	1/2	0	0	½	-1	0	-1/2	1	0	5	10
R3	0	1	-1	0	1	0	-1	-1	0	1	2	2

Table 9:Simplex Table 3

The highest value is 27/2 so, the key column in x and R3 is the key row because the lowest ratio is 2. The key element is 1.

Now,

We need to update the table.

New R0 = old R0 – 27/2 * R3

Old R0	-27/2 * R3	New R0
1	0	1
27/2	27/2	0
-9	-27/2	9/2
0	0	0
27/2	27/2	0
-10	0	-10
-10	-27/2	7/2
-47/2	-27/2	-10
0	0	0
0	27/2	-27/2
82	27	55

Table 10:Calculation of new R0

New R1 = Old R1 – R3/2

Old R1	– R3/2	New R1
0	0	0
½	-1/2	0
1	1/2	3/2
1	-0	1
-1/2	-1/2	-1
0	-0	0
0	1/2	1/2
½	1/2	1
0	-0	0
0	-1/2	-1/2
4	-1	3

Table 11:Calculation for New R1

New R2 = Old R2 – R3/2

Old R2	– R3/2	New R2
O	0	O
½	-1/2	0
0	1/2	1/2
0	0	0
½	-1/2	0
-1	0	-1
0	1/2	1/2
-1/2	1/2	0
1	0	1
0	-1/2	-1/2
5	-1	4

Table 12:Calculation of new R2

Simplex Table 4:

Row	Z'	x	y	z	S1	S2	S3	A1	A2	A3	Constant	Ratio
R0	1	0	9/2	0	0	-10	7/2	-10	0	-27/3	55	-
R1	0	0	3/2	1	-1	0	1/2	1	0	-1/2	3	2
R2	0	0	1/2	0	-1	0	1/2	0	1	-1/2	4	8
R3	0	1	-1	0	0	-1	-1	-1	0	1	2	-2

Table 13 Simplex Table 4

Here 9/2 is the highest value so y is the key column and 3/2 is the key element because 2 in R1 has the lowest ratio.

Now,

New R1 = Old R1 * 2/3

Old R1	*2/3	New R1
0	*2/3	0
0	*2/3	0
3/2	*2/3	1
1	*2/3	2/3
-1	*2/3	-2/3
0	*2/3	0
½	*2/3	1/3
1	*2/3	2/3
0	*2/3	0
-1/2	*2/3	-1/3
3	*2/3	2

Table 14:Calculation of New R1

New R0 = Old R0 – 9/2 * New R1

Old R0	– 9/2 * New R1	New R0
1	0	1
0	0	0
9/2	9/2	0
0	3	-3
0	-3	3
-10	0	-10
7/2	3/2	2
-10	3	-13
0	0	0
-27/2	-3/2	-12
55	9	46

Table 15:Calculation of new R0

Updating the other rows to elements of key column 0 except key element.

New R2 = Old R2 – 1/2 * New R1

Old R2	– 1/2 * New R1	New R2
0	0	0
0	0	0
½	-1/2	0
0	-1/3	-1/3
0	1/3	1/3
-1	-0	-1
½	-1/6	1/3
0	-1/3	-1/3
1	-0	1
-1/2	1/6	-1/3
4	-1	3

Table 16:Calculating New R2

New R3 = Old R3 + 1 * New R1

Old R3	+ 1 * New R1	New R3
0	0	0
1	0	1
-1	1	0
0	2/3	2/3
1	-2/3	1/3
0	0	0
1	1/3	4/3
-1	2/3	-1/3
0	0	0
1	-1/3	2/3
2	2	4

Table 17:Calculating New R3

Simplex Table 5:

Row	Z’	x	y	z	S1	S2	S3	A1	A2	A3	Constant	Ratio
R0	1	0	0	-3	3	-10	2	-13	0	-12	46	-
R1	0	0	1	2/3	-2/3	0	1/3	2/3	0	-1/3	2	-3
R2	0	0	0	-1/3	1/3	-1	1/3	-1/3	1	-1/3	3	9
R3	0	1	0	2/3	1/3	0	4/3	-1/3	0	2/3	4	12

Table 18 Simplex Table 5

Here, the highest positive value is in column S2 that is 3 so, S1 is the key column, and the smallest positive ratio is in R2 that is 9 so, the key element is 1/3.

Now,

Updating the key rows using formula,

New R2 = Old R2 * 3

Old R2	* 3	New R2
0	* 3	0
0	* 3	0
0	* 3	0
-1/3	* 3	-1
1/3	* 3	1
-1	* 3	-3
1/3	* 3	1
-1/3	* 3	-1
1	* 3	3
-1/3	* 3	-1
3	* 3	9

Table 19:Calculating New R2

New R0 = Old R0 – 3 * New R2

Old R0	– 3 * New R2	New R0
1	-0	1
0	-0	0
0	-0	0
-3	3	0
3	-3	0
-10	9	-1
2	-3	-1
-13	3	-10
0	-9	-9
-12	3	-9
46	-27	19

Table 20 Calculation of New R0

Updating the rows.

New R3 = Old R3 – 1/3 * R2

Old R3	– 1/3 * R2	New R3
0	0	0
1	-0	1
0	-0	0
2/3	1/3	1
1/3	-1/3	0
0	1	1
4/3	-1/3	1
-1/3	1/3	0
0	-1	-1
2/3	1/3	1
4	-3	1

Table 21 Calculation of New R3

Updating Row 1,

New R1 = Old R1 + 2/3 * R2

Old R1	+ 2/3 * R2	New R1
0	0	0
0	0	0
1	0	1
2/3	-2/3	0
-2/3	2/3	0
0	-2	-2
1/3	2/3	1
2/3	-2/3	0
0	2	2
-1/3	-2/3	-1
2	6	8

Table 22 Calculation of New R1

Simplex Table 6:

Row	Z’	x	y	z	S1	S2	S3	A1	A2	A3	Constant	Ratio
R0	1	0	0	0	0	-1	-1	-10	-9	-9	19	-
R1	0	0	1	0	0	-2	1	0	2	-1	8	-
R2	0	0	0	-1	1	-2	1	-1	3	-1	9	-
R3	0	1	0	0	0	1	1	0	-1	1	1	-

Table 23 Simplex Table 6 Optimal solution reached

Here, we reached the optimal solution because all the coefficients of variables in R0 <= 0.

Therefore,

Minimum cost = 19$

X = 1

Y = 8

Z = 0

Overall,

Optimal Quantities of Nutrition:

i. Food A (x) = 1 units
ii. Food B (y) = 8 units
iii. Food C (z) = 0 units

The minimum value was found to be 19$ as indicated as constant value in R0. The simplex method successfully calculated the optimal purchasing quantities of the three types of food to meet the requirement of the diet.

The required diet was at least 8 units of vitamins, 9 units of minerals and 10 units of carbohydrates. Berkshire Health shall bring up the resources:

i. 1 unit of Food A
ii. 8 units of Food B
iii. Food C does not reduce total cost, so it is eliminated.

This nutrients diet successfully satisfy the requirements with low cost making the diet healthy and cost efficient.

2.3.C. Solve the problem using the Excel Solver and interpret the results.

<u>Solution:</u>

Initial Template of Excel Solver

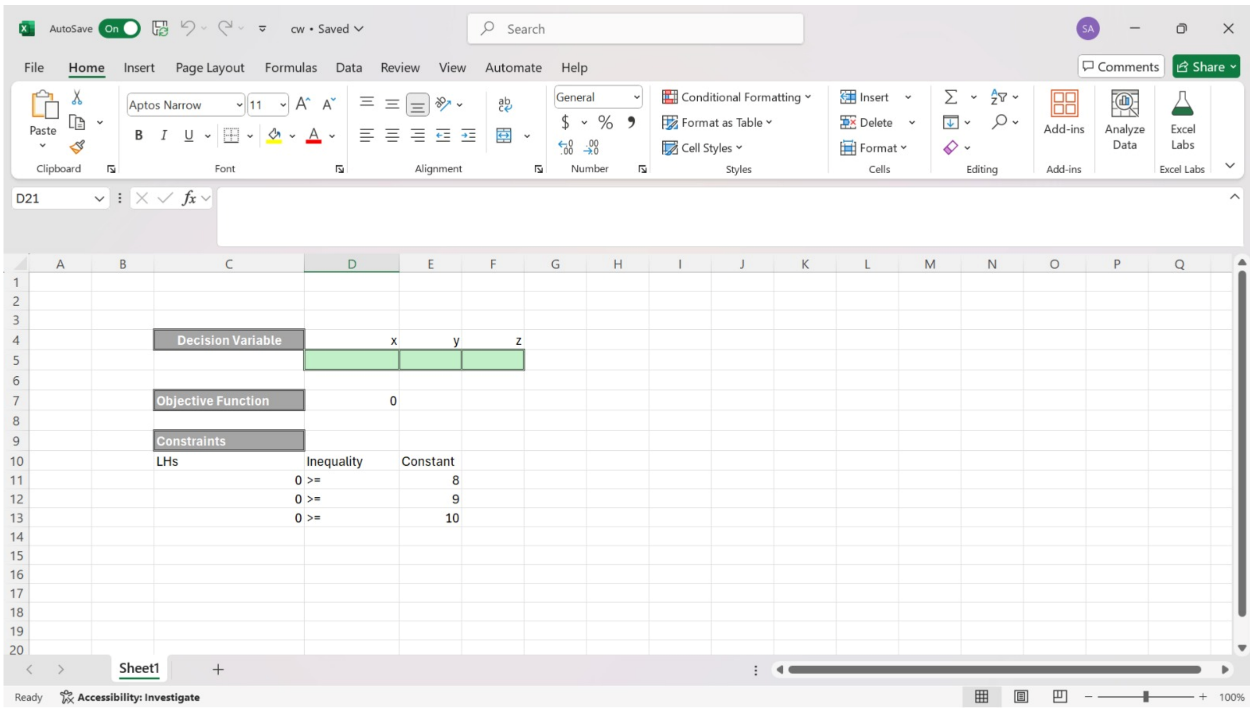


Figure 10:Initial Template of Excel Solver

Formula Of Excel Solver Spreadsheet

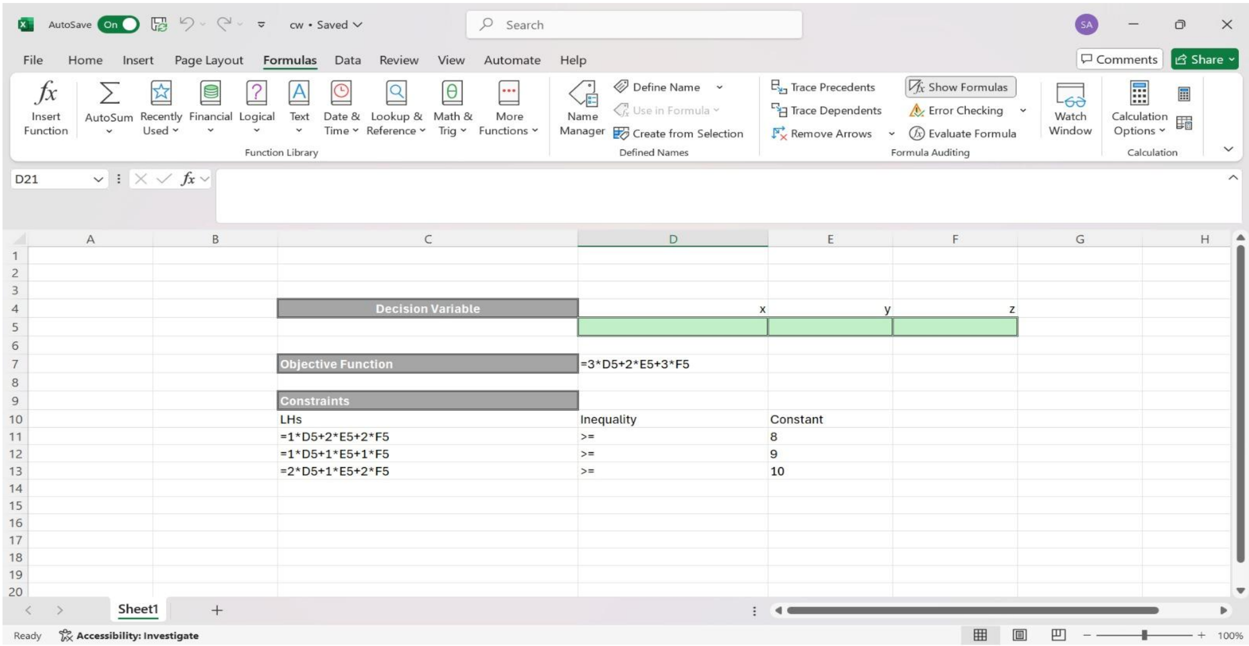


Figure 11:Formula Of Excel Solver Spreadsheet

Solution Of Question in Excel Solver Spreadsheet

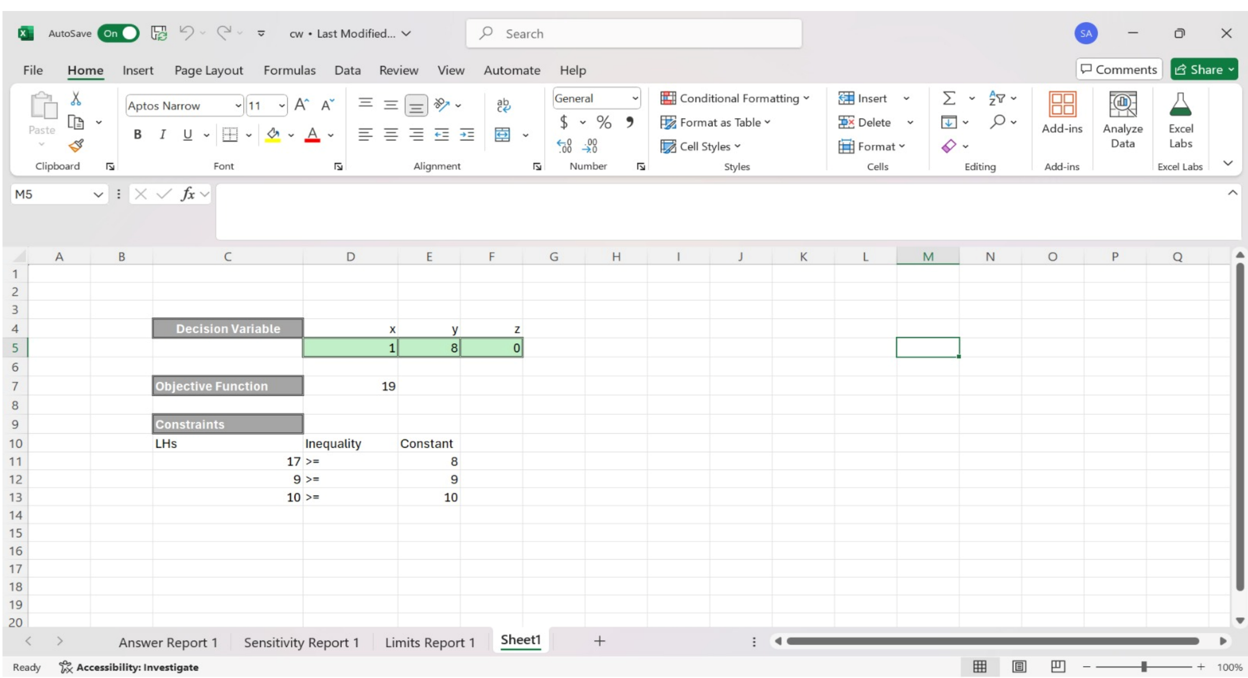
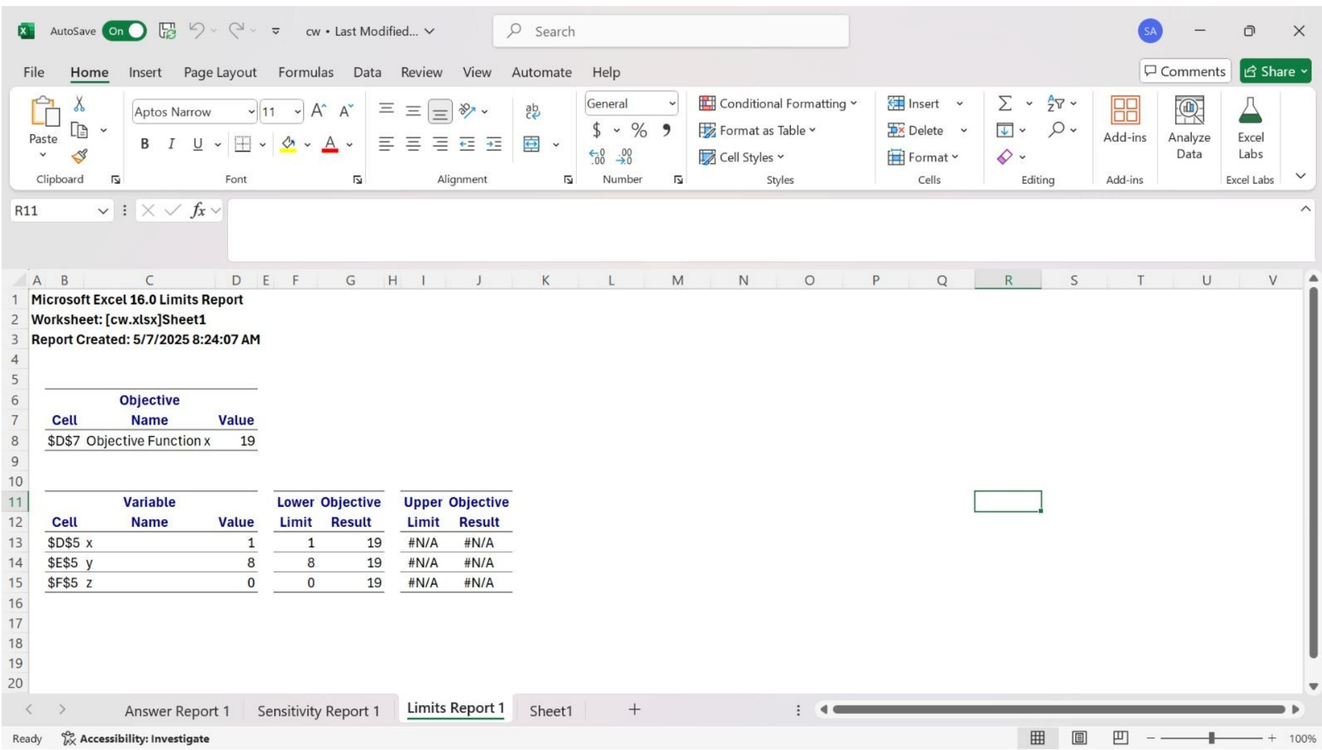


Figure 12:Solution Of Question in Excel Solver Spreadsheet

Limit Report:

The report where all the sensitive analysis is done by running the excel solver model with each decision variable, objective and minimization and maximization while holding all the others variable constant**.** (solver, 2025)


Microsoft Excel 16.0 Limits Report
Worksheet: [cw.xlsx]Sheet1
Report Created: 5/7/2025 8:24:07 AM

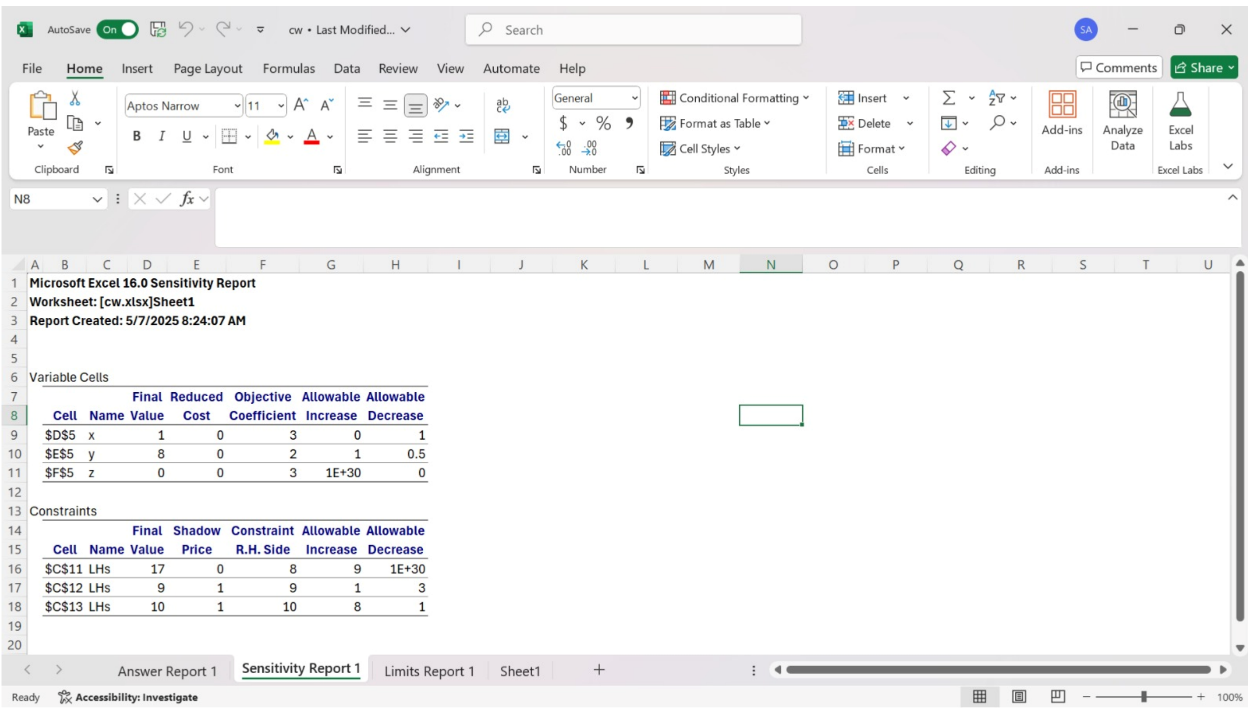
	Objective	
Cell	Name	Value
D7	Objective Function x	19

	Variable		Lower	Objective	Upper	Objective
Cell	Name	Value	Limit	Result	Limit	Result
D5	x	1	1	19	#N/A	#N/A
E5	y	8	8	19	#N/A	#N/A
F5	z	0	0	19	#N/A	#N/A

Figure 13:Limit Report

Sensitivity Report:

The report where we understand how an optimal solution changes when model coefficient are adjusted. After complete the finding of optimal solution ,the report generate and analyze how the objective function coefficients and constraints impact the solution. (brunel, 2025)



Microsoft Excel 16.0 Sensitivity Report
Worksheet: [cw.xlsx]Sheet1
Report Created: 5/7/2025 8:24:07 AM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
D5	x	1	0	3	0	1
E5	y	8	0	2	1	0.5
F5	z	0	0	3	1E+30	0

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
C11	LHs	17	0	8	9	1E+30
C12	LHs	9	1	9	1	3
C13	LHs	10	1	10	8	1

Figure 14:Sensitivity Report

Answer Report:

The summary of optimal solution including the original and final decision values of constraints, decision variable and present status of each constraints is known as Answer Report. (solver, 2025)

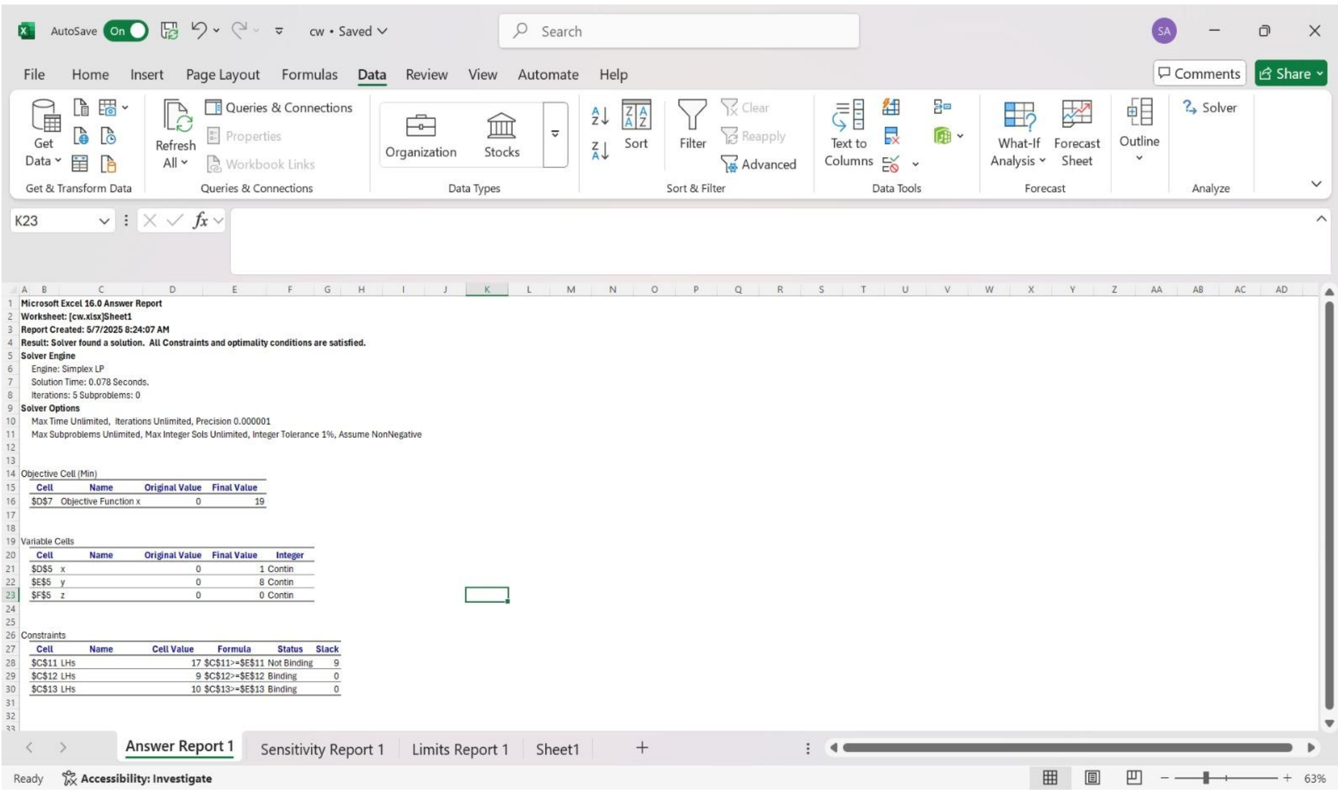


Figure 15:Answer Report

2.4.D. A memorandum to Berkshire Health Care

Memorandum

To: Berkshire Health Care Management

From: Group 134

Date: 2025-05-18

Subject: Optimal food purchase plan for patient diet.

Dear Management Team,

I am very delightful to let you know that the conclusion of our analysis is that we identify the budget friendly mix of Food A, Food B and Food C that satisfies the patients' nutritional diets while keeping the budget as low as possible.

After examining and many reviews I have made a planned diet for Berkshire Health Care patients with minimum budget while satisfying the requirements of nutrients goal. They are:

i. **Optimal Purchase plan:**

Food A	1 unit
Food B	8 units
Food c	0 units

Table 24:Optimal Purchase plan

a. Food A: Only eating 1 unit of Food A is most cost efficient while still satisfying the nutrients requirements. Food A contains rich vitamins, minerals and carbohydrate at a minimum budget.
b. Food B: Consuming 8 units of Food B is very cost efficient. The Food B contains all the necessary nutrients with the right amount of quantity on a low cost.
c. Food C: Food C is better not to be used to reduce the cost . This section of food may contain proper nutrients, but it is very expensive.

ii. **Minimum cost:** If used the plan that is provided the total cost to meet all the dietary requirement for each patients is 19$. This is the most cheapest way to fulfill the diet requirements.

iii. **Diet requirements:**

Nutrients	Minimum required
Vitamins	8 units
Minerals	9 units
Carbohydrate	10 units

Now a question may arise, why would this plan work? The answer to that is simple. Food B is the most cost effective even compared to food A for providing vitamins and minerals richer than food A while Food provide the required carbohydrates the diet requirements are fulfilled with the minimum cost. It is very budget friendly plus full fills all the requirements.

iv. Recommendation:

To maintain a budget friendly yet healthy diet that fulfills all the nutrients requirements the Berkshire Health Care should purchase 1 unit of Food A and 8 units of Food B daily for each patients.

Best regards,

Sonam Acharya, Siddhant Tamrakar, Namrata Lamichhane

Adviser

Berkshire Health Care

Solution: Part B

Decision Variable

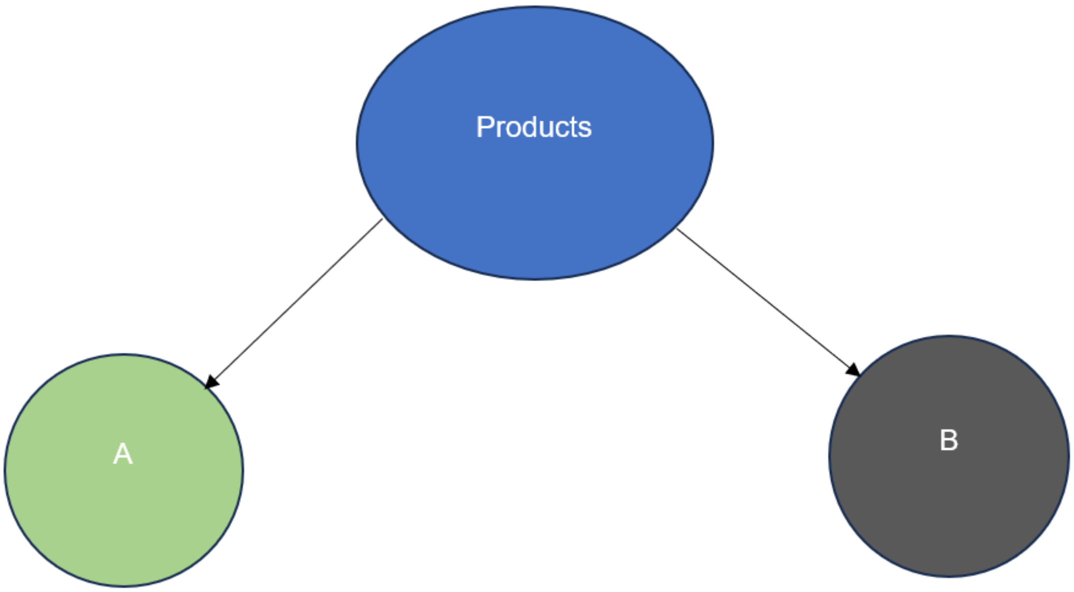


Figure 16:Problem Analysis

Let,

- x= number of liquid product jars purchased
- y = number of dry product cartons purchased

Objective Function

Minimize $Z=3x+2y$

Constraints

1. **Chemical A Constraints:**

   5x+1y >= 10………[1]

2. **Chemical B Constraints:**

   2x+2y>=12………[2]

3. **Chemical C Constraints:**

   1x+4y>=12………[3]

4. **Non Negativity Constraints:**

   x>=0 , y>=0

Changing Inequalities into equalities:

- 5x+y=10……..….[4]
- 2x+2y=12……….[5]
- x+4y=12……….[6]

From Equation [4],

5x+y=10

When x=0 we get y=10

When y=0 we get x=2

x	0	10
y	2	0

Therefore, the equation [4] Passes through the points (0,10) and (2,0).

Origin Test Of Equation [1] ,

Put x = 0 and y = 0 in

$$5x+1y >= 10$$

we get,

$$5*0+1*0>=10$$

$$0>=10 \text{(False)}$$

Hence , 0 >= 10 which is false, so origin lies outside the equation [1].

From Equation [5],

$$2x+2y=12$$

When x=0 we get y=6

When y=0 we get x=6

X	0	6
Y	6	0

Since, The equation [5] Passes through the points (0,6) and (6,0).

Origin Test Of Equation [2] ,

Put x = 0 and y = 0 in

$$2x+2y>=12$$

we get,

$$2*0+2*0>=12$$

$$0>=12 \text{(False)}$$

Hence , 0 >= 12 which is false, so origin lies Outside the equation [2].

From Equation [6],

x+4y=> 12

When x=0 we get y=3

When y=0 we get x=12

X	0	3
Y	12	0

Therefore, the equation [4] Passes through the points (0,3) and (12,0).

Origin Test Of Equation [3] ,

Put x = 0 and y = 0 in

1x+4y>=12

we get,

1*0+4*0>=12

0>=12(False)

Hence , 0 >= 12 which is false, so origin lies outside the equation [3].

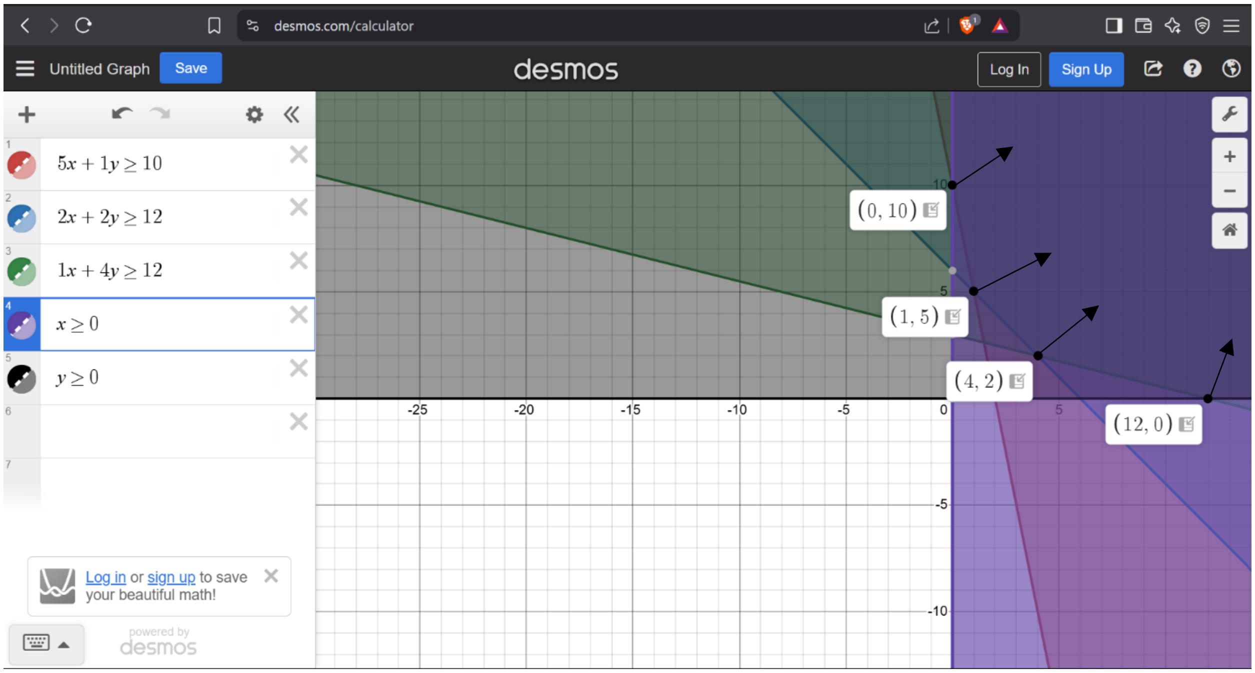


Figure 17: Graph Of Part B

From the above Graph Feasible region,

Vertices	X	y	Z=3x+2y
(0,10)	0	10	20
(1,5)	1	5	13
(12,0)	12	0	36
(4,2)	4	2	16

The minimum cost occurs at (x,y)=(1,5) with total cost £13.

Therefore, Mr. Harris should purchase 1 jar of liquid product and 5 cartons of dry product, for a minimum total cost of £13.

3. Problem 3

Solution:

3.1. Find the breakeven points & explain the breakeven points in terms of number of items and cost.

- **Fixed cost:** Such expenses are not affected by how much a company produces. It doesn't matter if the business is fully productive or barely produced, these costs will remain steady.

  Whether there are one or one thousand visitors, the company still needs to pay hosting and registration fees and must still maintain the website. They are not related to production or sales and must be paid regardless of what the business does.

  Variable Cost: If the amount of production rises or falls, variable costs can also increase or decrease. When a company produces more, its production costs go up and when production drops, its costs decrease.

  For example, labor costs are common. The demand for items or services may rise, requiring more employees and costing more wages. If fewer goods or services are produced due to less work, the costs associated with labor also come down. As production activity increases, these costs go up as well.

  Cost Function: The cost function is used to measure the price of producing various products. It helps work out a projection of how much will be spent as production increases. It is often noted as C(x), with x being the number of units that were produced. With changes in production, the cost also rises or falls.

  Demand function: How many of a product are willing to buy depends partly on the price or their own income. It's basically a way to understand the relationship between how much people are willing to purchase and the conditions influencing that decision.

  Revenue Function: This refers to the total amount of money a business earns by selling its products. The total revenue is represented by R(x), where x shows the number of items sold. It makes it easier for a company to see the relationship between sales and their income.

Break-Even Point: The break-even point is when a business brings in total income that is equal to its total expense. The company doesn't generate any profit, but it doesn't suffer any losses. When all the costs are covered, the next sales generate extra money as profit.

It's necessary for businesses to grasp this idea to see how many sales they must make to avoid losing money and begin turning a profit. (investopedia, 2025)

To Find Break Even Points,

Reverse function for manufacturing company R(X)=10-x

Cost function for manufacturing company C(x)=$x^2 - 8x + 20$

Let, x be the output

We know,

In break-even points,

Reverse function R(X)=Cost function C(X)

or, 10-X=$x^2 - 8x + 20$

or, $x^2 - 8x + 20 + x - 10 = 0$

or, $x^2 - 7x$+10=0

Now,

Comparing, $x^2 - 7x$+10=0 with $ax^2 + bx + c = 0$ i.e. quadratic equation

We get,

A=1 ,B= -7,C=10

solving this equation,

$$x = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

or, $x = \frac{-(-7)\pm\sqrt{(-7)^2-4\times1\times10}}{2\times1}$

or,$x = \frac{7\pm\sqrt{49-40}}{2}$

or,$x = \frac{7\pm\sqrt{9}}{2}$

$$\text{or}, x = \frac{7 \pm 3}{2}$$

Taking $+\text{Ve}$ value,

$$x_1 = \frac{7+3}{2}$$

$$x_1 = 5$$

Taking $-\text{Ve}$ value,

$$x_2 = \frac{7-3}{2}$$

$$x_2 = 2$$

Therefore,

Either $x_1 = 5$ & $x_2 = 2$

Now,

Putting the value of x_1 in c(x)

$$y^1 = (x_1)^2 - 8x_1 + 20$$

$$= 5^2 - 8 \times 5 + 20$$

= 25 – 40 + 20 =5

Putting the value x_2 in c (x),

$$y_2 = (x_2)^2 - 8x_2 + 20$$

$$= (2)^2 - 8 \times 2 + 20$$

$$= 4 - 16 + 20 = 8$$

Thus,

The break-even points i.e. the exact amount of revenue and total cost for a manufacturing company are (5,5) and (2,8).

3.2. The revenue and cost functions on the graph

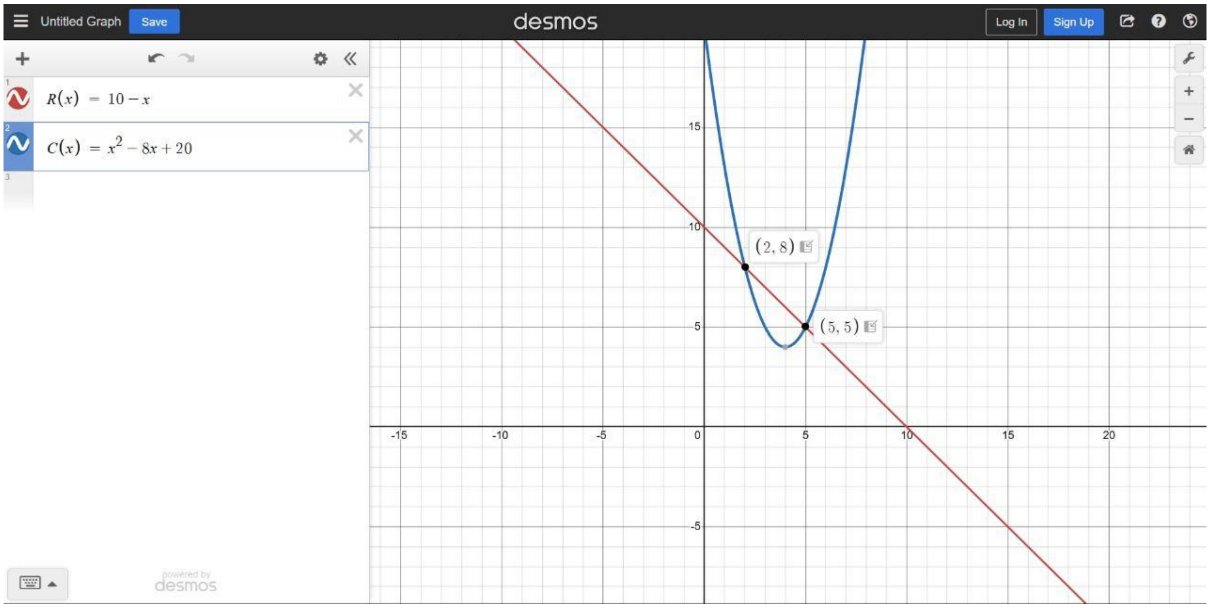


Figure 18:Break-Even point plotting in Graph Paper

This study examines the relationship between a company's production, income and expenses. When we analyzed the revenue and cost functions, we found the points where the company exactly breaks even in terms of its costs and revenue. At these stages, the business is breaking even; it makes no profit or loss.

We also formed a profit function by deducting the expenses from the income. Thanks to this, we established the optimal level for the company's profit. After making the calculations, we see that the company could make the most profit. When costs are at their lowest and income reaches its highest, this happens at that production level.

Being aware of these points is very crucial for the company. It demonstrates the earning level and guides them to identify the best amount of goods to sell. With this analysis, making decisions becomes easier, money is saved, and business grows over time.

3.3.profit function $P(x)$ find, The level production, maximum profit.

Here,

Reverse function for manufacturing company R(X)=10-x

Cost function for manufacturing company C(x)=$x^2 - 8x + 20$

Let, x be the output

We know,

In break-even points,

Reverse function R(X)=Cost function C(X)

or, 10-X=$x^2 - 8x + 20$

or, $x^2 - 8x + 20 + x - 10 = 0$

or, $x^2 - 7x$+10=0

Now,

Comparing, $x^2 - 7x$+10=0 with $ax^2 + bx + c = 0$ i.e. quadratic equation

We get,

A=1 ,B= -7,C=10

To determine profit function P(X),

We know,

P(X)=R(X)-C(X)

or, P(X)=(10-X)-($x^2 - 8x + 20$)

or, P(X)=10-x - $x^2 - 8x - 20$

or, P(X)=- $x^2 + 7x$-10

1.The level of production that maximize the profit.

Solution:

We know, Profit Function P(X)= - $x^2 - 7x$+10

Comparing the profit function with $ax^2 + bx + c = 0$ then

We get,

a=-1 , b=7 , c=10

We know,

Level of production,

X= $\frac{-b}{2a}$

= $\frac{-7}{2\times(-1)}$

= $\frac{7}{2}$

=3.5

Therefore ,The production level that maximize the profit is when x=3.5

2. **The maximum profit,**

Putting the value of x=3.5 in Profit function P(X),

P(X)= - $x^2 + 7x$-10

P(3.5)= -$(3.5)^2$+7×3.5-10

=-12.25+24.5-10

=2.25

So, P $\left(\frac{7}{2}\right) = 2.25$

Therefore, The maximum profit is 2.25

4. Conclusion

Well at the end of the year and end of the project we have wrapped up this semester journey. It shows the clear growth of all individuals as well as teams. In the project, as we begin the starting concepts is about tax calculation, tax formulas, linear programming and graphing. Step by step we start working with code like implementation of simplex method to find optimal solutions, calculating complex tax calculations and formulas.

The biggest achievement throughout the project is teamwork and know about how the challenges are faced together. Our team members have contributed too much to this project by making different time schedules. Finding error and debugging error is the memorable part of learning on each other, We have also built communication skills throughout the journey .

The logic and problem solving module help us to carry out into different new fields such as data analysis, operation research or any role that have thinking and collaboration capabilities. We have proved that any teamwork can break down any types of hardest questions .

Overall, this project was more than the coursework it was a shared adventure. Our team have gained technical skills as well as strengthened our communication skills. We have gain confidence that no challenge is too much tough we have the right team members and right mindset.

5. References

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6. Logbook Entries

The book where all the activities were stored or the events that group member has done throughout the day is known as logbook entries. The logbook entries consists of Metting No ,Date and time at the heading and some topics are also included such as items discussed, achievements throughout the work, problems faced while doing project, tasks for another meeting with all the team member's signature.

6.1. Logbook Entry of Metting 1

Logbook Entry Sheet

Meeting No: 1 **Date: 2025/5/12**

Start Time: 12:00 **Finish Time: 1:00**

2. **Items Discussed**: We kicked things off by chatting through how we'd tackle the assignment. Since it felt a bit overwhelming, we split the questions up among the team. Together, we agreed on what we wanted to achieve and set a clear deadline for wrapping everything up.

Achievements:
We split the coursework into three clear-cut parts—one for each of us—and suddenly everything clicked, since everyone had a well-defined task to tackle

Problems (if any): No problem yet.

Tasks for Next Meeting: At our next meeting, we'll dive into Problem 2 together.

Student's Name	Student's Signature
Sonam Acharya	Sonam
Siddhant Tamrakar	siddhant
Namrata Lamichhane	Namrata

Figure 19:Logbook Entry of Metting 1

6.2. Logbook Entry of Metting 2

Logbook Entry Sheet

Meeting No: 2 **Date: 2025/5/13**

Start Time: 8:00 **Finish Time: 8:30**

Items Discussed:
We dove into Question 2, trying out different solution paths—from sketching the constraints in Excel to running the simplex method by hand We also walked through how to generate both the Sensitivity and Answer reports, and agreed to include screenshots as proof of our work

Achievements:
We all understood our assigned tasks clearly, with no uncertainty. We confidently tackled the problems using both the Simplex Method and the graphical approach to linear programming. We also smoothly put together the answer report, sensitivity report, conclusion, and every other required component

Problems (if any): We kept running into roadblocks with Question 2—it just wasn't clear, and every time we tried, we ended up with different answers.

Tasks for Next Meeting :At our last meeting, we agreed to concentrate our efforts on thoroughly addressing question number two before moving on to the next one. We also set ourselves the goal of completing all of our question number 1 by our next gathering

Student's Name	Student's Signature
Sonam Acharya	Sonam
Siddhant Tamrakar	siddhant
Namrata Lamichhane	Namrata

Figure 20:Logbook Entry of Metting 2

6.3. Logbook Entry of Metting 3

Logbook Entry Sheet

Meeting No: 3 **Date: 2025/5/14**

Start Time: 11:00 **Finish Time: 12:30**

Items Discussed:
In our meeting, we tackled the key challenges of the tax-computation questions, mapped out how we'll organize and present our answers, agreed on specific deadlines for each section of the coursework, and outlined in detail all the components that must appear in the conclusion

Achievements:
By joining forces, we managed to tackle every question in just one day—identifying the correct solutions swiftly and wrapping up the coursework far sooner than we'd expected

Problems (if any): While the coursework itself wasn't stressful, we still struggled to find a quiet, private spot where we could discuss it and prepare the logbook.

Tasks for Next Meeting : We agreed to tackle question two during our next meeting and to provide feedback on question one.

Student's Name	Student's Signature
Sonam Acharya	Sonam
Siddhant Tamrakar	siddhant
Namrata Lamichhane	Namrata

Figure 21:Logbook Entry of Metting 3

6.4. Logbook Entry of Metting 4

Logbook Entry Sheet

Meeting No: 4 **Date: 2025/5/15**

Start Time: 2:00 **Finish Time: 2:30**

Items Discussed:
During class, we tackled break-even analysis both by solving the equations and by sketching the graphs. To keep our homework consistent, we reproduced that same approach in a neatly organized table. We also divided the coursework into separate sections so each of us could perform an initial review on our own, then reconvened to discuss our insights together

Achievements:
By dividing our work thoughtfully, we were able to tackle challenges quickly and accurately, which saved us a great deal of time. Collaborating so closely not only made the process more efficient but also deepened our understanding of how successful team projects come together—showing us the power of clear roles, open communication, and shared responsibility.

Problems (if any): No issues.

Tasks for Next Meeting : We agreed to tackle question solution In word file and check the answer of the coursework

Student's Name	Student's Signature
Sonam Acharya	Sonam
Siddhant Tamrakar	siddhant
Namrata Lamichhane	Namrata

Figure 22:Logbook Entry of Metting 4

6.5. Logbook Entry of Metting 5

Logbook Entry Sheet

Meeting No: 5 **Date: 2025/5/16**

Start Time: 1:00 **Finish Time: 2:30**

Items Discussed:
In this session, we outlined our plan for completing the task in a Word document.

Achievements:
We finalized the entire coursework in a Word document, confirmed that every answer was correct, and packed everything into a ZIP file under our leader's name to send to the second teacher.

Problems (if any): No issues, Because everyone contributed equally, we were able to solve the problem smoothly and without any difficulty.

Tasks for Next Meeting Thanks to our collective hard work and enthusiasm, we wrapped up every task by our fifth meeting, leaving only the final submission for our last gathering.

Student's Name	Student's Signature
Sonam Acharya	Sonam
Siddhant Tamrakar	siddhant
Namrata Lamichhane	Namrata

Figure 23:Logbook Entry of Metting 5

6.6. Logbook Entry of Metting 6

Logbook Entry Sheet

Meeting No: 6 **Date: 2025/5/19**

Start Time: 9:00 **Finish Time: 9:30**

Items Discussed:
In this session, we outlined our plan for submitting the file to my second teacher portal.

Achievements:
Packed everything into a ZIP file under our leader's name to send to the second teacher and submitted successfully to the mysecondTeacher.

Problems (if any): No issues on my end, but the session expiration problem occurred with our team leader second teacher's account..

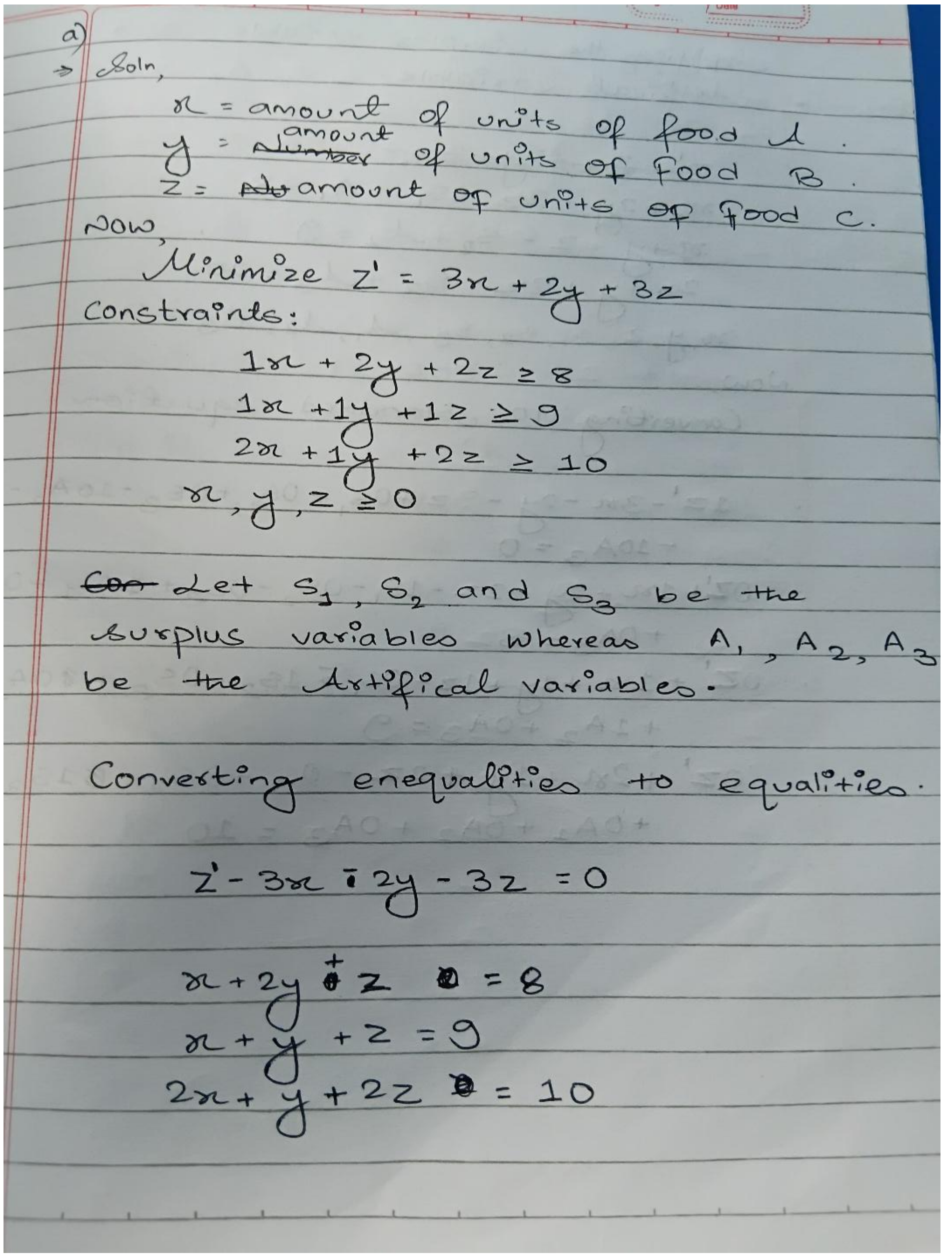
Tasks for Next Meeting: All the problem were solved very smoothly and finally we wrap up with the final submission.

Student's Name	Student's Signature
Sonam Acharya	Sonam
Siddhant Tamrakar	siddhant
Namrata Lamichhane	Namrata

Figure 24:Logbook Entry of Metting 6

7. Evidence

7.1. Evidence of Problem 2 Part A



a)

→ Soln,

x = amount of units of food A.

y = ~~Number~~ amount of units of Food B.

z = ~~Am~~ amount of units of food C.

Now,

Minimize $Z' = 3x + 2y + 3z$

Constraints:

$$1x + 2y + 2z \geq 8$$
$$1x + 1y + 1z \geq 9$$
$$2x + 1y + 2z \geq 10$$
$$x, y, z \geq 0$$

~~Con~~ Let S_1, S_2 and S_3 be the surplus variables whereas A_1, A_2, A_3 be the Artifical variables.

Converting enequalities to equalities.

$$Z' - 3x - 2y - 3z = 0$$

$$x + 2y + z = 8$$
$$x + y + z = 9$$
$$2x + y + 2z = 10$$

Figure 25:simplex constraints and decision variables

Applying the Surplus variable and Artificial variable.

$\cancel{z' - 3x - 2y - 3z}$

$$x + 2y + 3z - S_1 + A_1 = 8$$
$$x + y + z - S_2 + A_2 = 9$$
$$2x + y + 2z - S_3 + A_3 = 10$$
$$x, y, z, S_1, S_2, S_3, A_1, A_2, A_3 \geq 0$$

Now,
Converting to standard equation.

- $1z' - 3x - 2y - 3z + 0S_1 + 0S_2 + 0S_3 - 10A_1 - 10A_2 - 10A_3 = 0$
- $0z' + 1x + 2y + 2z - 1S_1 - 0S_2 - 0S_3 + 1A_1 + 0A_2 + 0A_3 = 8$
- $0z' + 1x + 1y + 1z - 0S_1 - 1S_2 - 0S_3 + 0A_1 + 1A_2 + 0A_3 = 9$
- $0z' + 2x + 1y + 2z - 0S_1 - 0S_2 - 1S_3 + 0A_1 + 0A_2 + 0A_3 = 10$

Figure 26:Converting To standard equation

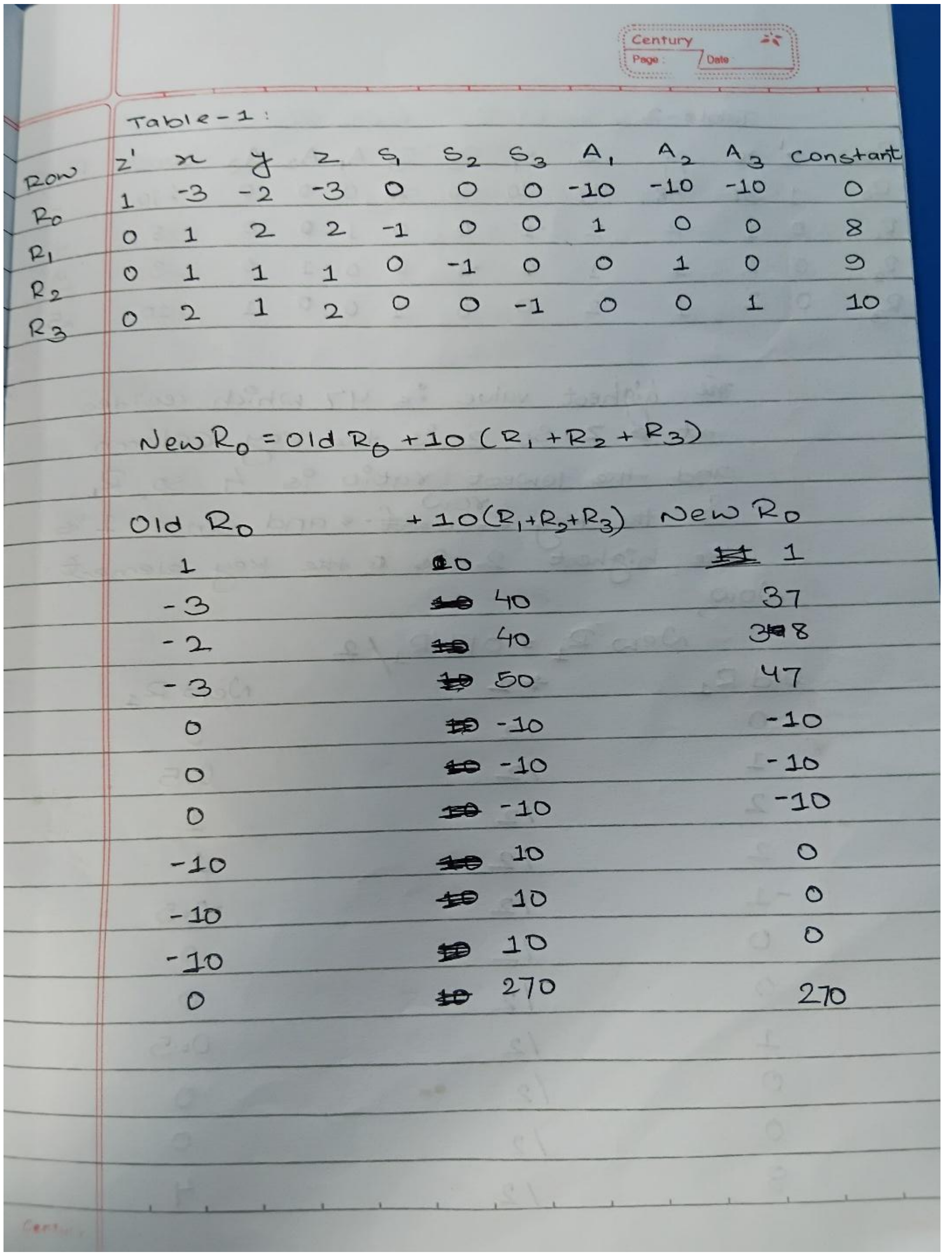


Table-1:

Row	z'	x	y	z	S_1	S_2	S_3	A_1	A_2	A_3	Constant
R_0	1	-3	-2	-3	0	0	0	-10	-10	-10	0
R_1	0	1	2	2	-1	0	0	1	0	0	8
R_2	0	1	1	1	0	-1	0	0	1	0	9
R_3	0	2	1	2	0	0	-1	0	0	1	10

New R_0 = Old R_0 + 10 (R_1 + R_2 + R_3)

Old R_0	+10(R_1+R_2+R_3)	New R_0
1	0	1
-3	40	37
-2	40	38
-3	50	47
0	-10	-10
0	-10	-10
0	-10	-10
-10	10	0
-10	10	0
-10	10	0
0	270	270

Figure 27:simplex tableau 1

Table-2

Row	z'	x	y	z	S_1	S_2	S_3	A_1	A_2	A_3	const	Ratio
R_0	1	37	38	47	-10	-10	-10	0	0	0	270	-
R_1	0	1	2	2	-1	0	0	1	0	0	8	4
R_2	0	1	1	1	0	-1	0	0	1	0	9	9
R_3	0	2	1	2	0	0	-1	0	0	1	10	5

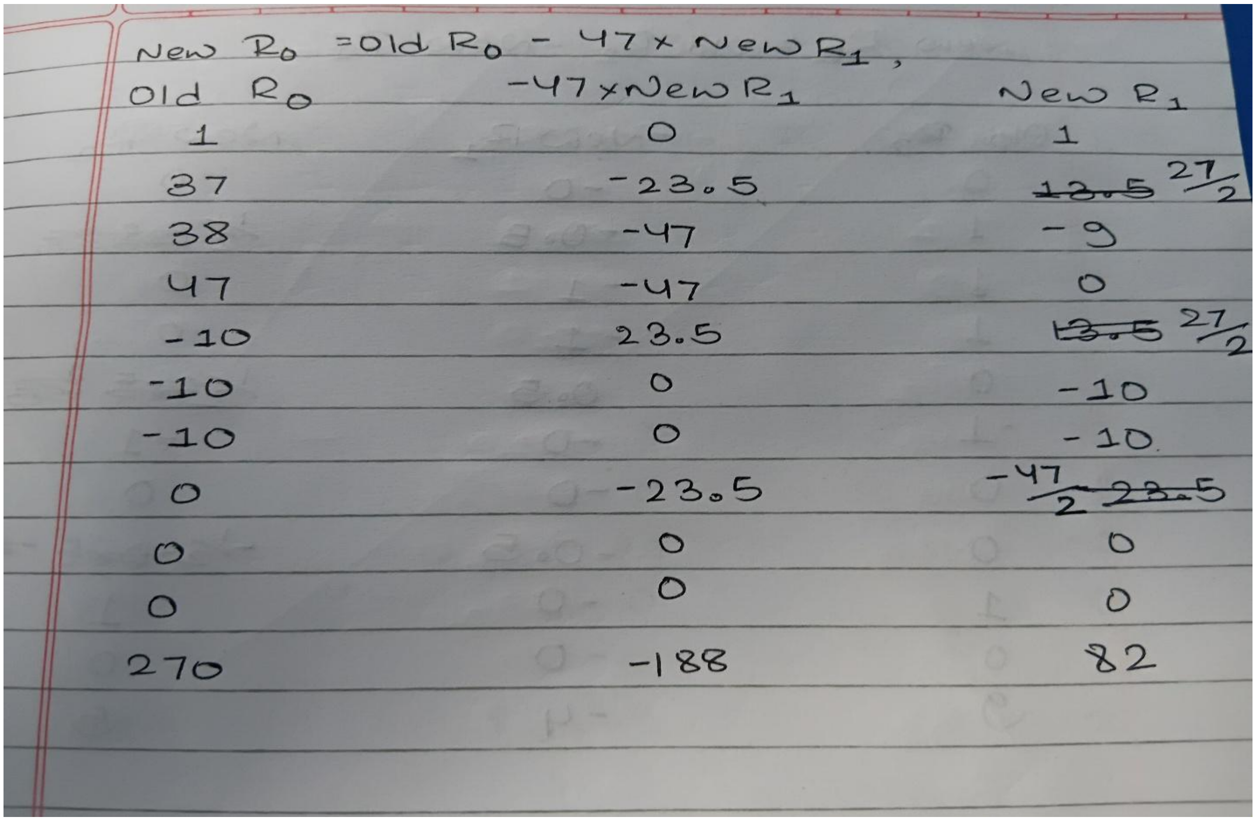
The highest value is 47 which resides at z so, z is the key column and the lowest ratio is 4 so, R_1 is the key ~~element~~ row and since 2 is the highest 2 is the key element.

Now,

$$\text{New } R_1 = \text{Old } R_1/2$$

Old R_1	÷2	New R_1
0	/2	0
1	/2	0.5
2	/2	1
2	/2	1
-1	/2	-0.5
0	/2	0
0	/2	0
1	/2	0.5
0	/2	0
0	/2	0
8	/2	4

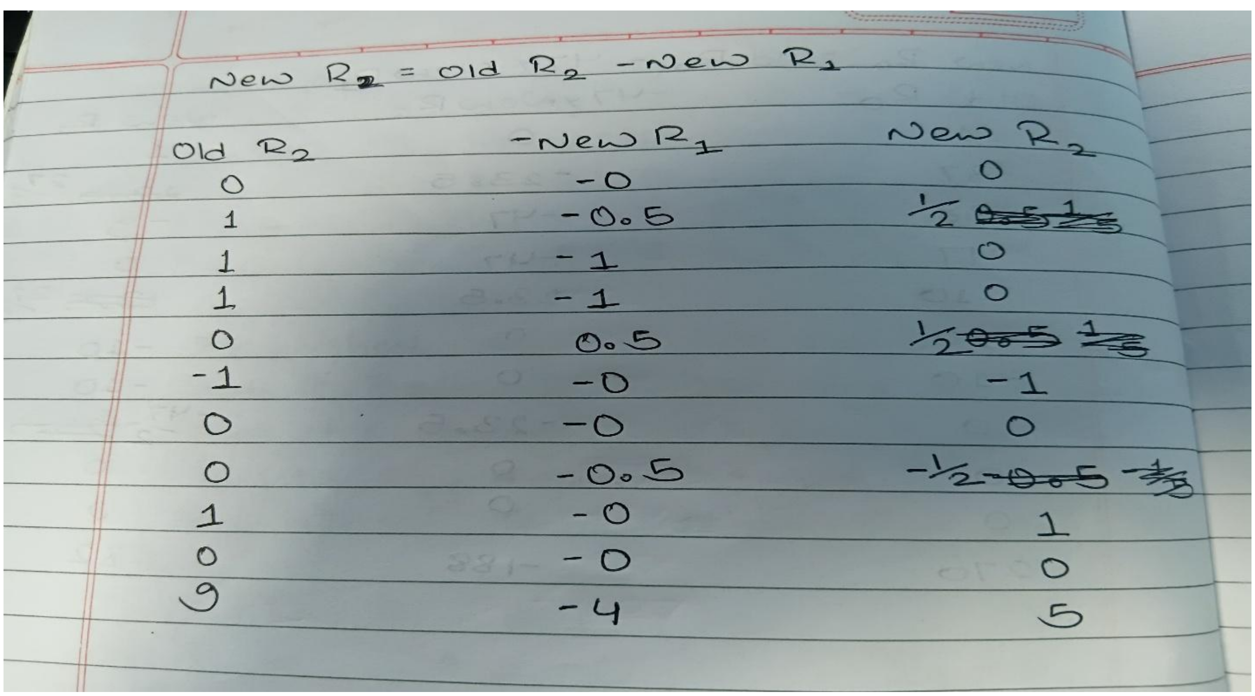
Figure 28:simplex tableau 2



New R_0 = Old R_0 − 47 × New R_1,

Old R_0	−47×New R_1	New R_1
1	0	1
37	−23.5	~~13.5~~ 27/2
38	−47	−9
47	−47	0
−10	23.5	~~13.5~~ 27/2
−10	0	−10
−10	0	−10
0	−23.5	−47/2 ~~23.5~~
0	0	0
0	0	0
270	−188	82

Figure 29:Finding New R1



New R_2 = Old R_2 − New R_1

Old R_2	−New R_1	New R_2
0	−0	0
1	−0.5	½ ~~0.5 1/2~~
1	−1	0
1	−1	0
0	0.5	½ ~~0.5 1/2~~
−1	−0	−1
0	−0	0
0	−0.5	−½ ~~−0.5 −1/2~~
1	−0	1
0	−0	0
9	−4	5

Figure 30:Finding New R2

New R_3 = Old $R_3 - 2 \times$ New R_1

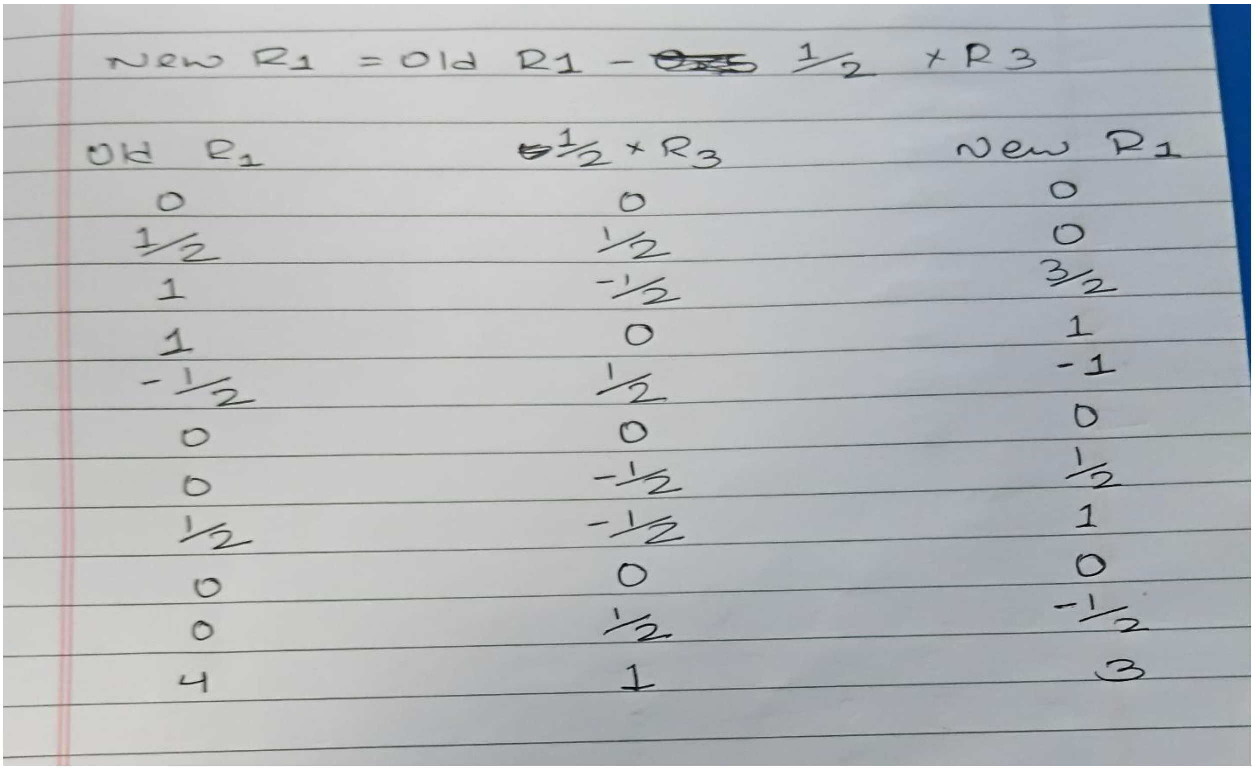
Old R_3	$-2 \times$ New R_1	New R_3
0	0	0
2	-1	1
1	-2	-1
2	-2	0
0	1	1
0	0	0
-1	0	-1
0	-1	-1
0	0	0
1	0	1
10	-2	2

Table - 3:

Row	z'	x	y	z	S_1	S_2	S_3	A_1	A_2	A_3	Const	Ratio
R_0	1	$27/2$	-9	0	$27/2$	-10	-10	$-47/2$	0	0	82	-
R_1	0	$1/2$	1	1	$-1/2$	0	0	$1/2$	0	0	4	8
R_2	0	$1/2$	0	0	$1/2$	-1	0	$-1/2$	1	0	5	10
R_3	0	1	-1	0	1	0	-1	-1	0	1	2	2

∴ The highest value is $27/2$ so, the key column is x and R_3 is the key row because the lowest ratio is 2. The key element is 1.

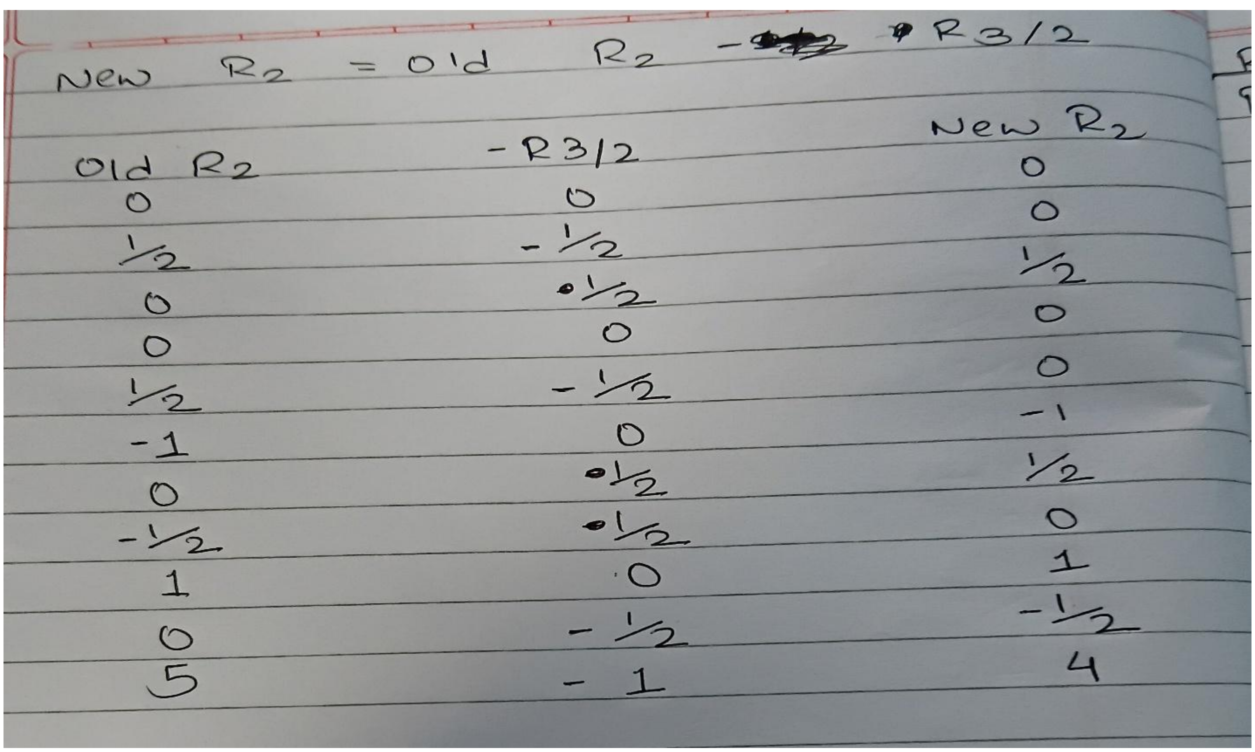
Figure 31: Finding New R3 & simplex tableau 3



New R_1 = Old R_1 − $\frac{1}{2} \times R_3$

Old R_1	$\frac{1}{2} \times R_3$	New R_1
0	0	0
$\frac{1}{2}$	$\frac{1}{2}$	0
1	$-\frac{1}{2}$	$\frac{3}{2}$
1	0	1
$-\frac{1}{2}$	$\frac{1}{2}$	−1
0	0	0
0	$-\frac{1}{2}$	$\frac{1}{2}$
$\frac{1}{2}$	$-\frac{1}{2}$	1
0	0	0
0	$\frac{1}{2}$	$-\frac{1}{2}$
4	1	3

Figure 32:Finding New R1



New R_2 = Old R_2 − $R3/2$

Old R_2	$-R3/2$	New R_2
0	0	0
$\frac{1}{2}$	$-\frac{1}{2}$	0
0	$\frac{1}{2}$	$\frac{1}{2}$
0	0	0
$\frac{1}{2}$	$-\frac{1}{2}$	0
−1	0	−1
0	$\frac{1}{2}$	$\frac{1}{2}$
$-\frac{1}{2}$	$\frac{1}{2}$	0
1	0	1
0	$-\frac{1}{2}$	$-\frac{1}{2}$
5	−1	4

Figure 33:Finding New R2

Row	z'	x	y	z	S_1	S_2	S_3	A_1	A_2	A_3	Const	Ratio
R_0	1	0	9/2	0	0	-10	7/2	-10	0	-27/2	55	
R_1	0	0	3/2	1	-1	0	1/2	1	0	-1/2	3	2
R_2	0	0	1/2	0	0	-1	1/2	0	1	-1/2	4	8
R_3	0	1	-1	0	1	0	1	-1	0	1	2	-2

Table 4 ↑

∴ Here, the highest value is 9/2 so, y is the keycolumn and the smallest and positive ratio is 2 so, R_1 is the key row & 3/2 is the key element.

Figure 34:simplex tableau 4

New R1 = Old R1 × 2/3

Old R_1	New R1 = Old R1 × 2/3
0	0
0	0
3/2	1
1	2/3
-1	-2/3
0	0
1/2	1/3
1	2/3
0	0
-1/2	-1/3
3	2

Updating the other rows.

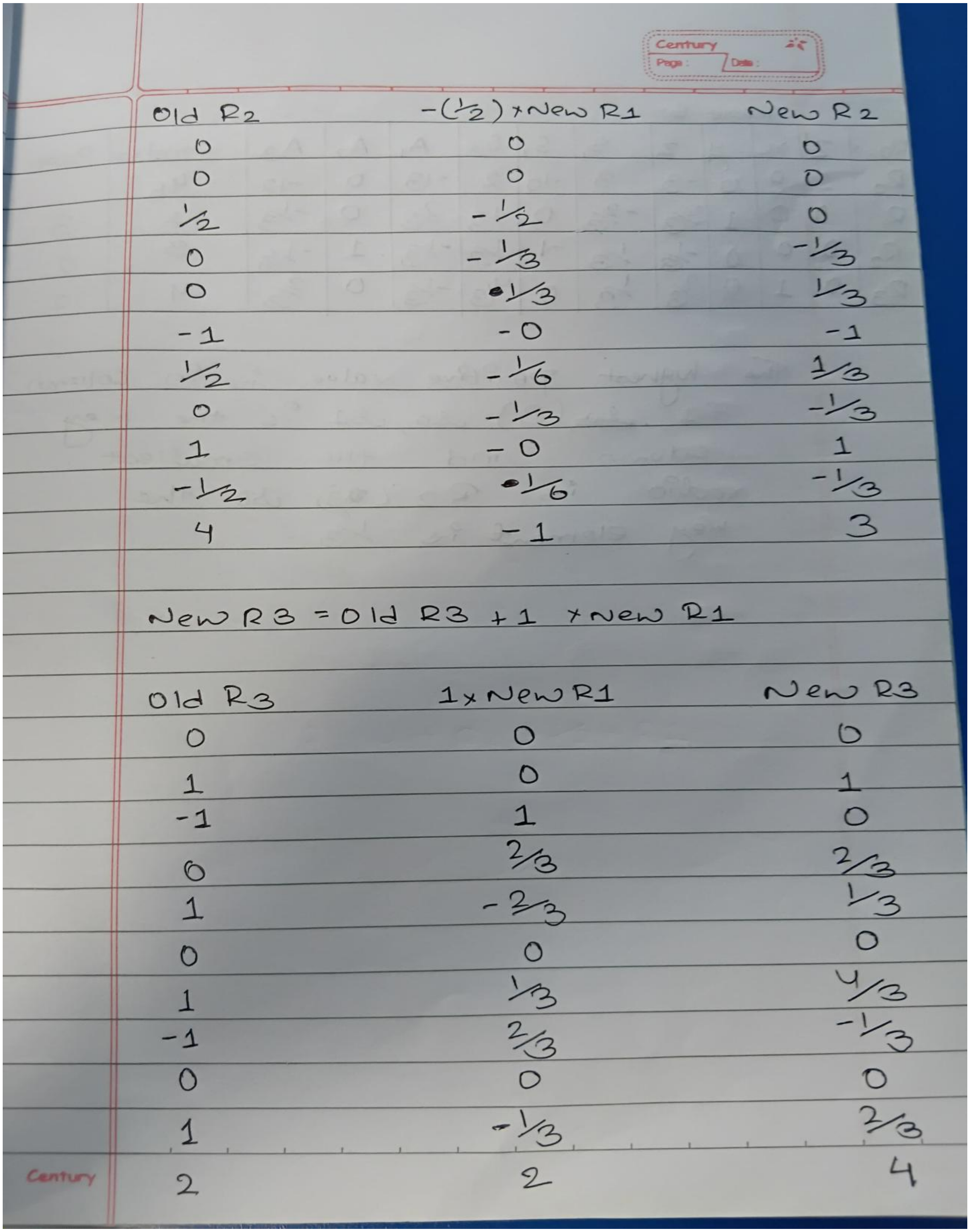
Figure 35:Updating the New R1

New R0 = Old R0 − (9/2) × New R1

Old R0	$-\frac{9}{2}$ × New R1	New R0
1	0	1
0	0	0
9/2	−9/2	0
0	−3	−3
0	3	3
−10	0	−10
7/2	−3/2	2
−10	−3	−13
0	0	0
−27/2	3/2	−12
55	−9	46

New R2 = Old R2 − $\frac{1}{2}$ × R1

Figure 36:Updating New R0



Old R2	-(1/2) x New R1	New R2
0	0	0
0	0	0
1/2	-1/2	0
0	-1/3	-1/3
0	1/3	1/3
-1	-0	-1
1/2	-1/6	1/3
0	-1/3	-1/3
1	-0	1
-1/2	1/6	-1/3
4	-1	3

New R3 = Old R3 + 1 x New R1

Old R3	1 x New R1	New R3
0	0	0
1	0	1
-1	1	0
0	2/3	2/3
1	-2/3	1/3
0	0	0
1	1/3	4/3
-1	2/3	-1/3
0	0	0
1	-1/3	2/3
2	2	4

Figure 37:Updating New R2 & R3

Table 5:

Row	z'	x	y	z	S_1	S_2	S_3	A_1	A_2	A_3	Constant	Ratio
R_0	1	0	0	-3	3	-10	2	-13	0	-12	46	
R_1	0	0	1	2/3	-2/3	0	1/3	2/3	0	-1/3	2	-3
R_2	0	0	0	-1/3	1/3	-1	1/3	-1/3	1	-1/3	3	9
R_3	0	1	0	2/3	1/3	0	4/3	-1/3	0	2/3	4	12

The highest positive value is in column S1, ~~S0~~, (3) so, S1 is the key column and the smallest ratio is R2 (9) so, the key element is 1/3.

Figure 38:simplex tableau 5

New R2 = Old R2 × 3

Old R2	New R2 = Old R2×3
0	0
0	0
0	0
-1/3	-1
1/3	1
-1	-3
1/3	1
-1/3	-1
1	3
-1/3	-1
3	9

Figure 39:Updating New R2

Table: 5

New R_0 = Old R_0 − 3 × New R2

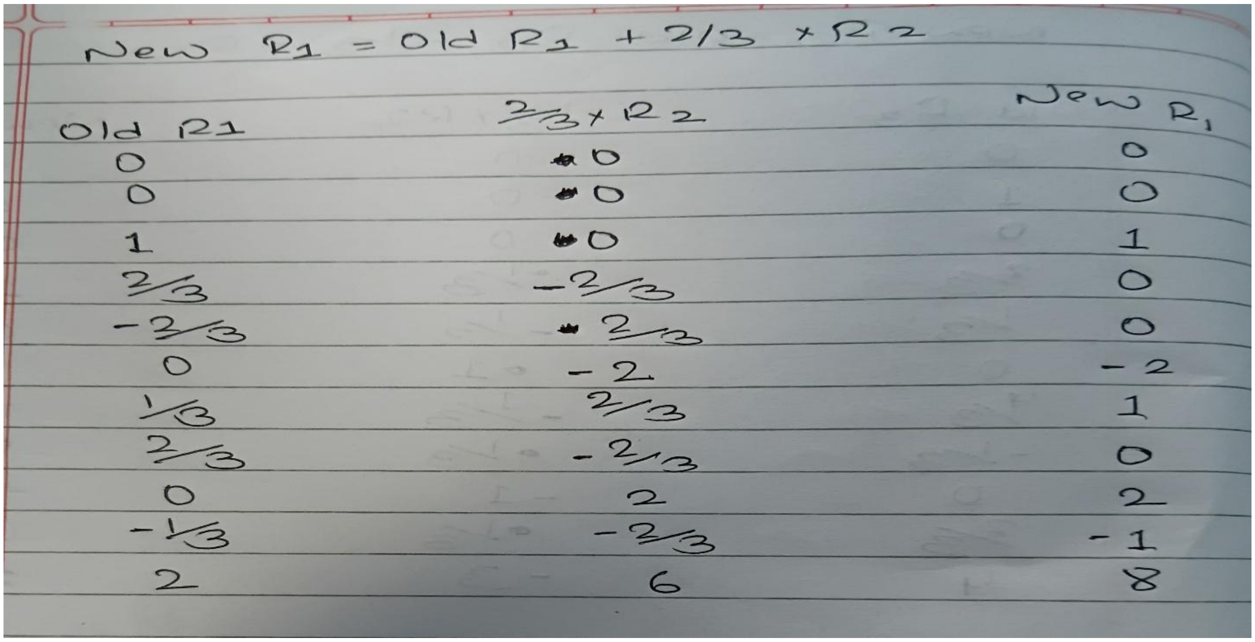
Old R_0	−3 × New R_2	New R_0
1	−0	1
0	−0	0
0	−0	0
−3	3	0
3	−3	0
−10	9	−1
2	−3	−1
−13	3	−10
0	−9	−9
−12	3	−9
46	−27	19

Figure 40:Updating New R0

New R_3 = Old R_3 − 1/3 × R2

Old R_3	−1/3 × R2	New R_3
0	0	0
1	−0	1
0	0	0
2/3	·1/3	1
1/3	−1/3	0
0	·1	1
4/3	−1/3	1
−1/3	·1/3	0
0	−1	−1
2/3	·1/3	1
4	−3	1

Figure 41:Finding New R3



New R_1 = Old R_1 + 2/3 × R_2

Old R1	2/3 × R2	New R_1
0	0	0
0	0	0
1	0	1
2/3	-2/3	0
-2/3	2/3	0
0	-2	-2
1/3	2/3	1
2/3	-2/3	0
0	2	2
-1/3	-2/3	-1
2	6	8

Figure 42:Updating New R1

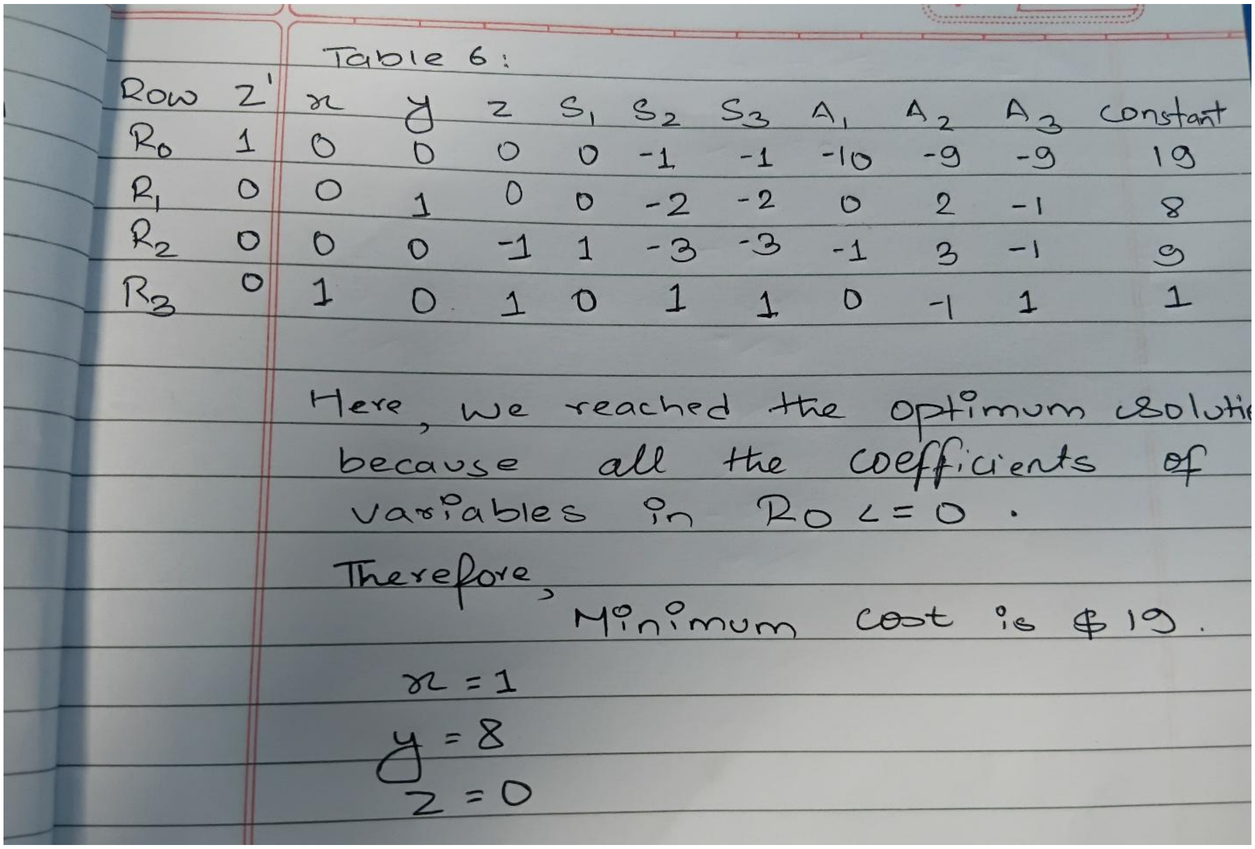


Table 6:

Row	Z'	x	y	z	S_1	S_2	S_3	A_1	A_2	A_3	constant
R_0	1	0	0	0	0	-1	-1	-10	-9	-9	19
R_1	0	0	1	0	0	-2	-2	0	2	-1	8
R_2	0	0	0	-1	1	-3	-3	-1	3	-1	9
R_3	0	1	0	1	0	1	1	0	-1	1	1

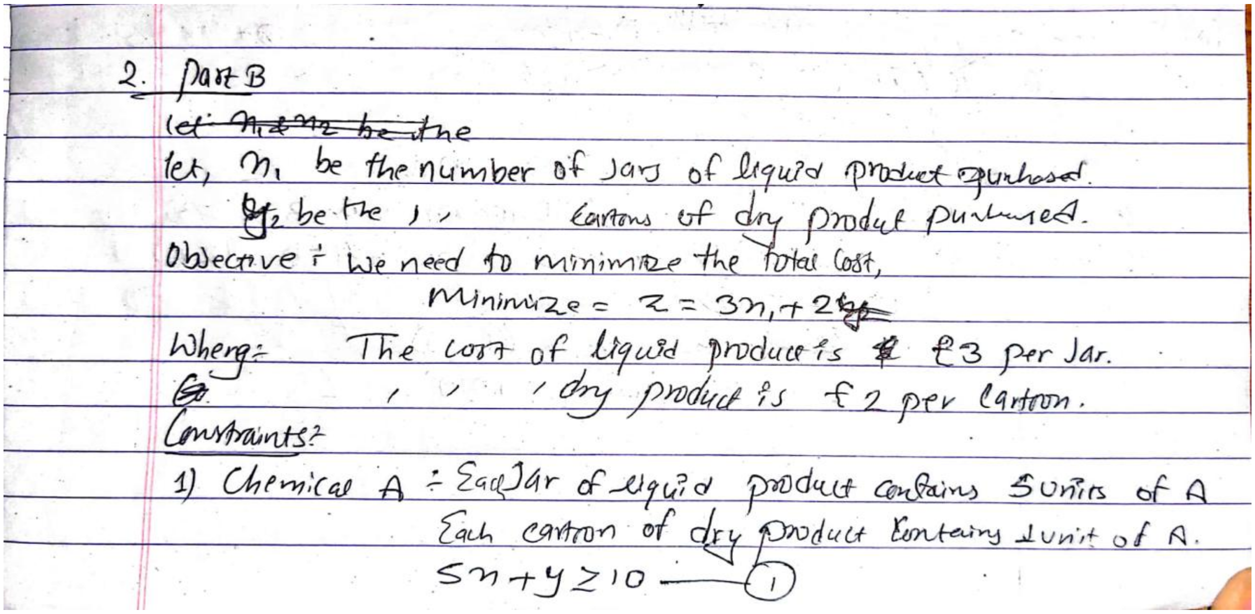
Here, we reached the optimum solution because all the coefficients of variables in $R_0 <= 0$.

Therefore,
Minimum cost is $19.

$x = 1$
$y = 8$
$z = 0$

Figure 43:simplex tableau 6 & Final Ans

7.2. Evidence of Problem 2 Part B



2. Part B

~~let x_1 & x_2 be the~~

let, x_1 be the number of jars of liquid product purchased.

x_2 be the ,, ,, cartons of dry product purchased.

Objective: We need to minimize the total cost,

Minimize = $Z = 3x_1 + 2x_2$

Where: The cost of liquid product is £3 per jar.

,, ,, ,, dry product is £2 per carton.

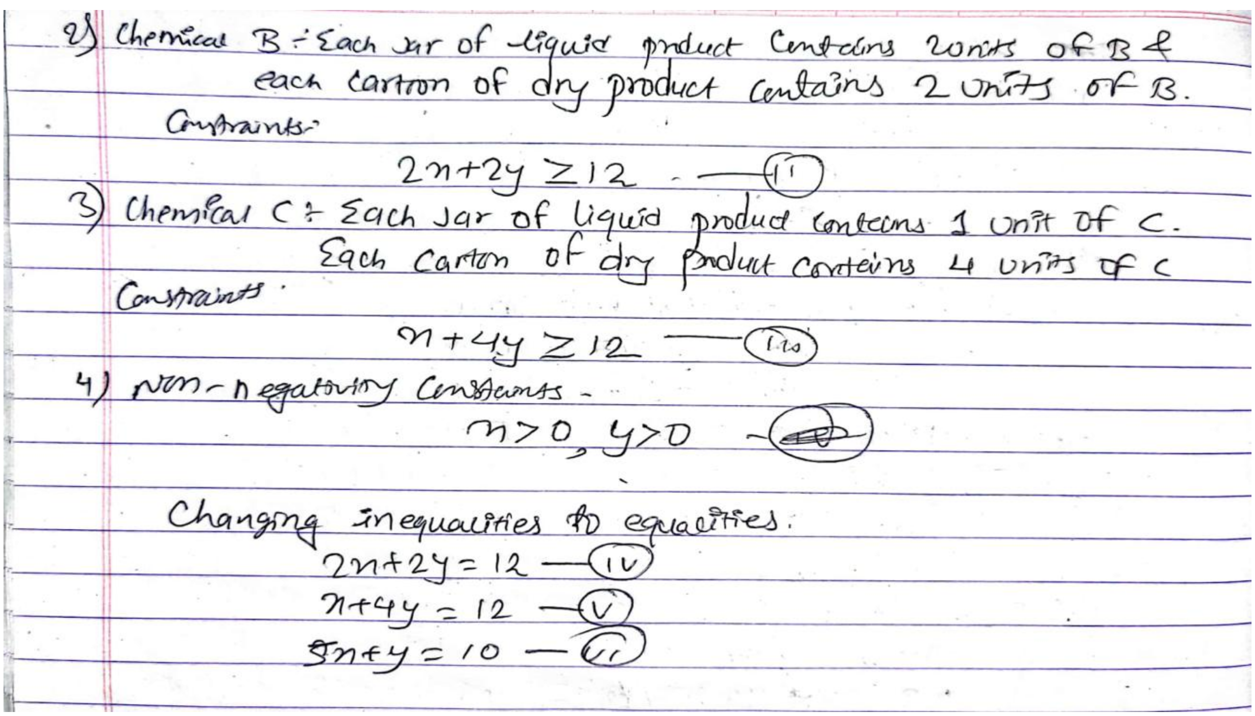
Constraints:

1) Chemical A: Each jar of liquid product contains 5 units of A

Each carton of dry product contains 1 unit of A.

$5x + y \geq 10$ — (i)

Figure 44: Let x and y be the product



2) Chemical B: Each jar of liquid product contains 2 units of B & each carton of dry product contains 2 units of B.

Constraints:

$2x + 2y \geq 12$ — (ii)

3) Chemical C: Each jar of liquid product contains 1 unit of C.

Each carton of dry product contains 4 units of C

Constraints:

$x + 4y \geq 12$ — (iii)

4) Non-negativity constraints:

$x > 0, y > 0$

Changing inequalities to equalities.

$2x + 2y = 12$ — (iv)

$x + 4y = 12$ — (v)

$5x + y = 10$ — (vi)

Figure 45:Constraints Declaration Part

From eqn 4,

$5x + y = 10$

When $x=0$, we get $y=10$

When $y=0$, we get $x=2$

x	0	10
y	2	0

Origin test of eqn (1)

put $x=0, y=0$ in

$5x + 1y \geq 10$

We get

$5 \times 0 + 1 \times 0 \geq 10$

$0 \geq 10$ (false)

So, $0 \geq 10$ which is false, so, origin ~~passes~~ lies outside the eqn (1) & the eqn(4) passes through (0,10) & (2,0)

From eqn 5,

$2x + 2y = 12$

When $x=0$ we get $y=6$

When $y=0$ we get $x=6$

x	0	6
y	6	0

Since, the eqn passes through (0,6) & (6,0)

origin test of eqn (11)

put $x=0, y=0$ in eqn

$2x + 2y \geq 12$

We get

$2 \times 0 + 2 \times 0 \geq 12$

$0 \geq 12$ (false)

So, $0 \geq 12$ is false then origin lies outside the eqn (2).

From eqn 6,

~~x+y~~ $x + 4y \geq 12$

When, $x=0$ we get $y=3$

when $y=0$ we get $x=12$

x	0	3
y	12	0

Therefore, eqn(4) passes through the points (0,3) & (12,0)

Origin test of eqn 3,

put $x=0$, & $y=0$ in eqn

$1x + 4y \geq 12$

We get $1 \times 0 + 4 \times 0 \geq 12$

$0 \geq 12$ (false)

Figure 46:Finding the optimal points

Hence, $0 >= 12$ which is false, so, origin lies outside the equation (3).

From the above graph, feasible region

Vertices	x	y	$Z = 3x + 2y$
(0,10)	0	10	20
(1,5)	1	5	13
(12,0)	12	0	36
(4,2)	4	2	16

The minimum cost occurs at $(x,y) = (1,5)$ with total cost £13.

Therefore, Mr. Harts should purchase 1 jar of liquid product & 5 cartons of dry product, for a minimum cost of £13.

Figure 47: Vertices From The Graph

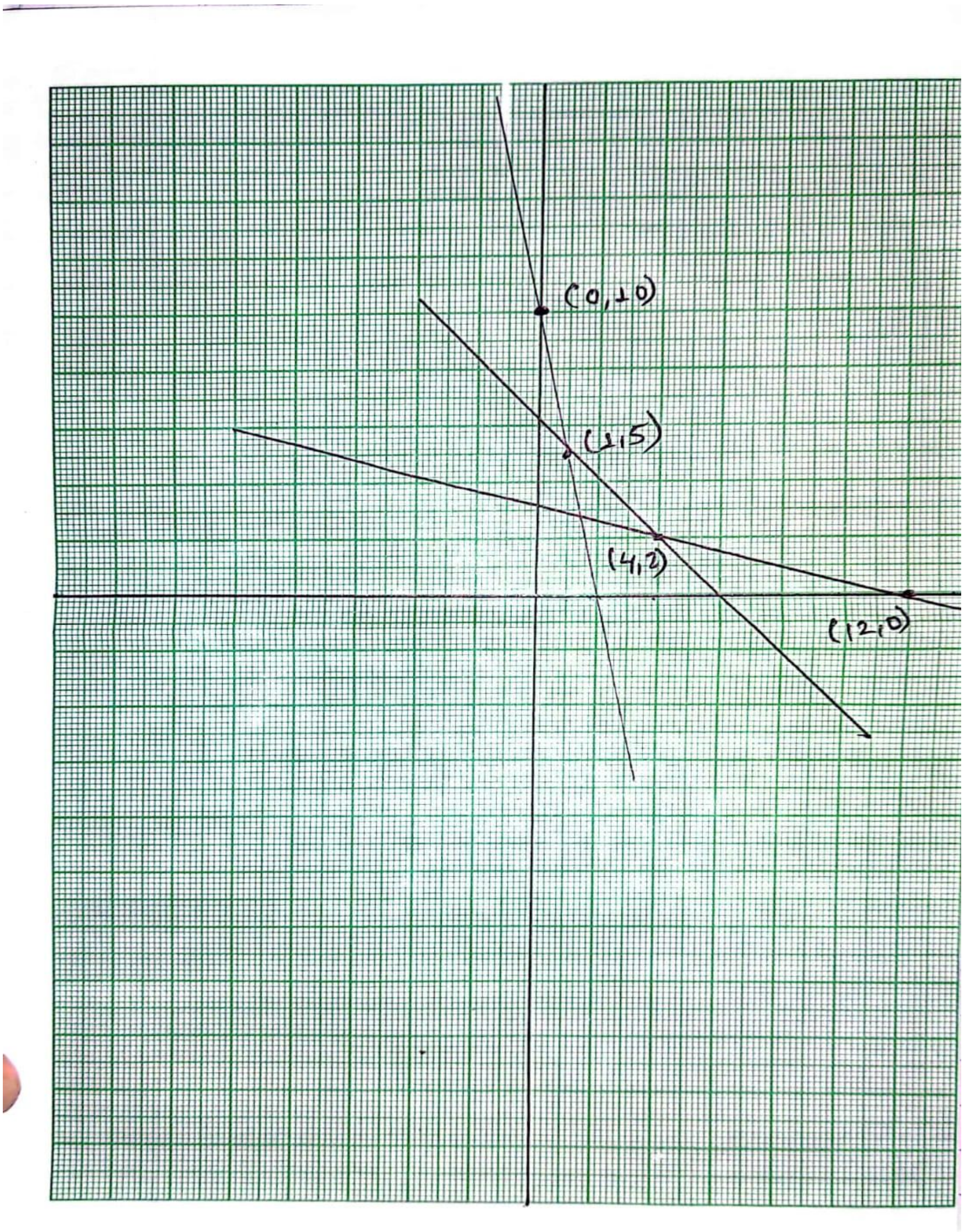


Figure 48:Graph Of Problem 2 Part B

7.3. Evidence of Problem 3

DATE
PAGE No.

To find Break Even points,

Reverse function for manufacturing company $R(x) = 10-$

cost function for manufacturing company $C(x) = x^2 - 8x + 20$

Let, x be the output

We know,

In break-even points,

Reverse function $R(x)$ = cost function $C(x)$

or, $10 - x = x^2 - 8x + 20$

or, $x^2 - 8x + 20 + x - 10 = 0$

or, $x^2 - 7x + 10 = 0$

Now,

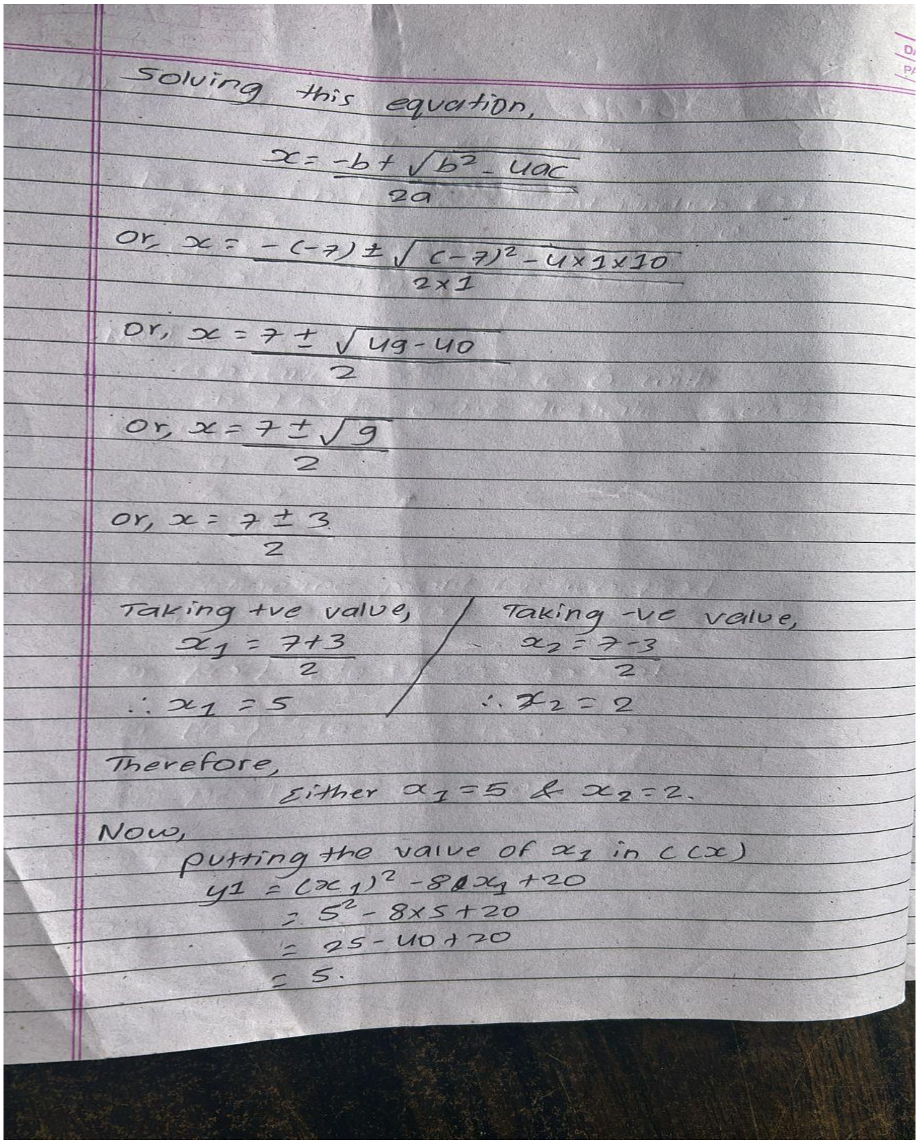
comparing, $x^2 - 7x + 10 = 0$ with $ax^2 + bx + c = 0$

i.e quadratic eqvation.

We get,

$A = 1$, $B = -7$, $C = 10$

Figure 49:To Find breakeven points



Solving this equation,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

or, $x = \frac{-(-7) \pm \sqrt{(-7)^2 - 4 \times 1 \times 10}}{2 \times 1}$

or, $x = \frac{7 \pm \sqrt{49 - 40}}{2}$

or, $x = \frac{7 \pm \sqrt{9}}{2}$

or, $x = \frac{7 \pm 3}{2}$

Taking +ve value,

$x_1 = \frac{7+3}{2}$

$\therefore x_1 = 5$

Taking -ve value,

$x_2 = \frac{7-3}{2}$

$\therefore x_2 = 2$

Therefore,

Either $x_1 = 5$ & $x_2 = 2$.

Now,

putting the value of x_1 in $c(x)$

$y1 = (x_1)^2 - 8x_1 + 20$

$= 5^2 - 8 \times 5 + 20$

$= 25 - 40 + 20$

$= 5.$

Figure 50:solving the quadratic equation

3.3 profit function $P(x)$ find, The level production, maximum profit.

Here,

Reverse function for manufacturing company

$R(x) = 10 - x$

cost function for manufacturing company

$C(x) = x^2 - 8x + 20$

Let, x be the output

we know,

In break-even points,

Reverse function $R(x)$ = cost function $C(x)$

or, $10 - x = x^2 - 8x + 20$

or, $x^2 - 8x + 20 + x - 10 = 0$

or, $x^2 - 7x + 10 = 0$

Now,

comparing, $x^2 - 7x + 10 = 0$ with $ax^2 + bx + c = 0$

i.e quadratic equation.

we get,

$A = 1$

$B = -7$

$C = 10$

Figure 51:solving for profit function

DATE
PAGE No.

To determine profit function $P(x)$

We know,

$$P(x) = R(x) - C(x)$$

$$\text{or, } P(x) = (10 - x) - (x^2 - 8x + 20)$$

$$\text{or, } P(x) = 10 - x - x^2 - 8x - 20$$

$$\text{or, } P(x) = -x^2 + 7x - 10$$

1. The level of production that maximize the profit.

Solution:

We know, Profit function $P(x) = -x^2 - 7x + 10$

Comparing the profit function with $ax^2 + bx + c = 0$ then,

We get,

$$a = -1, \; b = 7, \; c = 10$$

We know,

Level of production,

$$x = \frac{-b}{2a}$$

$$= \frac{-7}{2 \times (-1)}$$

$$= \frac{7}{2}$$

$$= 3.5$$

Therefore, The production level that maximize the profit is when $x = 3.5$

Figure 52:solution of profit function & Level of production

2. The maximum profit,

putting the value of $x = 3.5$ in profit function $P(x)$

$$P(x) = -x^2 + 7x - 10$$

$$P(3.5) = -(3.5)^2 + 7 \times 3.5 - 10$$

$$= -12.25 + 24.5 - 10$$

$$= 2.25$$

So, $P\left(\frac{7}{2}\right) = 2.25$

Therefore, The maximum profit is 2.25

Figure 53:solution to find the maximum profit

Thankyou!