

Linear Programming and CPLEX

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CPLEX Optimization Options:

- Primal, Dual Simplex Methods
- Network Flow Problems
- MIPs (Mixed Integer Linear Programming) Problems
- Barrier Method
- Quadratic Programming Problems

CPLEX: Data Entry Options

- **Using interactive Base System to enter Problem Line by Line**
- **Using the CPLEX Callable Library to write C/C++ codes**
- **Reading Data from Formatted Files**

CPLEX File Formats

Input file format:

- **MPS (Mathematical Programming System)**
 - Industry standard ASCII-text file format
- **LP (Linear Programming)**
 - CPLEX specific file format

Output file format:

- **TXT** – ASCII text file for solutions

LP File Format

Minimize / Maximize (or **Maximum/MAX/Minimum/MIN**)

// Objective function (LP):

Obj: $x1 + 2x2 + 3x3 + x4 + x5$

//Quadratic programming problems

Obj: $x1 + x2 + [x1^2 + 4x1*x2 + 7xx^2]$

Subject To (or **such that, st, S.T., ST**)

//Constraints:

C1: $-x1 + x2 + x3 + 10x4 + x5 \leq 20$

C2: $x1 - 3x2 + x3 - 7x5 \leq 30$

C3: $x2 - 4x4 \leq 0$

Continues



Bounds (or **bound**)

// default lower bound is 0, default upper bound is $+\infty$

// In this example, $0 \leq x_2 \leq \infty$

// $+\infty$: +infinity, +inf; $-\infty$: -infinity, -inf

// x5 free: $-\text{inf} \leq x_5 \leq +\text{inf}$

$0 \leq x_1 \leq 40$

$0 \leq x_4 \leq 3$

x5 free

// Mixed Integer Linear Programming Problems

General (or **Generals, GEN**)

// $x_4 = \{0,1,2,3\}$

x4

Binary (or **Binaries, BIN**)

// $x_3 = \{0,1\}$

x3

End

Running CPLEX

Sun-66> cplex

Welcome to CPLEX Linear Optimizer 6.5.3
with Mixed Integer & Barrier Solvers
Copyright (c) ILOG 1997-1999
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Type 'help' for a list of available commands.

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

CPLEX>

CPLEX> help

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
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 may be executed in either of two formats:

1. Incremental entry--enter the command name, and CPLEX will prompt you for additional required information.
2. Single-line entry--CPLEX accepts single-line command strings, provided simple syntax rules are observed.

CPLEX> read o10x10.lp

// Read data file filename.lp

Problem 'o10x10.lp' read.

Read time = 0.48 sec.

CPLEX> primopt (or netopt, mipopt, tranopt) // Choose one optimizer

Tried aggregator 1 time.

LP Presolve eliminated 32 rows and 4 columns.

Reduced LP has 890 rows, 137 columns, and 2536 nonzeros.

Presolve time = 0.07 sec.

Iteration log . . .

Iteration: 1 Scaled infeas = 57.249021

Iteration: 64 Scaled infeas = 0.492926

Switched to devex.

Iteration: 142 Scaled infeas = 0.152720

Iteration: 212 Objective = -0.000008

Iteration: 287 Objective = -0.000010

Iteration: 349 Objective = -0.000011

Iteration: 411 Objective = -0.000011

Iteration: 473 Objective = -0.000012

Iteration: 543 Objective = -0.000012

Removing shift (12).

Iteration: 571 Scaled infeas = 0.000015

Iteration: 574 Objective = -0.000012

Primal - Optimal: Objective = -1.1865723383e-005

// Optimal value of the objective function

Solution time = 2.25 sec. Iterations = 598 (214)

// Running time

```
CPLEX> write output_file.sol txt // Write out solution
```

```
Solution written to file 'output_file.sol'.
```

```
CPLEX> quit // Quit CPLEX interactive System
```

```
Sun-66> cat output_file.sol
```

```
PROBLEM NAME o10x10.1p
DATA NAME
OBJECTIVE VALUE -1.186572E-005
STATUS OPTIMAL SOLN
ITERATION 598
```

```
OBJECTIVE obj (MIN)
RHS
RANGES
BOUNDS
```

```
SECTION 1 - ROWS
```

NUMBER	.....ROW.....	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	obj	BS	-1.186572E-005	1.186572E-005	NONE	NONE	1
2	c1	EQ	3.3	0	3.3	3.3	-6.365636E-006
3	c2	EQ	3.3	0	3.3	3.3	-1.001304E-006
4	c3	EQ	3.3	0	3.3	3.3	3.096276E-006
5	c4	EQ	3.3	0	3.3	3.3	4.270664E-006

```
SECTION 2 - COLUMNS
```

NUMBER	.....COLUMN.....	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
924	V1	BS	3.3	-2.741202E-006	0	NONE	0
925	V2	BS	3.27053	-5.361394E-006	3	NONE	0
926	V3	BS	3.250789	-1.040196E-005	3	NONE	0