LINGO 8.0 Software

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Introduction to LINGO 8.0

- LINGO is a software tool designed to efficiently build and solve linear, nonlinear, and integer optimization models

Creating a LINGO Model

- An Optimization model consists of 3 parts
  - Objective Function
    - A single formula that describes exactly what the model should optimize
  - Variables
    - Quantities that can be changed to produce the optimal value of the objective function
  - Constraints
    - formulas that define the limits on the values of the variables

A Sample Model

```
! A cookie store can produce drop cookies and decorated
  cookies, which sell for $1 and $1.50 apiece,
  respectively.  The two bakers each work 8 hours per day
  and can produce up to 400 drop cookies and 200 decorated
  cookies.  It takes 1 minute to produce each drop cookie
  and 3 minutes to produce each decorated cookie.  What
  combination of cookies produced will maximize the
  baker's profit? ;

MAX = 1*Drop + 1.5*Deco;

Drop <= 400;
Deco <= 200;

1/60*Drop + 3/60*Deco <=16;
```

Things to notice

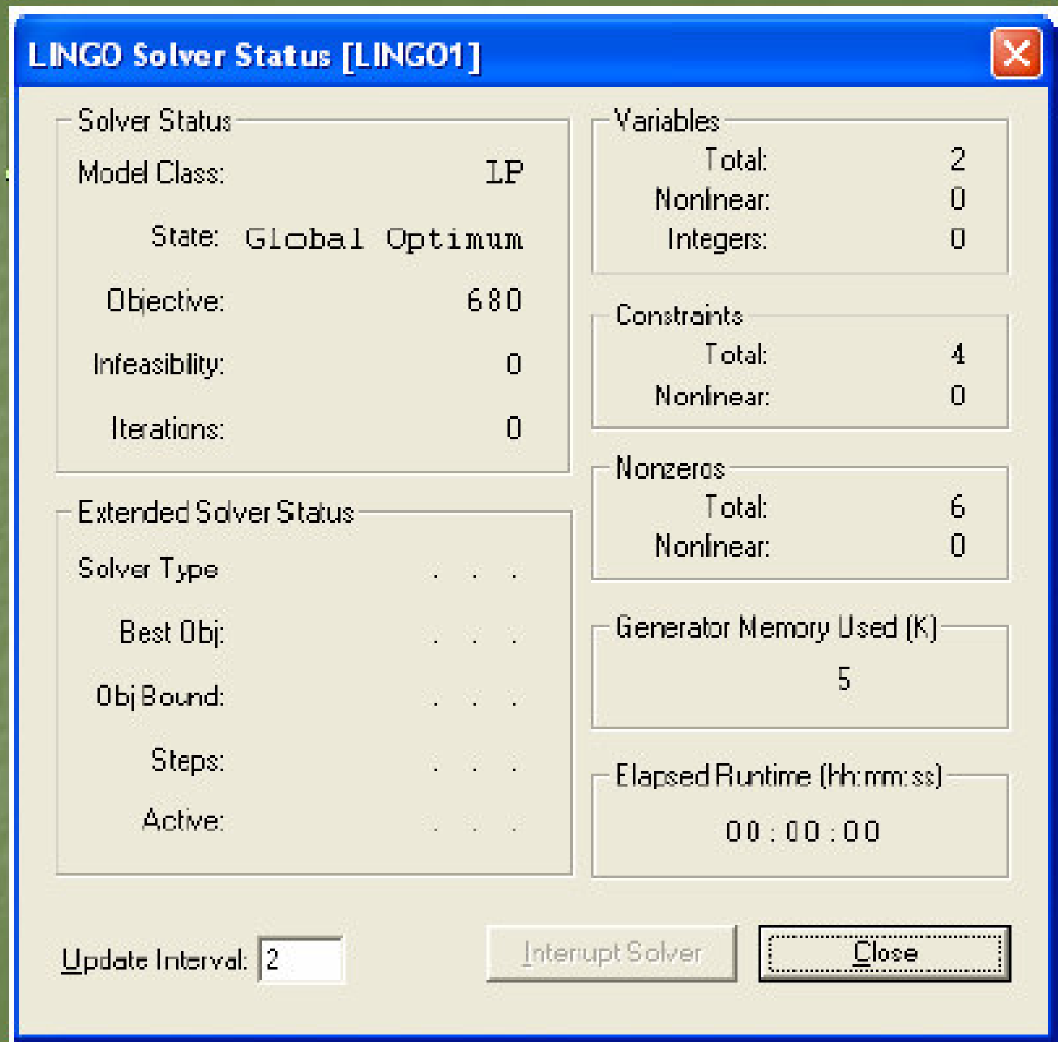
- Comments in the model are initiated with an exclamation point (!) and appear in green text
- LINGO specified operators and functions appear in blue text
- All other text is shown in black
- Each LINGO statement must end in a semi-colon (;)
- Variable names are not case-sensitive and must begin with a letter (A-Z)

Solving a LINGO Model

- Once the model has been entered into the Model Window, it can be solved by:
  - clicking the *Solve* button
  - Selecting Solve from the LINGO menu
  - Using the ctrl+s keyboard shortcut
- Errors (if any) will be reported

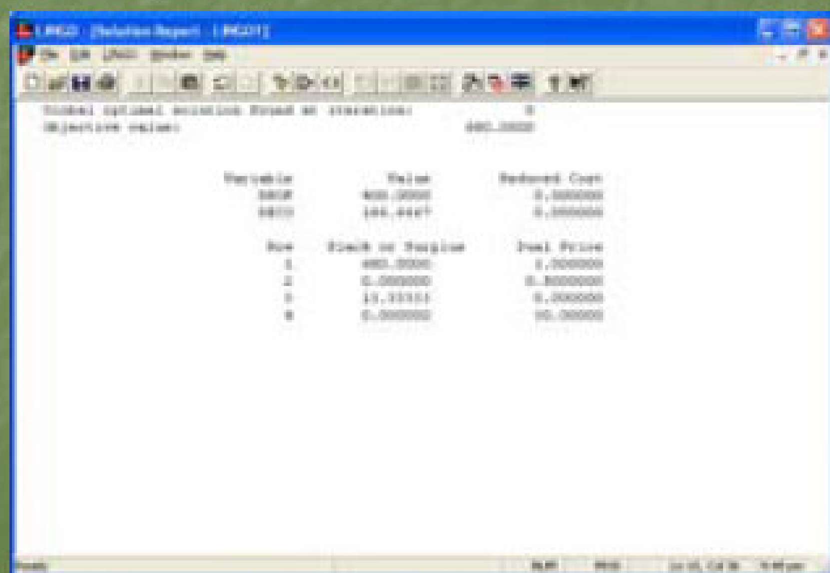
LINGO Solver Status Window

- If no errors are found, the LINGO Solver Status window appears


LINGO Solver Status [LINGO1]
Solver Status
Model Class: LP
State: Global Optimum
Objective: 680
Infeasibility: 0
Iterations: 0
Extended Solver Status
Solver Type
Best Obj:
Obj Bound:
Steps:
Active:
Variables
Total: 2
Nonlinear: 0
Integers: 0
Constraints
Total: 4
Nonlinear: 0
Nonzeros
Total: 6
Nonlinear: 0
Generator Memory Used (K)
5
Elapsed Runtime (hh:mm:ss)
00:00:00
Update Interval: 2
Interrupt Solver
Close

LINGO Solution Report Window

- Close the Solver Status window to see the Solution Report window



LINGO Solution Report Window

- Slack or Surplus
  - Zero if a constraint is completely satisfied as an equality
  - Positive shows how many more units of the variable could be added to the optimal solution before the constraint becomes an equality
  - Constraint has been violated if negative

LINGO Solution Report Window

- Reduced Cost
  - How much the objective function would degrade if one unit of a variable (not included in the current solution) were to be included
- Dual Price
  - How much the objective function would improve if the constraining value is increased by one unit

Using Sets in LINGO

- LINGO allows you to group many instances of the same variable into sets
  - Example: If a model involved 27 delivery trucks, then these 27 trucks could be described more simply as a single set
- Sets may also include attributes for each member, such as the hauling capacity for each delivery truck

Using Sets

- *SETS* section must be defined before any of the set members are used in the model's constraints
- Primitive set example:

```
SETS:
  Trucks/TR1..TR27/:Capacity;
ENDSETS
```

Set Looping Statement Examples

```
@FOR(Trucks(T): Capacity(T)<=3000);
```

- This @FOR statement sets the hauling capacity for all 27 delivery trucks in the Trucks set to at most 3000 pounds

```
TOTAL_HAUL=@SUM(Trucks(J): Capacity(J));
```

- This @SUM statement calculates the total hauling capacity from the individual trucks

LINGO Data Example

```
SETS:
    SET1 /A, B, C/: X, Y;
ENDSETS

DATA:
    X = 1, 2, 3;
    Y = 4, 5, 6;
ENDDATA
```

Variable Types in LINGO

- All variables in a LINGO model are considered to be non-negative and continuous unless otherwise specified
- LINGO's four variable domain functions can be used to override the default domain for given variables

Variable Types in LINGO (cont.)

- @GIN – any positive integer value
- @BIN – a binary value (ie, 0 or 1)
- @FREE – any positive or negative real value
- @BND – any value within the specified bounds

Mathematical Functions

- @ABS(X) – returns the absolute value of *X*
- @SIGN(X) – returns -1 if *X* is negative and +1 if *X* is positive
- @EXP(X) – calculates e^X
- @LOG(X) – calculates the natural log of *X*
- @SIN(X) – returns the sine of *X*, where *X* is the angle in radians
- @COS(X) – returns the cosine of *X*
- @TAN(X) – returns the tangent of *X*

An Example

Example

- Bisco's new sugar-free, fat-free chocolate squares are so popular that the company cannot keep up with demand. Regional demands shown in the following table total 2000 cases per week, but Bisco can produce only 60% (1200 cases) of that number.

	NE	SE	MW	W
Demand	620	490	510	380
Profit	1.6	1.4	1.9	1.2

- The table also shows the different profit levels per case experienced in the regions due to competition and consumer tastes. Bisco wants to find a maximum profit plan that fulfils between 50% and 70% of each region's demand.

Problem Formulation

$$\max \sum_{i=1}^{4} p_i x_i$$

$$\sum_{i=1}^{4} x_i \le 1200$$

$$l_i \le x_i \le u_i, i = 1,2,3,4$$

Problem Formulation (con.)

$$\max\ 1.60\,x1 + 1.40\,x2 + 1.90\,x3 + 1.20\,x4$$

$$x1 + x2 + x3 + x4 \le 1200$$

$$x1 \ge 310$$

$$x1 \le 434$$

$$x2 \ge 245$$

$$x2 \le 343$$

$$x3 \ge 255$$

$$x3 \le 357$$

$$x4 \ge 190$$

$$x4 \le 266$$

LINGO Solution - 1

```
max= 1.60 *x1 + 1.40* x2 + 1.90 *x3 + 1.20 *x4;
  x1 + x2 + x3 + x4 <=1200;
  x1 >= 310;
  x1 <= 434;
  x2 >= 245;
  x2 <= 343;
  x3 >= 255;
  x3 <= 357;
  x4 >= 190;
  x4 <= 266;
```

LINGO Solution 1 (con.)

Global optimal solution found at iteration: 4
Objective value: 1902.100

Variable	Value	Reduced Cost
X1	408.0000	0.000000
X2	245.0000	0.000000
X3	357.0000	0.000000
X4	190.0000	0.000000
X5	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	1902.100	1.000000
2	0.000000	1.600000
3	98.00000	0.000000
4	26.00000	0.000000
5	0.000000	-0.2000000
6	98.00000	0.000000
7	102.0000	0.000000
8	0.000000	0.3000000
9	0.000000	-0.4000000
10	266.0000	0.000000

LINGO Solution 2 (con.)

- **Defining sets**

  SETS:

  REGIONS / NE SE MW W/: LBOUND,

  UBOUND, PROFIT, CASES;

  ENDSETS

- Each of the elements in the set has four attributes: LBOUND, UBOUND, PROFIT, and CASES
- The last one being the decision variable and the others being constants.

LINGO Solution 2 (con.)

- **Enter the data**

```
DATA:
    LBOUND = 310 245 255 190;
    UBOUND = 434 343 357 266;
    PROFIT = 1.6 1.4 1.9 1.2;
ENDDATA
```

LINGO Solution 2 (con.)

- **Objective function**

  MAX = @SUM(REGIONS(I): PROFIT(I)*CASES(I));

LINGO Solution 2 (con.)

- **Capacity constraint**

  @SUM(REGIONS(I): CASES(I)) <=1200;

- **Minimum/maximum cases**

  @FOR(REGIONS(I):
  CASES(I) <= UBOUND(I);
  CASES(I) >= LBOUND(I));

LINGO Solution 2 (con.)

Global optimal solution found at iteration: 6
Objective value: 1902.100

Variable	Value	Reduced Cost
LBOUND(NE)	310.0000	0.000000
LBOUND(SE)	245.0000	0.000000
LBOUND(MW)	255.0000	0.000000
LBOUND(W)	190.0000	0.000000
UBOUND(NE)	434.0000	0.000000
UBOUND(SE)	343.0000	0.000000
UBOUND(MW)	357.0000	0.000000
UBOUND(W)	266.0000	0.000000
PROFIT(NE)	1.600000	0.000000
PROFIT(SE)	1.400000	0.000000
PROFIT(MW)	1.900000	0.000000
PROFIT(W)	1.200000	0.000000
CASES(NE)	408.0000	0.000000
CASES(SE)	245.0000	0.000000
CASES(MW)	357.0000	0.000000
CASES(W)	190.0000	0.000000

Row	Slack or Surplus	Dual Price
1	1902.100	1.000000
2	0.000000	1.600000
3	26.00000	0.000000
4	98.00000	0.000000
5	98.00000	0.000000
6	0.000000	-0.2000000
7	0.000000	0.3000000
8	102.0000	0.000000
9	76.00000	0.000000
10	0.000000	-0.4000000

درس برنامه ریزی حرکت قطارها

پیوست ۱:
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