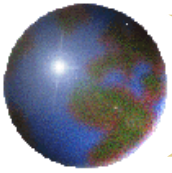


# How LINGO diagnoses solution issues

LINDO Systems

[www.lindo.com](http://www.lindo.com)



When we try to solve a problem,

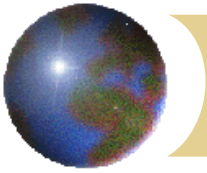
Possible Outcomes:

Infeasible

Feasible

Optimum(Finite/Infinite)

Unbounded



## Formulations with Anomalies

- 1) Unbounded, Clearly a mistake.
- 2) Infeasible,  
Could be a mistake, but could be a misunderstanding of what is simultaneously possible.
- 3) Multiple or Alternative Optima  
Quite common, but not good.  
God's way of telling us to put more detail into the objective function. Real people are not indifferent between alternatives.



# Example #1: Unique Solution

LSL3-4

minimize  $z = 5x_1 + 11x_2$

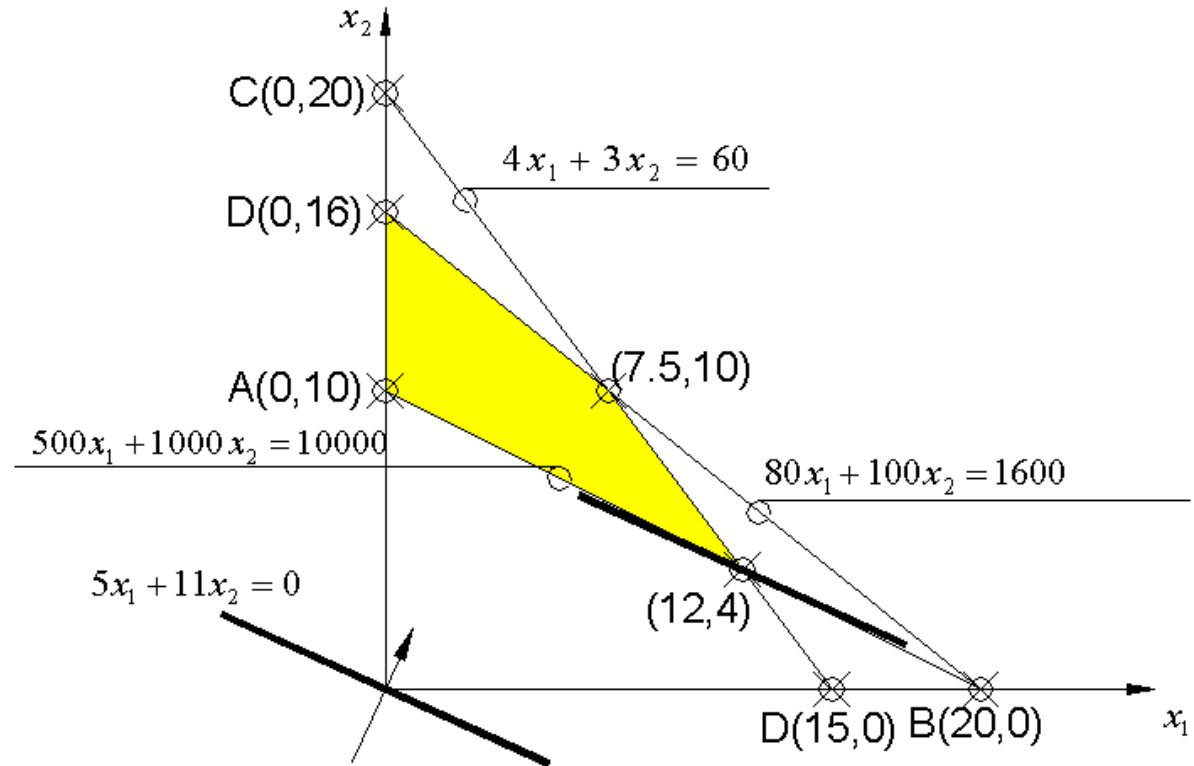
s.t.

$$500x_1 + 1000x_2 \geq 10000$$

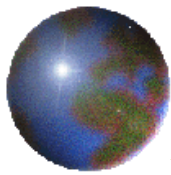
$$4x_1 + 3x_2 \leq 60$$

$$80x_1 + 100x_2 \leq 1600$$

$$x_1, x_2 \geq 0$$



- Unique, bounded objective function value  $z^* = 104$
- Nonempty, bounded feasible region



# LINGO Model

LSL3-5

File Edit Solver Window Help

min = 5\*x1+11\*x2;  
 500\*x1+1000\*x2>=10000;  
 4\*x1+3\*x2<=60;  
 80\*x1+100\*x2<=1600;

Variable	Value	Reduced Cost
X1	12.00000	0.000000
X2	4.000000	0.000000

Row	Slack or Surplus	Dual Price
1	104.0000	-1.000000
2	0.000000	-0.1160000E-01
3	0.000000	0.2000000
4	240.0000	0.000000

Solver Status

Model Class: LP  
 State: Global Opt  
 Objective: 104  
 Infeasibility: 0  
 Iterations: 2

Variables

Total: 2  
 Nonlinear: 0  
 Integers: 0

Constraints

Total: 4  
 Nonlinear: 0

Nonzeros

Total: 8  
 Nonlinear: 0

Extended Solver Status

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

Generator Memory Used (K)

23

Elapsed Runtime (hh:mm:ss)

00 : 00 : 00



# Example #2: Unique Solution

LSL3-6

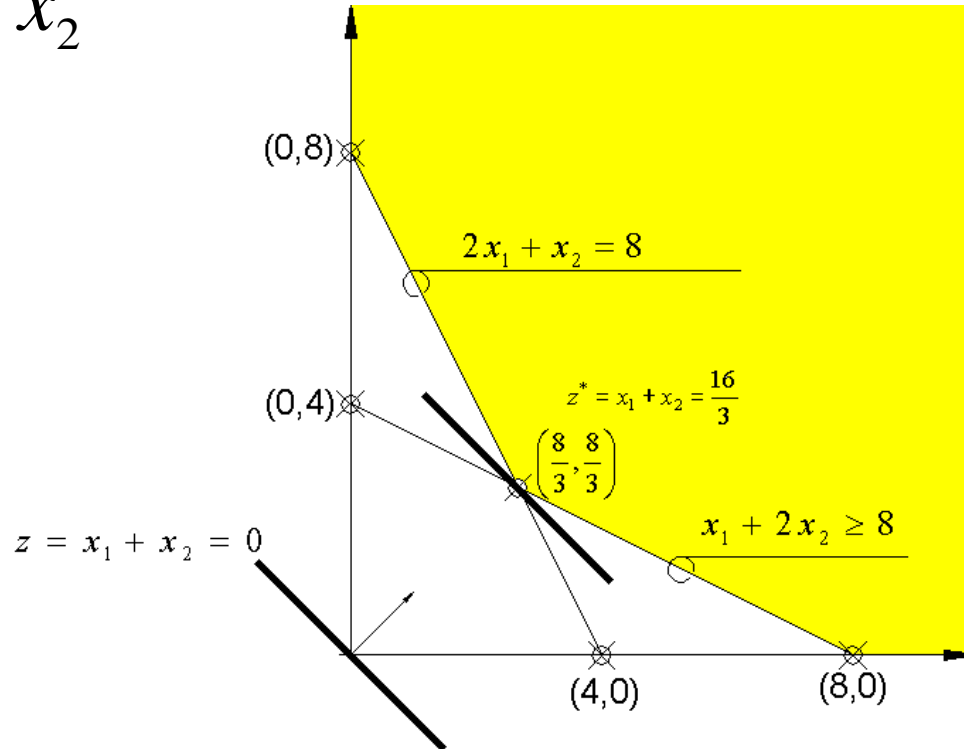
$$\min : z = x_1 + x_2$$

*s.t.*

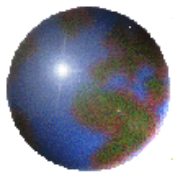
$$2x_1 + x_2 \geq 8$$

$$x_1 + 2x_2 \geq 8$$

$$x_1, x_2 \geq 0$$



- Unique, bounded objective function value  $z^*=5.33$
- Nonempty, unbounded feasible region



# LINGO Model

LSL3-7



```

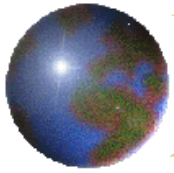
min =x1+x2;
2*x1+x2>=8;
x1+2*x2>=8;

```

Variable	Value	Reduced Cost
X1	2.666667	0.000000
X2	2.666667	0.000000

Row	Slack or Surplus	Dual Price
1	5.333333	-1.000000
2	0.000000	-0.3333333
3	0.000000	-0.3333333

<b>Solver Status</b> Model Class: LP State: Global Opt Objective: 5.33333 Infeasibility: 0 Iterations: 2		<b>Variables</b> Total: 2 Nonlinear: 0 Integers: 0	
<b>Extended Solver Status</b> Solver Type: . . . . Best Obj: . . . . Obj Bound: . . . . Steps: . . . . Active: . . . .		<b>Constraints</b> Total: 3 Nonlinear: 0	
		<b>Nonzeros</b> Total: 6 Nonlinear: 0	
		<b>Generator Memory Used (K)</b> 23	
		<b>Elapsed Runtime (hh:mm:ss)</b> 00:00:00	



# Example #3: No Solutions: Infeasible

LSL3-8

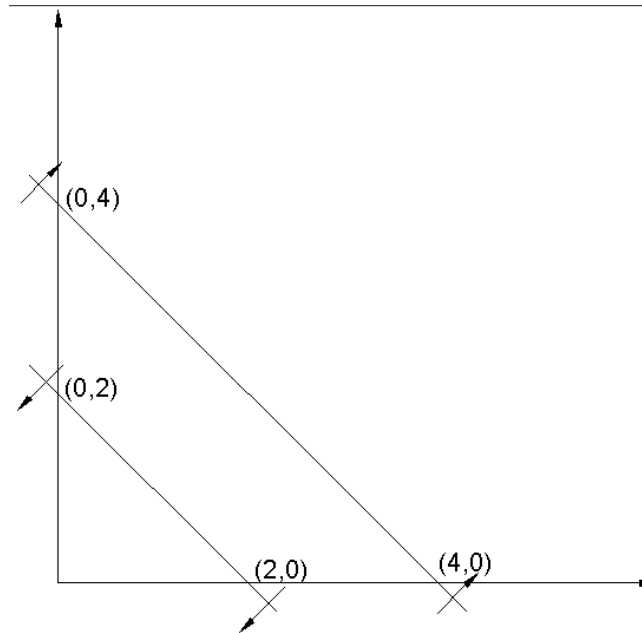
*maximize*  $z$

*s.t.*

$$x_1 + x_2 \leq 2$$

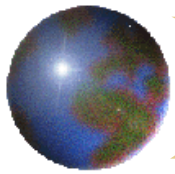
$$2x_1 + 2x_2 \geq 8$$

$$x_1, x_2 \geq 0$$



- First two inequalities are inconsistent  $\rightarrow$  empty feasible region
- $z^*$  does not exist





# LINGO Model

LSL3-9

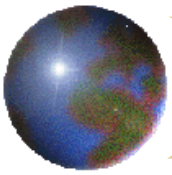
```
max=x1;  
x1+x2<=2;  
2*x1+2*x2>=8;
```

LINGO Error Message

Error Code: 81

Error Text:  
No feasible solution found.

Solver Status		Variables	
Model Class:	IP	Total:	2
State:	Infeasible	Nonlinear:	0
Objective:	4	Integers:	0
Infeasibility:	4	Constraints	
Iterations:	2	Total:	3
Extended Solver Status		Nonlinear:	0
Solver Type:	. . .	Nonzeros	
Best Obj:	. . .	Total:	5
Obj Bound:	. . .	Nonlinear:	0
Steps:	. . .	Generator Memory Used (K)	
Active:	. . .	22	
Update Interval: 2		Elapsed Runtime (hh:mm:ss)	
<input type="button" value="Interrupt Solver"/>		00 : 00 : 00	
<input type="button" value="Close"/>			



# Example #4: No Solution: Unbound

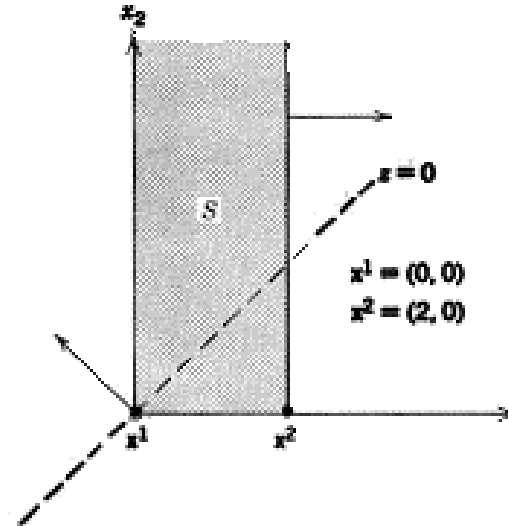
LSL3-10

$$\text{maximize } z = -x_1 + x_2$$

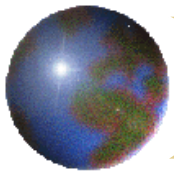
s.t.

$$x_1 \leq 2$$

$$x_1, x_2 \geq 0$$



- Unbounded objective function value
- Unbounded feasible region
- Note: unbounded objective function value  $\rightarrow$  unbounded feasible region, but the reverse is not true (see the next example)



# LINGO Model

LSL3-11

```
max = -x1+x2;  
x1<=2;
```

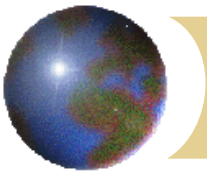
<b>Solver Status</b>		<b>Variables</b>	
Model Class:	IP	Total:	2
State:	Unbounded	Nonlinear:	0
Objective:	-1e+030	Integers:	0
Infeasibility:	0	<b>Constraints</b>	
Iterations:	0	Total:	2
		Nonlinear:	0
<b>Extended Solver Status</b>		<b>Nonzeros</b>	
Solver Type:	. . .	Total:	3
Best Obj:	. . .	Nonlinear:	0
Obj Bound:	. . .	<b>Generator Memory Used (K)</b>	
Steps:	. . .	22	
Active:	. . .	<b>Elapsed Runtime (hh:mm:ss)</b>	
		00 : 00 : 00	
Update Interval:	2	<b>Interrupt Solver</b> <b>Close</b>	

LINGO Error Message

Error Code: 82

Copy Explain OK

Error Text:  
Unbounded solution.



# Example #5: Infinite # of Solutions

LSL3-12

maximize  $z = 15A + 30C$

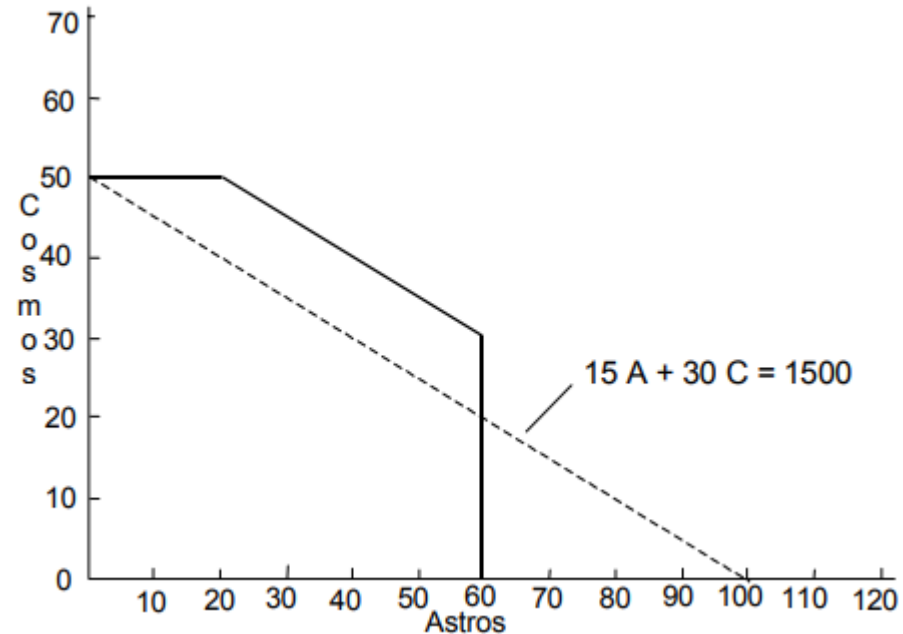
s.t.

$A \leq 60$

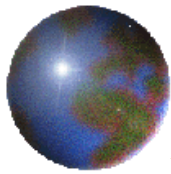
$C \leq 50$

$A + 2C \leq 120$

$A, B \geq 0$



- Infinite # of solutions along the edge between  $x^1$  and  $x^2$
- Nonempty, bounded feasible region



# LINGO Model

LSL3-13

MAX = 15 \* A + 30 \* C;

A <= 60;

C <= 50;

A + 2 \* C <= 120;

Optimal solution found at step: 1

Objective value: 1800.000

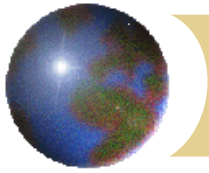
Variable	Value	Reduced Cost
A	20.00000	0.0000000
C	50.00000	0.0000000

Row	Slack or Surplus	Dual Price
1	1800.000	1.000000
2	40.00000	0.000000
3	0.000000	0.000000
4	0.000000	15.00000

Lingo 17.0 Solver Status [Lingo1] ✖

<b>Solver Status</b> Model Class: IP State: Global Opt Objective: 1800 Infeasibility: 0 Iterations: 0		<b>Variables</b> Total: 2 Nonlinear: 0 Integers: 0
<b>Extended Solver Status</b> Solver Type: . . . Best Obj: . . . Obj Bound: . . . Steps: . . . Active: . . .		<b>Constraints</b> Total: 4 Nonlinear: 0
		<b>Nonzeros</b> Total: 6 Nonlinear: 0
Update Interval: <input type="text" value="2"/>		<b>Generator Memory Used (K)</b> 23
		<b>Elapsed Runtime (hh:mm:ss)</b> 00:00:00



Thank you for your attention.

For more information,  
please visit [www.m-focus.co.th](http://www.m-focus.co.th)

or

Call 02-513-9892