

PROBLEM 1

$$\text{MAX } Z = 4x_1 + 6x_2 + x_3$$

$$x_1 \leq 5$$

$$x_2 \leq 7$$

$$4x_1 + 3x_2 + x_3 \leq 19$$

$$x_1, x_2, x_3 \geq 0$$

$$\begin{aligned} Z - 4x_1 - 6x_2 - x_3 &= 0 \\ x_1 + S_1 &= 5 \\ x_2 + S_2 &= 7 \\ 4x_1 + 3x_2 + x_3 + S_3 &= 19 \\ x_1, x_2, S_1, S_2, S_3 &\geq 0 \end{aligned}$$

$$\begin{bmatrix} 1 & -4 & -6 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 4 & 3 & 0 & 0 & 1 \end{bmatrix} \begin{matrix} Z \\ X_1 \\ X_2 \\ X_3 \\ S_1 \\ S_2 \\ S_3 \end{matrix} = \begin{matrix} 0 \\ 5 \\ 7 \\ 19 \end{matrix}$$

$$B^{-1} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}$$

$$CB = (0 \ 0 \ 0)$$

B	XB	β_0 Z	β_1 S1	β_2 S2	β_3 S3	x1	x2
Z	0	1	0	0	0	-4	-6
S1	5	0	1	0	0	1	0
S2	7	0	0	1	0	0	1
S3	19	0	0	0	1	4	3

$$\text{MAX } (1 \ 0 \ 0 \ 0) \quad \begin{matrix} -4 & -6 \\ 1 & 0 \\ 0 & 1 \\ 4 & 3 \end{matrix}$$

MAX (4 6 1)

=6

B1-1.a2= -6
 0
 1
 3

Xb= 0
 5
 7
 19

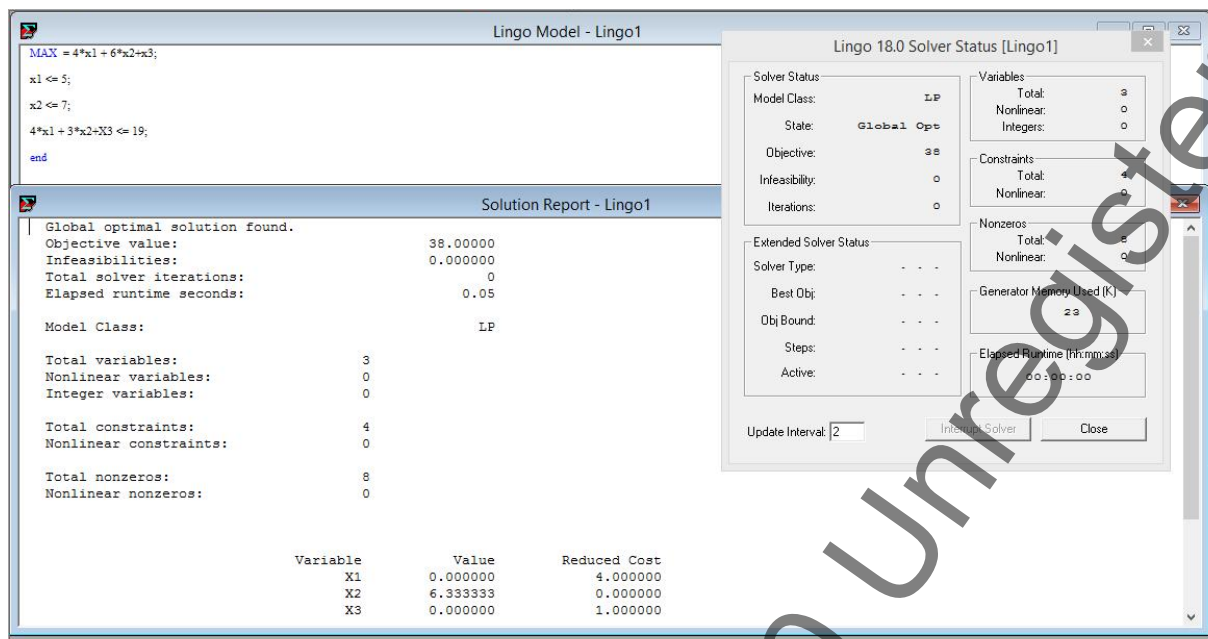
Min(7,19/3)

=6.333

<i>B</i>	<i>XB</i>				β_0 <i>Z</i>	β_1 <i>S1</i>	β_2 <i>S2</i>	β_3 <i>S3</i>	y_2 <i>Ck-Zk</i>	ORAN	<i>x1</i>	<i>x2</i>
<i>Z</i>	0				1	0	0	0	-6	---	-4	-6
<i>S1</i>	5				0	1	0	0	0	---	1	0
<i>S2</i>	7				0	0	1	0	1	7	0	1
<i>S3</i>	19				0	0	0	1	3	6.3333	4	3
<i>XB</i>	β_1	β_2	β_3	<i>y2</i>								
<i>R1</i>	0	0	0	0	-6							
<i>R2</i>	5	1	0	0	0							
<i>R3</i>	7	0	1	0	1							
<i>R4</i>	19	0	0	1	3							
<i>B</i>	<i>XB</i>		β_0 <i>Z</i>	β_1 <i>S1</i>	β_2 <i>S2</i>	β_3 <i>x2</i>	y_2 <i>Ck-Zk</i>	ORAN	<i>x1</i>	<i>S3</i>		
<i>Z</i>	38		1	0	0	2		---	-4	0		
<i>S1</i>	5		0	1	0	0		---	1	0		
<i>S2</i>	0.6667		0	0	1	-0.3333		---	0	0		
<i>x2</i>	6.3333		0	0	0	0.3333		---	4	1		

$x_1=0, x_2=6.3333, x_3=0$

Max Z=38



PROBLEM 2

$$\text{MAX } Z = x_1 + 2x_2 + 4x_3$$

$$x_1 + x_2 \leq 6$$

$$x_2 + x_3 \leq 4$$

$$x_1 + x_2 + x_3 \leq 13$$

$$x_1, x_2, x_3 \geq 0$$

$$Z - x_1 - 2x_2 - 4x_3 = 0$$

$$x_1 + x_2 + S_1 = 6$$

$$x_2 + x_3 + S_2 = 4$$

$$x_1 + x_2 + x_3 + S_3 = 13$$

$$x_1, x_2, x_3, S_1, S_2, S_3 \geq 0$$

1	-1	-2	-4	0	0	0	Z	
0	1	1	0	1	0	0	X1	0
0	0	1	1	0	1	0	X2	6
0	1	1	1	0	0	1	X3	4
							S1	1
							S2	3
							S3	

B	XB	β_0 Z	β_1 S1	β_2 S2	β_3 S3	y_1 Ck-Zk	ORAN	x1	x2	x3
Z	0	1	0	0	0		---	-1	-2	-4
S1	6	0	1	0	0		---	1	1	0
S2	4	0	0	1	0		---	0	1	1
S3	13	0	0	0	1		---	1	1	1

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$\text{MAX}=(1\ 2\ 4)$
 $\Rightarrow 4$

$Y_3=B^{-1}a_3=$

$$\begin{pmatrix} -4 \\ 0 \\ 1 \\ 1 \end{pmatrix}$$

$Xb=$

$$\begin{pmatrix} 0 \\ 6 \\ 4 \\ 13 \end{pmatrix}$$

$\text{Min}=(4\ 13)$
 $\Rightarrow 4$

B	XB	β_0 Z	β_1 S_1	β_2 S_2	β_3 S_3	y_3 C_k-Z_k	ORAN	x_1	x_2	x_3
Z	0	1	0	0	0	-4	---	-1	-2	-4
S_1	6	0	1	0	0	0	---	1	1	0
S_2	4	0	0	1	0	1	4	0	1	1
S_3	13	0	0	0	1	1	13	1	1	1

X B	β_1	β_2	β_3	y_3 3	
R_1	0	0	0	0	-4
R_2	6	1	0	0	0
R_3	4	0	1	0	1
R_4	13	0	0	1	1

B	XB	β_0 Z	β_1 S_1	β_2 x_3	β_3 S_3	y_3 C_k-Z_k	ORAN	x_1	x_2	S_2
Z	16	1	0	4	0		---	-1	-2	0
S_1	6	0	1	0	0		---	1	1	0
x_3	4	0	0	1	0		---	0	1	1
S_3	9	0	0	-1	1		---	1	1	0

$\text{MAX}=(1\ -2\ 4)$
 $\text{MAX}=1$

<i>B</i>	<i>XB</i>	β_0 <i>Z</i>	β_1 <i>S1</i>	β_2 <i>x3</i>	β_3 <i>S3</i>	<i>y1</i> <i>Ck-Zk</i>	ORAN	<i>x1</i>	<i>x2</i>	<i>S2</i>
<i>Z</i>	16	1	0	4	0	-1	---	-1	-2	0
<i>S1</i>	6	0	1	0	0	1	6	1	1	0
<i>x3</i>	4	0	0	1	0	0	---	0	1	1
<i>S3</i>	9	0	0	-1	1	1	9	1	1	0

<i>X</i> <i>B</i>	β_1	β_2	β_3	<i>y</i> <i>1</i>	
<i>R1</i>	1 6	0	4	0	- 1
<i>R2</i>	6	1	0	0	1
<i>R3</i>	4	0	1	0	0
<i>R4</i>	9	0	-1	1	1

<i>B</i>	<i>XB</i>	β_0 <i>Z</i>	β_1 <i>x1</i>	β_2 <i>x3</i>	β_3 <i>S3</i>	<i>y1</i> <i>Ck-Zk</i>	ORAN	<i>S1</i>	<i>x2</i>	<i>S2</i>
<i>Z</i>	22	1	1	4	0		---	0	-2	0
<i>x1</i>	6	0	1	0	0		---	1	1	0
<i>x3</i>	4	0	0	1	0		---	0	1	1
<i>S3</i>	3	0	-1	-1	1		---	0	1	0

MAX=(-1 -3 -4)

X1=6,X2=0,X3=4

MAXZ=22

Global optimal solution found.
Objective value: 22.00000
Infeasibilities: 0.000000
Total solver iterations: 3
Elapsed runtime seconds: 0.03

Model Class: LP

Total variables: 3
Nonlinear variables: 0
Integer variables: 0

Total constraints: 4
Nonlinear constraints: 0

Total nonzeros: 10
Nonlinear nonzeros: 0

Variable	Value	Reduced Cost
X1	6.000000	0.000000
X2	0.000000	3.000000
X3	4.000000	0.000000

Row	Slack or Surplus	Dual Price
1	22.00000	1.000000
2	0.000000	1.000000
3	0.000000	4.000000
4	3.000000	0.000000

Lingo 18.0 Solver Status [Lingo1]

Solver Status

Model Class: LP
State: Global Opt
Objective: 22
Infeasibility: 0
Iterations: 3

Extended Solver Status

Solver Type: - - -
Best Obj: - - -
Obj Bound: - - -
Steps: - - -
Active: - - -

Variables

Total: 3
Nonlinear: 0
Integers: 0

Constraints

Total: 4
Nonlinear: 0

Nonzeros

Total: 10
Nonlinear: 0

Generator Memory Used (K): 29

Elapsed Runtime (hh:mm:ss): 00:00:00

Update Interval: 2

Interrupt Solver

Close

Lingo 18.0 Solver Status [Lingo1]

Solver Status:

Model Class: LP
State: Global Opt
Objective: 22
Infeasibility: 0
Iterations: 3

Extended Solver Status:

Solver Type: - - -
Best Obj: - - -
Obj Bound: - - -
Steps: - - -
Active: - - -

Variables:

Total: 3
Nonlinear: 0
Integers: 0

Constraints:

Total: 4
Nonlinear: 0

Nonzeros:

Total: 10
Nonlinear: 0

Generator Memory Used (K):

23

Elapsed Runtime (hh:mm:ss)

00:00:00

Update Interval: 2
Interrupt Solver
Close

PROBLEM 3

MAX Z = 3x1 + 4x2 + 5x3

x1 + 2x2 <= 12

$4x_2 + 3x_3 \leq 32$

$x_1 + x_2 + 2x_3 \leq 10$

$x_1, x_2, x_3 \geq 0$

$$\begin{aligned} Z - x_1 - 4x_2 - 5x_3 &= 0 \\ x_1 + 2x_2 + S_1 &= 12 \\ 4x_2 + 3x_3 + S_2 &= 32 \\ x_1 + x_2 + 2x_3 + S_3 &= 10 \\ x_1, x_2, x_3, S_1, S_2, S_3 &\geq 0 \end{aligned}$$

1	-3	-4	-5	0	0	0	Z	
0	1	2	0	1	0	0	X1	0
0	0	4	3	0	1	0	X2	= 12
0	1	1	2	0	0	1	X3	32
							S1	10
							S2	
							S3	

B	XB	β_0 Z	β_1 S1	β_2 S2	β_3 S3	y_1 Ck-Zk	ORAN	x1	x2	x3
Z	0	1	0	0	0		---	-3	-4	-5
S1	12	0	1	0	0		---	1	2	0
S2	32	0	0	1	0		---	0	4	3
S3	10	0	0	0	1		---	1	1	2

$MAX=(3 \ 4 \ 5)$

$=5$

$MIN(32/3, 10/2)$

$=5$

B	XB	β_0 Z	β_1 S1	β_2 S2	β_3 S3	y_3 Ck-Zk	ORAN	x1	x2	x3
Z	0	1	0	0	0	-5	---	-3	-4	-5
S1	12	0	1	0	0	0	---	1	2	0
S2	32	0	0	1	0	3	10.6667	0	4	3
S3	10	0	0	0	1	2	5	1	1	2

X	β_1	β_2	β_3	y_3
B				
R1	0	0	0	0
				-5

$R2$	1 2	1	0	0	0
$R3$	3 2	0	1	0	3
$R4$	1 0	0	0	1	2

B	XB	β_0 Z	β_1 $S1$	β_2 $S2$	β_3 x_3	y_3 $Ck-Zk$	ORAN	x_1	x_2	S_3
Z	25	1	0	0	2.5		---	-3	-4	0
$S1$	12	0	1	0	0		---	1	2	0
$S2$	17	0	0	1	-1.5		---	0	4	0
x_3	5	0	0	0	0.5		---	1	1	1

$$\text{MAX}=(1/2 \quad 3/2 \quad 5/2)$$

$$=1.5$$

$$\text{MIN}=(6,6.8,10)$$

$$=6$$

B	XB	β_0 Z	β_1 $S1$	β_2 $S2$	β_3 x_3	y_2 $Ck-Zk$	ORAN	x_1	x_2	S_3
Z	25	1	0	0	2.5	-1.5	---	-3	-4	0
$S1$	12	0	1	0	0	2	6	1	2	0
$S2$	17	0	0	1	-1.5	2.5	6.8	0	4	0
x_3	5	0	0	0	0.5	0.5	10	1	1	1

X B	β_1	β_2	β_3	y_2	
$R1$	2 5	0	0	2.5	- 1.5
$R2$	1 2	1	0	0	2
$R3$	1 7	0	1	- 1.5	2.5
$R4$	5	0	0	0.5	0.5

B	XB	β_0 Z	β_1 x_2	β_2 $S2$	β_3 x_3	y_2 $Ck-Zk$	ORAN	x_1	$S1$	$S3$
Z	34	1	0.75	0	2.5		---	-3	0	0
x_2	6	0	0.5	0	0		---	1	1	0
$S2$	2	0	-1.25	1	-1.5		---	0	0	0
x_3	2	0	-0.25	0	0.5		---	1	0	1

$$X1=0, X2=6, X3=2 \text{ MAXZ}=34$$

Lingo Model - Lingo1

```
MAX = 3*x1 + 4*x2 + 5*x3;  
x1 + 2*x2 <= 12;  
4*x2 + 3*x3 <= 32;  
x1 + x2 + 2*x3 <= 10;  
end
```

Solution Report - Lingo1

Global optimal solution found.

Objective value:	34.000000
Infeasibilities:	0.000000
Total solver iterations:	2
Elapsed runtime seconds:	0.03

Model Class: LP

Total variables:	3
Nonlinear variables:	0
Integer variables:	0

Total constraints:	4
Nonlinear constraints:	0

Total nonzeros:	10
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	0.000000	0.2500000
X2	6.000000	0.000000
X3	2.000000	0.000000

Lingo 18.0 Solver Status [Lingo1]

Solver Status

Model Class:	LP
State:	Global Opt
Objective:	34
Infeasibility:	0
Iterations:	2

Extended Solver Status

Solver Type:	- - -
Best Obj:	- - -
Obj Bound:	- - -
Steps:	- - -
Active:	- - -

Variables

Total:	3
Nonlinear:	0
Integers:	0

Constraints

Total:	4
Nonlinear:	0

Nonzeros

Total:	10
Nonlinear:	0

Generator Memory Used (K): 23

Elapsed Runtime (hh:mm:ss): 00:00:00

Update Interval: 2

Interrupt Solver Close