



Problem Statement



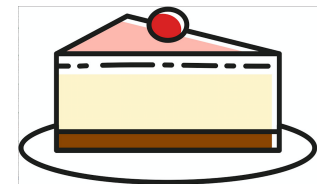
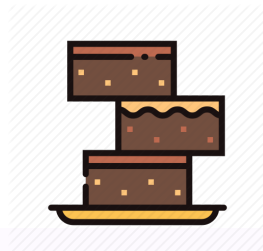
Problem Statement

- Consider the problem of diet optimization based on cost and different nutritional factors.



Problem Statement

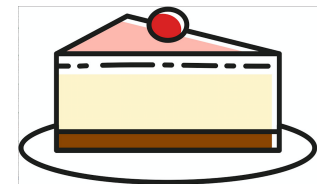
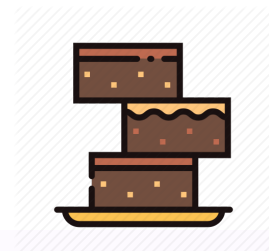
- Consider the problem of diet optimization based on cost and different nutritional factors.
- There are four different types of food with nutrition values and cost per unit as follows:





Problem Statement

- Consider the problem of diet optimization based on cost and different nutritional factors.
- There are four different types of food with nutrition values and cost per unit as follows:



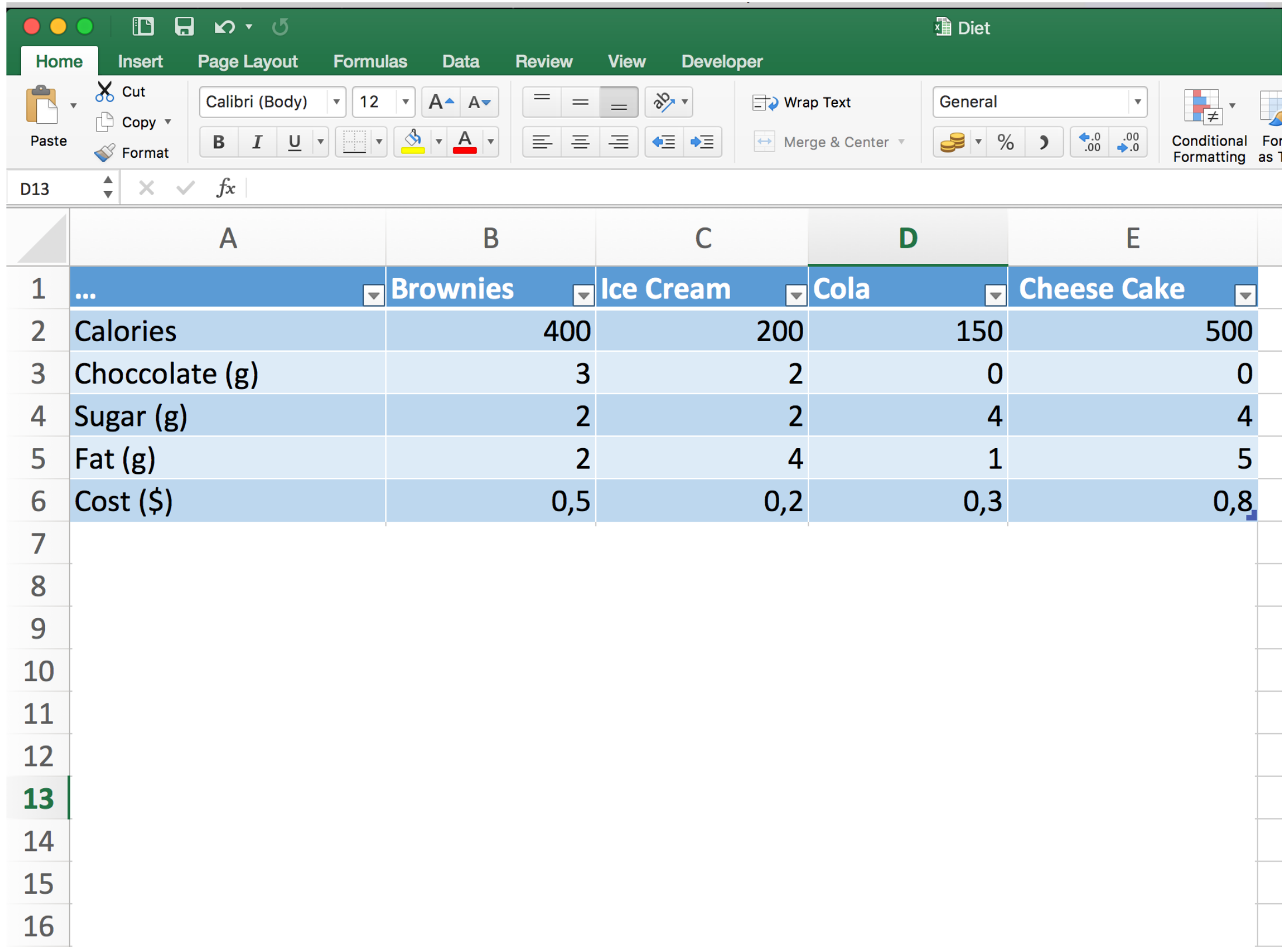
	Brownies	Ice Cream	Cola	Cheese Cake
Calories	400	200	150	500
Chocolate	3	2	0	0
Sugar	2	2	4	4
Fat	2	4	1	5
Cost	\$0.50	\$0.20	\$0.30	\$0.80

Task:

Find a minimum-cost diet that contains

- at least 500 calories
- at least 6 grams of chocolate
- at least 10 grams of sugar
- at least 8 grams of fat.

1) Prepare the xls sheet with the problem data



The screenshot shows an Excel spreadsheet titled "Diet". The ribbon includes tabs for Home, Insert, Page Layout, Formulas, Data, Review, View, and Developer. The Home tab is active, showing options for Paste, Cut, Copy, Format, font settings (Calibri, size 12), bold, italic, underline, text color, fill color, alignment, and number formatting. The spreadsheet has columns A through E and rows 1 through 16. Row 1 contains item names: "...", "Brownies", "Ice Cream", "Cola", and "Cheese Cake". Rows 2 through 6 contain nutritional data: Calories, Choccolate (g), Sugar (g), Fat (g), and Cost (\$). The data is as follows:

	A	B	C	D	E
1	...	Brownies	Ice Cream	Cola	Cheese Cake
2	Calories	400	200	150	500
3	Choccolate (g)	3	2	0	0
4	Sugar (g)	2	2	4	4
5	Fat (g)	2	4	1	5
6	Cost (\$)	0,5	0,2	0,3	0,8
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

2) Identify decision variables

Diet					
Home Insert Page Layout Formulas Data Review View Developer					
Paste Cut Copy Format Calibri (Body) 12 A A Wrap Text General Merge & Center					
D13	fx				
	A	B	C	D	E
1	...	Brownies	Ice Cream	Cola	Cheese Cake
2	Calories	400	200	150	500
3	Choccolate (g)	3	2	0	0
4	Sugar (g)	2	2	4	4
5	Fat (g)	2	4	1	5
6	Cost (\$)	0,5	0,2	0,3	0,8
7					
8	DECISION VARIABLES				
9		Brownies	Ice Cream	Cola	Cheese cake
10	Eaten	3	0	1	7
11					
12					
13					
14					
15					
16					

3) Write and enter objective function (target cell)

The screenshot shows an Excel spreadsheet titled "Diet". The formula bar for cell B12 displays the objective function formula: $=B10*B6+C10*C6+D10*D6+E10*E6$. The spreadsheet is organized as follows:

	A	B	C	D	E
1	...	Brownies	Ice Cream	Cola	Cheese Cake
2	Calories	400	200	150	500
3	Choccolate (g)	3	2	0	0
4	Sugar (g)	2	2	4	4
5	Fat (g)	2	4	1	5
6	Cost (\$)	0,5	0,2	0,3	0,8
7					
8	DECISION VARIABLES				
9		Brownies	Ice Cream	Cola	Cheese cake
10	Eaten	3	0	1	7
11					
12	Total Cost	7,4			
13					
14					
15					
16					

4) Set-up contained variables

	A	B	C	D	E
1	...	Brownies	Ice Cream	Cola	Cheese Cake
2	Calories	400	200	150	500
3	Choccolate (g)	3	2	0	0
4	Sugar (g)	2	2	4	4
5	Fat (g)	2	4	1	5
6	Cost (\$)	0,5	0,2	0,3	0,8
7					
8	DECISION VARIABLES				
9		Brownies	Ice Cream	Cola	Cheese cake
10	Eaten	3	0	1	7
11					
12	Total Cost	7,4			
13	Total Calories	4850			
14	Total Choccolate	9			
15	Total Sugar	38			
16	Total Fat	42			

4) Set-up contained variables

Diet					
Home Insert Page Layout Formulas Data Review View Developer					
<div> <div> <div>Paste</div> <div>Cut Copy Format</div> </div> <div> <div>Calibri (Body) 12</div> <div>A A</div> <div>= =</div> <div>Wrap Text</div> <div>General</div> <div>Conditional Formatting</div> </div> </div>					
<div> <div>B14</div> <div>=B10*B3+C10*C3+D10*D3+E10*E3</div> </div>					
	A	B	C	D	E
1	...	Brownies	Ice Cream	Cola	Cheese Cake
2	Calories	400	200	150	500
3	Choccolate (g)	3	2	0	0
4	Sugar (g)	2	2	4	4
5	Fat (g)	2	4	1	5
6	Cost (\$)	0,5	0,2	0,3	0,8
7					
8	DECISION VARIABLES				
9		Brownies	Ice Cream	Cola	Cheese cake
10	Eaten	3	0	1	7
11					
12	Total Cost	7,4			
13	Total Calories	4850			
14	Total Choccolate	9			
15	Total Sugar	38			
16	Total Fat	42			

Solver Parameters

Set Objective:

\$B\$12

To:

☐ Max

☒ Min

☐ Value Of:

0

By Changing Variable Cells:

\$B\$10:\$E\$10

Subject to the Constraints:

\$B\$13 >= 500

\$B\$14 >= 6

\$B\$15 >= 10

\$B\$16 >= 8

Add

Change

Delete

Reset All

Load/Save

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

GRG Nonlinear

Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Close

Solve

Solver Parameters

Set Objective:

\$B\$12

Minimise cost

To:

☐ Max

☒ Min

By Changing Variable Cells:

\$B\$10:\$E\$10

Subject to the Constraints:

\$B\$13 >= 500

\$B\$14 >= 6

\$B\$15 >= 10

\$B\$16 >= 8

Add

Change

Delete

Reset All

Load/Save

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

GRG Nonlinear

Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Close

Solve

Solver Parameters

Set Objective:

\$B\$12

To:

☐ Max

☒ Min

☐ Value Of:

0

By Changing Variable Cells:

\$B\$10:\$E\$10

Subject to the Constraints:

\$B\$13 >= 500

\$B\$14 >= 6

\$B\$15 >= 10

\$B\$16 >= 8

Add

Change

Delete

Reset All

Load/Save

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

GRG Nonlinear

Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Close

Solve

Solver Parameters

Set Objective:

\$B\$12

To:

☐ Max

☒ Min

☐ Value Of:

0

By Changing Variable Cells:

\$B\$10:\$E\$10

Subject to the Constraints:

\$B\$13 >= 500

\$B\$14 >= 6

\$B\$15 >= 10

\$B\$16 >= 8

Constrains

Add

Change

Delete

Reset All

Load/Save

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

GRG Nonlinear

Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Close

Solve

Solver Parameters

Set Objective:

To: ☐ Max ☒ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

\$B\$13 >= 500	<input type="button" value="Add"/> <input type="button" value="Change"/> <input type="button" value="Delete"/> <input type="button" value="Reset All"/>
\$B\$14 >= 6	
\$B\$15 >= 10	
\$B\$16 >= 8	

Linear problem=> Choose Simplex LP

Select a Solving Method:

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Solver Parameters

Set Objective:

To: ☐ Max ☒ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

\$B\$13 >= 500	<input type="button" value="Add"/> <input type="button" value="Change"/> <input type="button" value="Delete"/> <input type="button" value="Reset All"/> <input type="button" value="Load/Save"/>
\$B\$14 >= 6	
\$B\$15 >= 10	
\$B\$16 >= 8	

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

All variables ≥ 0

Solver Parameters

Set Objective:

\$B\$12

To:

☐ Max

☒ Min

☐ Value Of:

0

By Changing Variable Cells:

\$B\$10:\$E\$10

Subject to the Constraints:

\$B\$13 >= 500

\$B\$14 >= 6

\$B\$15 >= 10

\$B\$16 >= 8

Add

Change

Delete

Reset All

Load/Save

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

Simplex LP

Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problem smooth.

Click to solve!

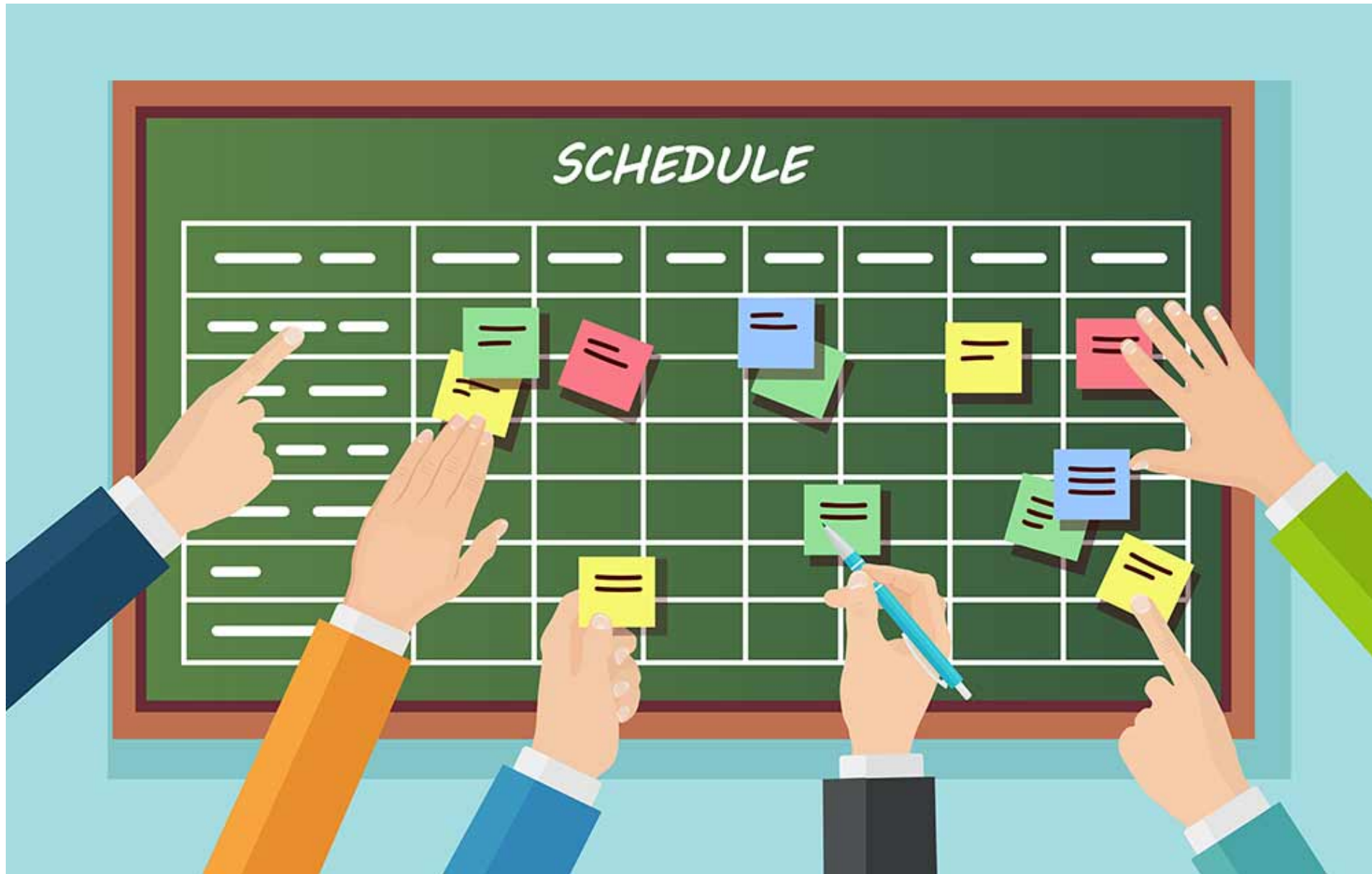
Close

Solve

<div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> <div></div> </div> </div> <div>Diet</div>					
<div> <div>Home</div> <div>Insert</div> <div>Page Layout</div> <div>Formulas</div> <div>Data</div> <div>Review</div> <div>View</div> <div>Developer</div> </div>					
<div> <div> <div>From FileMaker</div> <div>From HTML</div> <div>From Text</div> <div>New Database Query</div> </div> <div> <div>Refresh All</div> <div> <div>Connections</div> <div>Properties</div> <div>Edit Links</div> </div> </div> <div> <div> <div>A Z</div> <div>Z A</div> </div> <div>Sort</div> </div> <div> <div>Filter</div> <div> <div>Clear</div> <div>Advanced</div> </div> </div> <div> <div>Text to Columns</div> <div>Remove Duplicates</div> <div>Data Validation</div> <div>Consolidate</div> <div>What-If Analysis</div> </div> <div> <div>Gro</div> </div> </div>					
<div> <div>E15</div> <div> <div>✕</div> <div>✓</div> <div>fx</div> </div> </div>					
	A	B	C	D	E
1	...	Brownies	Ice Cream	Cola	Cheese Cake
2	Calories	400	200	150	500
3	Choccolate (g)	3	2	0	0
4	Sugar (g)	2	2	4	4
5	Fat (g)	2	4	1	5
6	Cost (\$)	0,5	0,2	0,3	0,8
7					
8	DECISION VARIABLES				
9		Brownies	Ice Cream	Cola	Cheese cake
10	Eaten	0	3	1	0
11					
12	Total Cost	0,9			
13	Total Calories	750			
14	Total Choccolate	6			
15	Total Sugar	10			
16	Total Fat	13			

	A	B	C	D	E
1	...	Brownies	Ice Cream	Cola	Cheese Cake
2	Calories	400	200	150	500
3	Choccolate (g)	3	2	0	0
4	Sugar (g)	2	2	4	4
5	Fat (g)	2	4	1	5
6	Cost (\$)	0,5	0,2	0,3	0,8
7					
8	DECISION VARIABLES				
9		Brownies	Ice Cream	Cola	Cheese cake
10	Eaten	0	3	1	0
11					
12	Total Cost	0,9	Optimal choices		
13	Total Calories	750			
14	Total Choccolate	6			
15	Total Sugar	10			
16	Total Fat	13			

Staff Scheduling



For employees working five consecutive days with two days off, find the schedule that meets demand from attendance levels while minimizing payroll costs.

Sch.	Days off	Employees		Sun	Mon	Tue	Wed	Thu	Fri	Sat
A	<i>Sunday, Monday</i>	1		0	0	1	1	1	1	1
B	<i>Monday, Tuesday</i>	1		1	0	0	1	1	1	1
C	<i>Tuesday, Wed.</i>	1		1	1	0	0	1	1	1
D	<i>Wed., Thursday</i>	1		1	1	1	0	0	1	1
E	<i>Thursday, Friday</i>	1		1	1	1	1	0	0	1
F	<i>Friday, Saturday</i>	1		1	1	1	1	1	0	1
G	<i>Saturday, Sunday</i>	1		0	1	1	1	1	1	0
Schedule Totals:		7		5	5	5	5	5	5	6
Total Demand:				20	5	15	14	15	18	24

For employees working five consecutive days with two days off, find the schedule that meets demand from attendance levels while minimizing payroll costs.

Sch.	Days off	Employees		Sun	Mon	Tue	Wed	Thu	Fri	Sat
A	<i>Sunday, Monday</i>	1		0	0	1	1	1	1	1
B	<i>Monday, Tuesday</i>	1		1	0	0	1	1	1	1
C	<i>Tuesday, Wed.</i>	1		1	1	0	0	1	1	1
D	<i>Wed., Thursday</i>	1		1	1	1	0	0	1	1
E	<i>Thursday, Friday</i>	1		1	1	1	1	0	0	1
F	<i>Friday, Saturday</i>	1		1	1	1	1	1	0	1
G	<i>Saturday, Sunday</i>	1		0	1	1	1	1	1	0
Schedule Totals:		7		5	5	5	5	5	5	6
Total Demand:				20	5	15	14	15	18	24
				40,00 €	30,00 €	30,00 €	30,00 €	30,50 €	30,50 €	35,00 €

Pay per employee per day

For employees working five consecutive days with two days off, find the schedule that meets demand from attendance levels while minimizing payroll costs.

Sch.	Days off	Employees		Sun	Mon	Tue	Wed	Thu	Fri	Sat
A	<i>Sunday, Monday</i>	1		0	0	1	1	1	1	1
B	<i>Monday, Tuesday</i>	1		1	0	0	1	1	1	1
C	<i>Tuesday, Wed.</i>	1		1	1	0	0	1	1	1
D	<i>Wed., Thursday</i>	1		1	1	1	0	0	1	1
E	<i>Thursday, Friday</i>	1		1	1	1	1	0	0	1
F	<i>Friday, Saturday</i>	1		1	1	1	1	1	0	1
G	<i>Saturday, Sunday</i>	1		0	1	1	1	1	1	0
Schedule Totals:		7		5	5	5	5	5	5	6
Total Demand:				20	5	15	14	15	18	24
				40,00 €	30,00 €	30,00 €	30,00 €	30,50 €	30,50 €	35,00 €

$$f(n_1, \dots, n_7) = n_1 p_1 + \dots + n_7 p_7$$

	A	B	C	D	E	F	G	H	I	J	K	L
1	Personnel scheduling for my Fast Food Company											
2	For employees working five consecutive days with two days off, find the schedule that meets demand											
3	from attendance levels while minimizing payroll costs.											
4	Sch.	Days off	Employees		Sun	Mon	Tue	Wed	Thu	Fri	Sat	
5	A	Sunday, Monday	1		0	0	1	1	1	1	1	
6	B	Monday, Tuesday	1		1	0	0	1	1	1	1	
7	C	Tuesday, Wed.	1		1	1	0	0	1	1	1	
8	D	Wed., Thursday	1		1	1	1	0	0	1	1	
9	E	Thursday, Friday	1		1	1	1	1	0	0	1	
10	F	Friday, Saturday	1		1	1	1	1	1	0	1	
11	G	Saturday, Sunday	1		0	1	1	1	1	1	0	
12												
13	Schedule Totals:		7		5	5	5	5	5	5	6	
14												
15	Total Demand:				20	5	15	14	15	18	24	
16												
17	Pay/Employee/Day:				40,00 €	30,00 €	30,00 €	30,00 €	30,50 €	30,50 €	35,00 €	
18	Payroll/Week:		1.165 €									

	A	B	C	D
1	Personnel scheduling for my Fast Food			
2	For employees working five consecutive days with			
3	from attendance levels while minimizing payroll costs			
4	Sch.	Days off	Employees	
5	A	Sunday, Monday	1	
6	B	Monday, Tuesday	1	
7	C	Tuesday, Wed.	1	
8	D	Wed., Thursday	1	
9	E	Thursday, Friday	1	
10	F	Friday, Saturday	1	
11	G	Saturday, Sunday	1	
12				
13	Schedule Totals:		7	
14				
15	Total Demand:			
16				
17	Pay/Employee/Day:		40,00 € 30,00 € 30,00 € 30,00 € 30,50 € 30,50 € 35,00 €	
18	Payroll/Week:		1.165 €	

Solver Parameters

Set Objective:

To: ☐ Max ☒ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

	A	B	C	D	E
1	Personnel scheduling for my Fast Food C				
2	For employees working five consecutive days with two d				
3	from attendance levels while minimizing payroll costs.				
4	Sch.	Days off	Employees		
5	A	Sunday, Monday	1		
6	B	Monday, Tuesday	1		
7	C	Tuesday, Wed.	1		
8	D	Wed., Thursday	1		
9	E	Thursday, Friday	1		
10	F	Friday, Saturday	1		
11	G	Saturday, Sunday	1		
12					
13	Schedule Totals:			7	
14					
15	Total Demand:				
16					
17	Pay/Employee/Day:				
18	Payroll/Week:			1.165 €	

Solver Parameters

Set Objective:

To: ☐ Max ☒ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

	A	B	C	D	E
1	Personnel scheduling for my Fast Food C				
2	For employees working five consecutive days with two d				
3	from attendance levels while minimizing payroll costs.				
4	Sch.	Days off	Employees		
5	A	Sunday, Monday	1		
6	B	Monday, Tuesday	1		
7	C	Tuesday, Wed.	1		
8	D	Wed., Thursday	1		
9	E	Thursday, Friday	1		
10	F	Friday, Saturday	1		
11	G	Saturday, Sunday	1		
12					
13	Schedule Totals:			7	
14					
15	Total Demand:				
16					
17	Pay/Employee/Day:				
18	Payroll/Week:			1.165 €	

Solver Parameters

Set Objective:

To: ☐ Max ☒ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

	A	B	C	D	E
1	Personnel scheduling for my Fast Food C				
2	For employees working five consecutive days with two d				
3	from attendance levels while minimizing payroll costs.				
4	Sch.	Days off	Employees		
5	A	Sunday, Monday	1		
6	B	Monday, Tuesday	1		
7	C	Tuesday, Wed.	1		
8	D	Wed., Thursday	1		
9	E	Thursday, Friday	1		
10	F	Friday, Saturday	1		
11	G	Saturday, Sunday	1		
12					
13	Schedule Totals:			7	
14					
15	Total Demand:				
16					
17	Pay/Employee/Day:				
18	Payroll/Week:			1.165 €	

Solver Parameters

Set Objective:

To: ☐ Max ☒ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

	A	B
1	Personnel scheduling	
2	For employees working five days a week	
3	from attendance levels which are given in the table below	
4	Sch.	Days off
5	A	Sunday, Monday
6	B	Monday, Tuesday
7	C	Tuesday, Wednesday
8	D	Wednesday, Thursday
9	E	Thursday, Friday
10	F	Friday, Saturday
11	G	Saturday, Sunday
12		
13	Schedule Totals:	7
14		
15	Total Demand:	
16		
17	Pay/Employee/Day:	
18	Payroll/Week:	1.165 €

Subject to the Constraints:

$\$D\$5:\$D\$11 = \text{integer}$

$\$D\$5:\$D\$11 \geq 1$

$\$F\$13:\$L\$13 \geq \$F\$15:\$L\15

Add

Change

Delete

Reset All

Load/Save

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

Simplex LP

Options

L

Sat

1

1

1

1

1

1

0

5

5

5

5

5

5

6

20

5

15

14

15

18

24

40,00 € 30,00 € 30,00 € 30,00 € 30,50 € 30,50 € 35,00 €

Personnel scheduling for my Fast Food Company

For employees working five consecutive days with two days off, find the schedule that meets demand

from attendance levels while minimizing payroll costs.

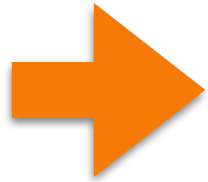
Sch.	Days off	Employees		Sun	Mon	Tue	Wed	Thu	Fri	Sat
A	Sunday, Monday	4		0	0	1	1	1	1	1
B	Monday, Tuesday	8		1	0	0	1	1	1	1
C	Tuesday, Wed.	1		1	1	0	0	1	1	1
D	Wed., Thursday	4		1	1	1	0	0	1	1
E	Thursday, Friday	6		1	1	1	1	0	0	1
F	Friday, Saturday	1		1	1	1	1	1	0	1
G	Saturday, Sunday	1		0	1	1	1	1	1	0

Schedule Totals:	25	20	13	16	20	15	18	24
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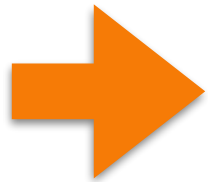
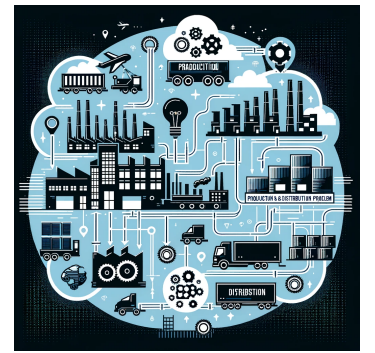
Total Demand:	20	5	15	14	15	18	24
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Pay/Employee/Day:	40,00 €	30,00 €	30,00 €	30,00 €	30,50 €	30,50 €	35,00 €
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Payroll/Week:	4.117 €
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Production and distribution planning problem



The Shipppping problem



The chair manufacturer



Retirement planning



The transportation problem

