**CPLEX contains three different forms**

1. **Interactive Optimizer**
   - an executable program
   - read a problem interactively or from files in standard formats
   - can output solution interactively or into text files

2. **Concert Technology**
   - C++ class libraries
   - Allow programmers to embed CPLEX in a C++ application

3. **Callable Library**
   - C library
   - Enable programmers to embed CPLEX in C, VB, Java, and FORTRAN

**What CPLEX can do?**

- Linear programs: Dual Simplex, Primal Simplex
- Network programs: Network Optimizer
- Mixed Integer programs: Mixed Integer Optimizer
- Quadratic programs: Barrier Optimizer
- Parallel CPLEX: Parallel CPLEX Optimizer

**Starting Interactive Optimizer**

1. Double clicks on **cplex.exe**
   
   In our system, it usually locates at 
   C:/ILOG/cplex75/bin/msvc6/. Screen appears:

   ********************************************************************************
   Welcome to CPLEX Interactive Optimizer 7.5.0
      with Simplex, Mixed Integer & Barrier Optimizers
    Copyright (c) ILOG 1997-2001
  CPLEX is a registered trademark of ILOG

   Type 'help' for a list of available commands.
   Type 'help' followed by a command name for more information on commands.

   CPLEX>
   ********************************************************************************

2. ask for help
Enter help after CPLEX> prompt:
CPLEX> help or CPLEX> h

CPLEX> h

add             add constraints to the problem
baropt          solve using barrier algorithm
change          change the problem
display         display problem, solution, or parameter settings
enter           enter a new problem
help            provide information on CPLEX commands
mipopt          solve a mixed integer program
netopt          solve the problem using network method
optimize        solve the problem
primopt         solve using the primal method
quit            leave CPLEX
read            read problem or basis information from a file
set             set parameters
tranopt         solve using the dual method
write           write problem or solution info. to a file
xecute          execute a command from the operating system

Enter enough characters to uniquely identify commands & options.
Commands can be entered partially (CPLEX will prompt you for
further information) or as a whole.

Try to type:
help primopt or help p

CPLEX> h primopt

The PRIMOPT command solves the current problem using
a primal simplex method or crosses over to a basic solution
if a barrier solution exists.

Syntax:  PRIMOPT

A problem must exist in memory (from using either the
ENTER or READ command) in order to use the PRIMOPT command.

Sensitivity information (dual price and reduced-cost information) as well as other detailed information about the solution can be viewed using the DISPLAY command, after a solution is generated.

Syntax help <command name>

3. Enter a problem
Example:
Max \( x_1 + 2x_2 + 3x_3 \)
s.t. \( -x_1 + x_2 + x_3 \leq 2 \)
\( x_1 - 3x_2 + x_3 \leq 30 \)
\( 0 \leq x_1 \leq 40 \)
\( 0 \leq x_2 \leq +\infty \)
\( 0 \leq x_3 \leq +\infty \)

Type:
CPLEX> enter

4. Name a problem
Enter name for problem: example
Appear:
Enter new problem [‘end’ on a separate line terminates]:

5. Problem should be entered in the following order:
1. Objective function
2. Constraints
3. Bounds

- Object function
  Type:
  maximize
  \( x_1+2x_2+3x_3 \)
  you can also type:
  minimize
- Name of objective function: Obj is the default name
- Variable 255 characters
● Cannot be one of the follows: ee, e9, e24, e+<number>, or ee…

● Constraints
  Type:
  subject to (or st)
  \[-x_1 + x_2 + x_3 \leq 2\]
  \[x_1 - 3x_2 + x_3 \leq 30\]
  You can name constraints, for example:
  st
  time: \[-x_1 + x_2 + x_3 \leq 2\]
  labor: \[x_1 - 3x_2 + x_3 \leq 30\]

● Bounds
  Type:
  bounds
  \[x_1 \leq 40\]
  • automatically set by CPLEX:
    1. The default lower bound is 0
    2. The default upper bound is \(+\infty\)
  Type:
  end

6. Long constraints use <return> key to split
  Type:
  time: \[-x_1 + x_2 + x_3 \leq 2\]<return>
  \[x_3 \leq 20\]<return>

7. Display a problem
  Type:
  display
  List of display options:
  
  CPLEX> display

  Display Options:

  iis        display infeasibility diagnostics (IIS constraints)
  problem    display problem characteristics
  sensitivity display sensitivity analysis
  settings   display parameter settings
solution display existing solution

Display what:
----------------------------------------------------------------------------------

Type:
problem

List of problem characteristics:
----------------------------------------------------------------------------------

Display what: problem

Display Problem Options:

all display entire problem
binaries display binary variables
bounds display a set of bounds
constraints display a set of constraints or node supply/demand values
generals display general integer variables
histogram display a histogram of row or column counts
integers display integer variables
names display names of variables or constraints
qpvariables display quadratic variables
semi-continuous display semi-continuous and semi-integer variables
sos display special ordered sets
stats display problem statistics
variable display a column of the constraint matrix

Display which problem characteristic:
----------------------------------------------------------------------------------

Type:
all
----------------------------------------------------------------------------------

Display which problem characteristic: all
Maximize
   obj: x1 + 2 x2 + 3 x3
Subject To
   time: - x1 + x2 + x3 <= 2
labor: x1 - 3 x2 + x3 <= 30
Bounds
  0 <= x1 <= 40
  All other variables are >= 0.

Type:
display problem stats

------------------------------
CPLEX> display problem stats
Problem name: example
Constraints : 2 [Less: 2]
Variables : 3 [Nneg: 2, Box: 1]
Constraint nonzeros: 6
Objective nonzeros: 3
RHS nonzeros: 2
------------------------------

8. Solve a problem

- Default method: dual simplex

Type:
optimize

------------------------------
CPLEX> optimize
Tried aggregator 1 time.
No LP presolve or aggregator reductions.
Presolve time = 0.03 sec.

Iteration log . . .
Iteration: 1 Dual infeasibility = 0.000000
Iteration: 2 Dual objective = 153.000000

Dual - Optimal: Objective = 1.5300000000e+002
Solution time = 0.05 sec. Iterations = 2 (1)

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- Reports
Objective value
solution time in seconds
total iterative count
phase I iterative count

9. Using alternative optimizers
- primopt: primal simplex optimizer
- opt: dual simplex optimizer
- netopt: network optimizer
- baropt: barrier optimizer
- mipopt: mixed integer optimizer

Type:
primopt
Or type:
netopt
Or type
baropt

10. Interrupt optimization process
<control+C>

11. Display Post-Solution Information
Type:
display solution variables
display solution slacks
display solution dual

12. Display setting
Type:
Display setting all

13. Sensitivity analysis
Type:
display sensitivity obj

CPLEX> display sensitivity obj
Display objective sensitivity for which variable(s): x1

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Reduced Cost</th>
<th>Down</th>
<th>Current</th>
<th>Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>x1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Getting Started with ILOG CPLEX

14. Read LP files
   Type:
   read
   Appear:
   name of file to read:

   Type:
   example.lp

   Or type:
   read example.lp

15. Save results to a file
   Type:
   write

   CPLEX> write
   Name of file to write: c:\result.txt
   Solution written to file 'c:\result.txt'.

   Output file result.txt contains following information:

   DATA    NAME
   OBJECTIVE VALUE 153
   STATUS       OPTIMAL SOLN
   ITERATION    0
### OBJECTIVE

<table>
<thead>
<tr>
<th></th>
<th>obj</th>
<th>(MAX)</th>
</tr>
</thead>
</table>

### RHS

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

### RANGES

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

### BOUNDS

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

## SECTION 1 - ROWS

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>ROW</th>
<th>.AT ACTIVITY</th>
<th>.SLACK ACTIVITY</th>
<th>.LOWER LIMIT.</th>
<th>.UPPER LIMIT.</th>
<th>.DUAL ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>obj</td>
<td>BS</td>
<td>153</td>
<td>-153</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>2</td>
<td>time</td>
<td>UL</td>
<td>2</td>
<td>0</td>
<td>NONE</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>labor</td>
<td>UL</td>
<td>30</td>
<td>0</td>
<td>NONE</td>
<td>30</td>
</tr>
</tbody>
</table>

## SECTION 2 - COLUMNS

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>.COLUMN</th>
<th>.AT ACTIVITY</th>
<th>.INPUT COST..</th>
<th>.LOWER LIMIT.</th>
<th>.UPPER LIMIT.</th>
<th>.REDUCED COST.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>x1</td>
<td>UL</td>
<td>40</td>
<td>1</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>x2</td>
<td>BS</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>NONE</td>
</tr>
<tr>
<td>6</td>
<td>x3</td>
<td>BS</td>
<td>29</td>
<td>3</td>
<td>0</td>
<td>NONE</td>
</tr>
</tbody>
</table>

16. Quit ILOG CPLEX

Type:

```
quit
```