

# LINDO

(**L**INEAR, **I**NTERACTIVE,  
**D**ISCRETE, **O**PTIMIZER)

## INTRODUCTION

- Simple problem entrance
- Quick changes and additions
- File input
- Sensitivity Analysis

### REQUIREMENTS

- Variables
- Objective Function
- Constraints

# INTRODUCTION

- WINDOW / Open Command Window
- Fonts can be changed EDIT / Choose new font
- All right hand sides must be constants
- All variables should be non-negative

## Handling Unrestricted Variables

Assume  $X_1$  is unrestricted in the problem.

Let

$$X_1 = X_{1P} - X_{1N}$$

where  $X_{1P}$  and  $X_{1N}$  are nonnegative.

The value of  $X_1$  is positive or negative depending on whether

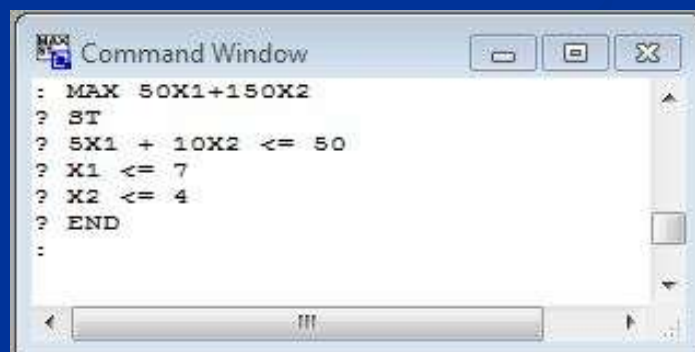
$$X_{1P} \geq X_{1N} \quad \text{or} \quad X_{1P} \leq X_{1N}$$

## Basic Commands

- **MAX / MIN** to write the objective function
- **SUBJECT TO** to enter the constraints
- **END** to end the problem entrance
  
- **GO** to solve the problem
- **LOOK n** to view the current line
- **LOOK ALL** to view the complete problem
  
- **ALTER n** to change the  $n^{\text{th}}$  line
- **EXT** to add new constraints the problem
- **DEL n** to delete  $n^{\text{th}}$  line

## Problem Entry

$\text{MAX } Z = 50X_1 + 150X_2$   
 Subject to  $5X_1 + 10X_2 \leq 50$   
 $X_1 \leq 7$   
 $X_2 \leq 4$

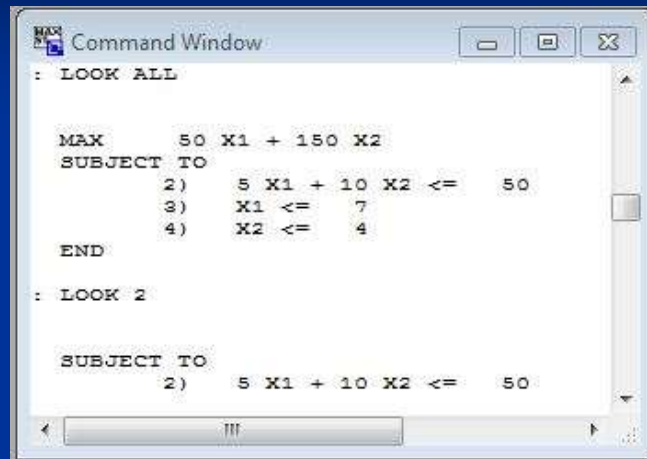


```

MAX
: MAX 50X1+150X2
? ST
? 5X1 + 10X2 <= 50
? X1 <= 7
? X2 <= 4
? END
:

```

# LOOK n (ALL)



```

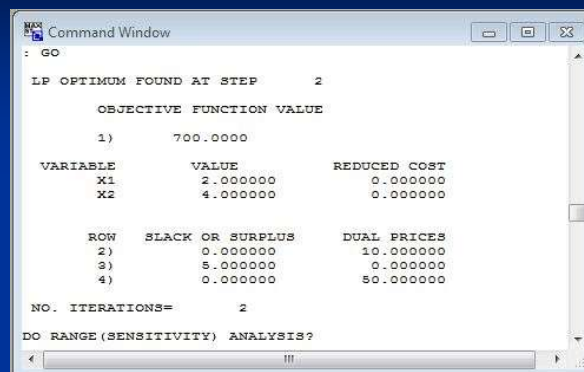
MAX
: LOOK ALL

MAX      50 X1 + 150 X2
SUBJECT TO
    2)    5 X1 + 10 X2 <= 50
    3)    X1 <= 7
    4)    X2 <= 4
END

: LOOK 2

SUBJECT TO
    2)    5 X1 + 10 X2 <= 50
  
```

## Solution



```

MAX
: GO

LP OPTIMUM FOUND AT STEP      2

      OBJECTIVE FUNCTION VALUE
    1)      700.0000

      VARIABLE            VALUE            REDUCED COST
      X1                  2.000000          0.000000
      X2                  4.000000          0.000000

      ROW    SLACK OR SURPLUS    DUAL PRICES
    2)           0.000000          10.000000
    3)           5.000000          0.000000
    4)           0.000000          50.000000

NO. ITERATIONS=         2

DO RANGE (SENSITIVITY) ANALYSIS?
  
```

- Iteration Number indicates the number of "Simplex Tableaus" required to solve the problems.
- OPTIMAL : Best solution of the objective function

# Solution

```

MAX Command Window
: GO

LP OPTIMUM FOUND AT STEP      2

      OBJECTIVE FUNCTION VALUE
    1)      700.0000

      VARIABLE            VALUE            REDUCED COST
      X1              2.000000            0.000000
      X2              4.000000            0.000000

      ROW    SLACK OR SURPLUS      DUAL PRICES
    2)           0.000000            10.000000
    3)           5.000000             0.000000
    4)           0.000000            50.000000

NO. ITERATIONS=         2

DO RANGE (SENSITIVITY) ANALYSIS?
  
```

- **VARIABLE:** Value of variables at optimal solution
- **SLACK / SURPLUS :** Indicates the flexibility in the problem

# Solution

```

MAX Command Window
: GO

LP OPTIMUM FOUND AT STEP      2

      OBJECTIVE FUNCTION VALUE
    1)      700.0000

      VARIABLE            VALUE            REDUCED COST
      X1              2.000000            0.000000
      X2              4.000000            0.000000

      ROW    SLACK OR SURPLUS      DUAL PRICES
    2)           0.000000            10.000000
    3)           5.000000             0.000000
    4)           0.000000            50.000000

NO. ITERATIONS=         2

DO RANGE (SENSITIVITY) ANALYSIS?
YES

RANGES IN WHICH THE BASIS IS UNCHANGED:

      VARIABLE            CURRENT      OBJ COEFFICIENT RANGES      ALLOWABLE
      X1              2.000000      COEF      ALLOWABLE      ALLOWABLE
      X2              4.000000      INCREASE  INCREASE  DECREASE
      X1              2.000000      25.000000  25.000000  50.000000
      X2              4.000000      INFINITY   INFINITY   50.000000

      ROW            CURRENT      RIGHTHAND SIDE RANGES      ALLOWABLE
      2              50.000000      RHS      ALLOWABLE      ALLOWABLE
      3              7.000000      INCREASE  INCREASE  DECREASE
      4              4.000000      1.000000  1.000000  2.500000
  
```

# Changes to Problem

```

MAX Command Window
: LOOK ALL

MAX      50 X1 + 150 X2
SUBJECT TO
2)      5 X1 + 10 X2 <= 50
3)      X1 <= 7
4)      X2 <= 4
END

: ALT 1
VAR:
DIR
NEW DIRECTION:
? MIN
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
2)      5 X1 + 10 X2 <= 50
3)      X1 <= 7
4)      X2 <= 4
END

```

# Changes to Problem

```

MIN Command Window
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
2)      5 X1 + 10 X2 <= 50
3)      X1 <= 7
4)      X2 <= 4
END

: ALT 2
VAR:
X1
NEW COEFFICIENT:
? 8
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
2)      8 X1 + 10 X2 <= 50
3)      X1 <= 7
4)      X2 <= 4
END

```

# Changes to Problem

```

MAX Command Window
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
2)      8 X1 + 10 X2 <= 50
3)      X1 <= 7
4)      X2 <= 4
END

: ALT 2
VAR:
DIR:
NEW DIRECTION:
? >=
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
2)      8 X1 + 10 X2 >= 50
3)      X1 <= 7
4)      X2 <= 4
END

```

# Changes to Problem

```

MAX Command Window
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
2)      8 X1 + 10 X2 >= 50
3)      X1 <= 7
4)      X2 <= 4
END

: ALT 4
VAR:
RHS
NEW COEFFICIENT:
? 8
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
2)      8 X1 + 10 X2 >= 50
3)      X1 <= 7
4)      X2 <= 8
END

```

# Changes to Problem

```

Command Window

: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
  2)      8 X1 + 10 X2 >= 50
  3)      X1 <= 7
  4)      X2 <= 4
END

: ALT 4
VAR:
X1
VARIABLE NOT IN THIS ROW. WANT IT INCLUDED?
? YES
NEW COEFFICIENT:
? 5
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
  2)      8 X1 + 10 X2 >= 50
  3)      X1 <= 7
  4)      5 X1 + X2 <= 4
END

```

# Delete / Extent

```

Command Window

: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
  2)      8 X1 + 10 X2 >= 50
  3)      X1 <= 7
  4)      X2 <= 8
END

: DEL 4
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
  2)      8 X1 + 10 X2 >= 50
  3)      X1 <= 7
END

: EXT
BEGIN EXTEND WITH ROW      4
? X2<=4
? END
: LOOK ALL

MIN      50 X1 + 150 X2
SUBJECT TO
  2)      8 X1 + 10 X2 >= 50
  3)      X1 <= 7
  4)      X2 <= 4
END

```



## Model Statement Function

**FREE** *<Variable>* Removes all bounds on *<Variable>*, allowing *<Variable>* to take on any real value, positive or negative.

**GIN** *<Variable>* Makes *<Variable>* a general integer (i.e., restricts it to the set of non-negative integers).

**INT** *<Variable>* Makes *<Variable>* binary (i.e., restricts it to be either 0 or 1).

**SLB** *<Variable>* *<Value>* Places a simple lower bound on *<Variable>* of *<Value>*. Use in place of constraints of form  $X \geq r$ .

**SUB** *<Variable>* *<Value>* Places a simple upper bound on *<Variable>* of *<Value>*. Use in place of constraints of form  $X \leq r$ .

## HOMEWORK

```

MAX
Command Window
MIN      40 X11 + 20 X12 + 20 X13 + 10 X14 + 20 X21 + 50 X22 + 50 X23
        + 60 X24
SUBJECT TO
2)      X11 + X12 + X13 + X14 =      30
3)      X21 + X22 + X23 + X24 =      50
4)      X11 + X21 =      20
5)      X12 + X22 =      20
6)      X13 + X23 =      30
7)      X14 + X24 =      10
END

```

```

MAX
Command Window
: MIN 40X11+20X12+20X13+10X14+20X21+50X22+50X23+60X24 ST
? X11+X12+X13+X14=30
? X21+X22+X23+X24=50
? X11+X21=20
? X12+X22=20
? X13+X23=30
? X14+X24=10
? END
: LOOK ALL

```

# HOMEWORK

```

MAX
Command Window

: GO

LP OPTIMUM FOUND AT STEP      2

      OBJECTIVE FUNCTION VALUE

    1)      2400.000

      VARIABLE                VALUE                REDUCED COST
      X11                     0.000000                50.000000
      X12                     20.000000                 0.000000
      X13                     0.000000                 0.000000
      X14                     10.000000                 0.000000
      X21                     20.000000                 0.000000
      X22                     0.000000                 0.000000
      X23                     30.000000                 0.000000
      X24                     0.000000                20.000000

      ROW    SLACK OR SURPLUS    DUAL PRICES
      2)              0.000000              0.000000
      3)              0.000000             -30.000000
      4)              0.000000              10.000000
      5)              0.000000             -20.000000
      6)              0.000000             -20.000000
      7)              0.000000             -10.000000

NO. ITERATIONS=         2

DO RANGE (SENSITIVITY) ANALYSIS?
  
```