LP for WINDOWS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

LP for Windows solves linear programming problems using any one of three most suitable algorithms: the revised simplex method for standard LP problems, the stepping-stones algorithm for transport problems, and the Bradford method for assignment problems.

SYSTEM REQUIREMENTS

The LP software is supplied to run under a 32-bit WINDOWS system.

OPTIONAL EQUIPMENT: one 80-column printer compatible with your computer.

FEATURES

- Easy operation with a mouse on a graphical user interface.
- Applies any one of three most suitable algorithms.
- Solves unbalanced transport problems where the total demands at all sinks are not equal to the total supplies from all sources.
- Prints primal and dual problem solutions.
- Reads and writes EXCEL text files and legacy *.WK1 worksheet files.
- Allows processing of very large files.
- Traps numerous errors and gives appropriate, meaningful messages.
- Prints output readable by text-processing and spreadsheet software.
- Includes sample files for immediate application.

TO INSTALL LP

For the very first installation:

Put the original LP for Windows CD in a drive. Close the drive door. Wait for the SETUP.EXE program to start and follow instructions.

The installation program requests you to enter through the keyboard the folder on which you want to install the software, your name, and your address or institutional affiliation.

Subsequent installations:

Subsequent installations proceed like the original one but without prompting you for your name and address.

*Installation instructions may change in the future. Consult the *.DOC files on your original disk for up-to-date information.*

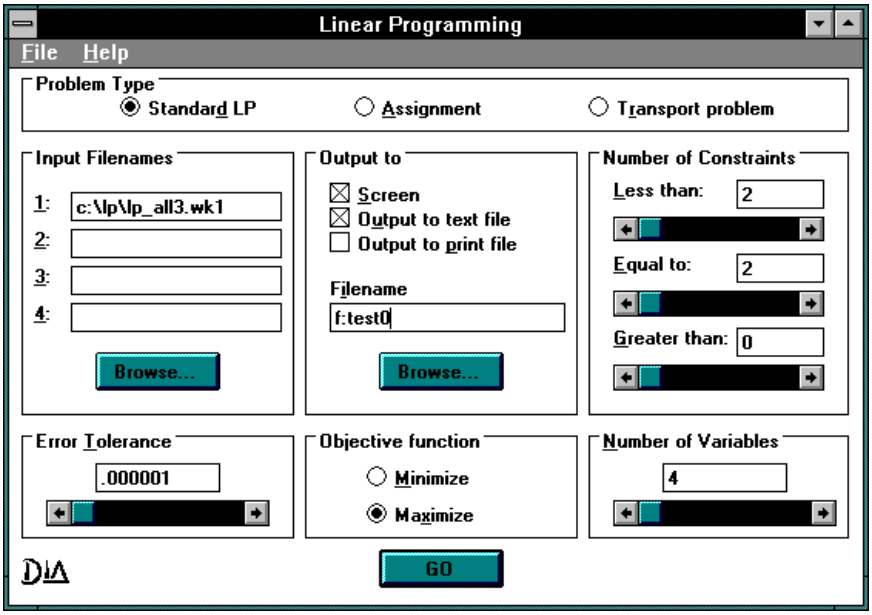
TO OPEN LP

Double-click the LP icon in *Program Files*. Wait for a menu and dialog box to appear on screen.

PRACTICE RUNS

Make three practice runs with each of the three algorithms. A sample data file will be used for each run. The ways to create new data files will be discussed later.

Start by opening LP and view the LP screen. There are radio buttons, check boxes, text boxes, scroll bars, and command buttons. There is a menu at the top. Some menu items will also be discussed later.



Below the menu bar are frames. Each frame is associated with a different task : the choice of a problem type, the choice of an input file, the filing and display of output, the description of the problem by number of constraints and variables, and the objective.

File names are set by typing in appropriate text boxes. The reason for the four input file text boxes will be discussed later when considering huge files. The frames around file name boxes hold browse buttons. A file name can be chosen also by browsing directories of files on disk.

PRACTICE RUNS . . .

The constraints and variables frames hold scroll bars so that the problem size can be indicated by scrolling with a mouse and not only by typing numbers.

The Problem Type and Objective function are chosen by clicking on a radio button. The GO button at the bottom is clicked when all choices are made and it is time to compute and solve the LP problem.

The various items inside frames are referred to as controls. Controls are activated with the mouse. The active control can also be picked by pressing the Tab key or the corresponding, underlined key. Press the F1 key for help about the active control. Pressing the ENTER key is equivalent to a mouse click on the GO button.

Now use the buttons and boxes on screen. Nearly all controls have to be used. Click on GO when all radio buttons, check boxes, and text boxes are set as desired. The various settings are discussed as numbered steps followed in practice runs A, B, and C.

A. STANDARD LP PROBLEM

The problem is to optimize by allocation of labour and land to the production of corn and hogs in ways that maximize the utility of corn and hogs to two consumers.[1]

1. Click on Standard LP or press Alt-D keys to choose the application of the Revised Simplex method. This choice is already made on start-up.

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[1] See R. G. D. Allen, **Mathematical Economics**, 2nd. Ed., London: Macmillan, 1960, Section 19.8, Example (a), page 685.

2. Choose the sample file called LP_ALL3.WK1. Make the choice by browsing a SAMPLES folder. Click the BROWSE button in the INPUT FILENAMES frame. Click on LP_ALL3.WK1 under FILENAME(S) in the INPUT FILE(S) dialog box. Click on OK.

3. The INPUT FILE(S) box disappears and the filename appears in the text box next to the 1 in the INPUT FILENAMES frame.

4. Move the mouse to the OUTPUT TO frame. Click on Screen to check-mark output to the computer screen.

5. Move the mouse and click on the text box in the OUTPUT TO frame. Type a file name such as TEST0. It makes no difference whether upper- or lower-case letters are used.

6. Move the mouse to the NUMBER OF CONSTRAINTS frame. The number of "less than or equal to" constraints is 2. The number of "equal to" constraints is also 2. Set these numbers by editing text boxes or by clicking on the corresponding scroll-bars.

7. Set the NUMBER OF VARIABLES to four.

8. In the OBJECTIVE FUNCTION frame click on MAXIMIZE or Alt-X keys

.

9. Click on GO or press the ENTER key.

10. A message box may appear saying that file TEST0 already exists. Click on YES or on NO depending on whether you do or do not want the output file to over-write the existing file. The contents of the existing file will be lost when YES is chosen.

PRACTICE RUNS . . .

Choose NO to return to the opening screen and to revise the output file name that had been entered in step 5 above.

11. Wait for the LP-SOLUTION message. Read the message saying where the results were filed. Then click on the OK button or press the ENTER key.

12. A new window appears with the output file name at the top and CLOSE and PRINT buttons at the bottom. See page 23 for an illustration of this RESULTS window. Use the scroll bars to view the entire output. Click on PRINT after turning on the printer to obtain a printed copy of the output. Click on CLOSE to return to the opening LP screen.

The first practice run is now complete. Further uses of the output in word-processors and in spreadsheet programs will be discussed later.

B. AN ASSIGNMENT PROBLEM

The problem is to optimize the employment of eight persons by their assignment to eight tasks in ways that minimize the total amount of time spent on all tasks. In general, choose *n* elements, one in each of *n* rows and one in each of *n* columns, so that the sum of those elements is minimized.

1. Click on Assignment or press the Alt-keys to choose the application of Mack's Bradford method. Notice the changes in the constraints and variables frames of the LP window.

2. Choose the sample file called ASSIGN.WK1 in the SAMPLES folder.

3. Move the mouse to the OUTPUT TO frame. Click on Screen or press the Alt-S-keys to check-mark output to the computer screen.

4. Select a format of the output file from text to print file. The print file is a comma-delimited file that can be read by spreadsheet programs.

5. Move the mouse and click on the text box in the OUTPUT TO frame or press on the Alt-I-keys. Type a file name such as TEST1.

6. Set the NUMBER OF ASSIGNMENTS to eight.

7. In the OBJECTIVE FUNCTION frame click on MINIMIZE or press the Alt-M-keys.

8. Click on GO or press the ENTER key. Notice how the input file name is moved to the text box marked 1 in case you had typed it in below that box.

9. Wait for the LP-SOLUTION message. Read the message saying where the results were filed. Then click on the OK button or press ENTER.

10. Review the output. Notice the commas separating columns. With these commas on file, the output can be imported to, for example, EXCEL as an imported print file. Click on PRINT after turning on the printer to obtain a printed copy of the output. Click on CLOSE to return to the opening LP screen. The second practice run is now complete.

PRACTICE RUNS . . .

C. A BALANCED TRANSPORTATION PROBLEM.

The problem is to minimize the transport cost involved in the supply of stores at five sinks with goods brought from three sources. The transport problem is a balanced one: the total demands at all five sinks equal the total supplies from all three sources.

1. Click on Transport Problem or press the R-key to choose the application of the stepping stones algorithm. Notice the changes in the constraints and variables frames of the LP window.

2. Choose the sample file called TRNSPRTB.WK1. Make the choice by browsing the SAMPLES folder. Click the BROWSE button in the INPUT FILENAMES frame. Click on TRNSPRTB.WK1 under FILENAME(S) in the INPUT FILE(S) dialog box. Click on OK.

3. The INPUT FILE(S) box disappears and the filename appears in the text box next to the 1 in the INPUT FILENAMES frame.

4. Move the mouse to the OUTPUT TO frame. Click on Screen or press the Alt-S-key to check-mark output to the computer screen.

5. Change the format of the output file from print to text file. Click on OUTPUT TO TEXT FILE and/or on OUTPUT TO PRINT FILE..

5. Move the mouse and click on the text box in the OUTPUT TO frame or press on the I-key. Type a file name such as TEST2.

6. Set the NUMBER OF SOURCES to three and the NUMBER OF SINKS to five.

7. There is no choice of minimizing or maximizing the objective function. Minimization is mandatory when solving transport problems.

8. Click on GO or press the ENTER key.

9. Wait for the LP-SOLUTION message. Read the message saying where the results were filed. Then click on the OK button or press the ENTER key.

10. Review the output. Click on PRINT after turning on the printer to obtain a printed copy of the output. Click on CLOSE to return to the opening LP screen.

The third and last practice run is now complete. See the chapter on unbalanced transport problems for shortage and surplus cases. The next task is to view sample files in the LP spreadsheet as preparation for file creation and file editing.

The solution to a transport problem is always an integer vector if all demands and supplies are also integers.

THE LP SPREADSHEET

Choose the Spreadsheet from the LP FILE menu or by using the Ctrl-N short-cut keys. The Spreadsheet has its own FILE menu. Choose OPEN to open one of the sample files. A new dialog box appears when OPEN is chosen. Enter the file name and file size in the dialog box. The file size is indicated by the numbers of rows and columns counted from 0 to the last. File input is slightly accelerated by providing the exact file size but the file size is not strictly necessary.

Sample file	Rows	Columns
lp_all3.wk1	5	5
assign.wk1	8	8
trnsprtb.wk1	4	6

Other items on the Spreadsheet menu bar, their short-cut keys and uses are:

Menu	Sub-menu	Short-cut Keys	Use
FILE			
	NEW	Ctrl-N	Create a new, blank spreadsheet.
	OPEN	Ctrl-O	Open a file for input.
	SAVE	Ctrl-S	Save the file with the same name.
	SAVE AS	Ctrl-A	Save with a new path and name.
	CLOSE		Close the active spreadsheet.
EDIT			
	COPY	Ctrl-C	Copy selected cells to *Windows Notepad.*
	PASTE	Ctrl-V	Fill selected cells with data in the Notepad.
	DELETE		Erase selected cells.
	ERASE		Erase all data.
	UNDO	Ctrl-U	Cancel cell edit.
	CUT	Ctrl-X	Delete selected cells after copying them to *Windows Notepad.*
	CALCULATOR	F9	Open an on-screen calculator.

OPTIONS

FREEZE TITLES		
Col. headings	Ctrl-H	Fix the row of headings.
Row stubs	Ctrl-T	Fix the column of stubs
INSERT ROWS/COLS	Ctrl-I	Increase the spreadsheet size.
DELETE ROWS/COLS	Ctrl-D	Reduce the spreadsheet size.
NUMBER FORMAT		Change the number format.

DELETING ROWS AND COLUMNS:

The number of rows and columns to delete can be selected by dragging the mouse. The deletion point is at the cell that took the last mouse click or where mouse dragging started.

FILES:

Files that can be opened are comma delimited DIF files created by EXCEL and similar applications, ASCII files in the text and print file formats, and binary files in the LOTUS 1-2-3 WK1 format.

Files can be saved as DIF files readable by EXCEL and other spreadsheet applications,, ASCII text and in the LOTUS WK1 format. File formats are explained in greater detail in a separate chapter.

FIXED ROWS AND COLUMNS:

Fix column headings and row stubs so that they will be kept in view while scrolling the spreadsheet. Fixed cells cannot be edited. Only the first row and the first column can be fixed.

INSERTING ROWS AND COLUMNS:

The number of rows and columns to insert can be selected by dragging the mouse. The insertion point is at the cell that took the last mouse click or where mouse dragging started. The number of rows and columns inserted is limited by the maximum matrix dimensions.

THE LP SPREADSHEET . . .

MATRIX DIMENSIONS:

The maximum matrix size is 1024 rows by 1024 columns. The number of rows (columns) cannot be increased beyond 1024 even if the number of columns (rows) is reduced below 1024.

NUMBER FORMATS:

Number formats apply globally to the entire spreadsheet. The possible formats, listed from least to most precise, are:

(1) fixed number of decimals and fixed number of integer digits.
(2) scientific, where, for example, 1.21E+002 means 121.
(3) free format using up to twenty spaces to represent numbers with the maximum precision possible.

Choice of the first and second formats entails a loss of precision. The loss is permanent if the altered numbers are saved with the same file name and in the same file folder.

EDITING CELLS:

Editing cells involves changing the focus to new cells, typing new numbers and headings, and copying to and from the Clipboard.

SELECTING CELLS:

Press	End	to go to the last column.
	Ctrl-End	to go to the last cell.
	Home	to go to the first column.
	Ctrl-Home	to go to the first cell.
	>	to increase the width of the selected columns.
	<	to decrease the width of the selected columns.
	Arrow key	to select an adjacent cell.
Click	on a cell	to type a value in the edit box that will be transferred to the current cell when a different one is selected or when the ENTER key is pressed.
	On a fixed cell	to select an entire row or column, e.g. to fill it with a constant value.

TO SELECT A RANGE OF CELLS:
for copying to Clipboard, pasting from Clipboard, filling with a constant, insertion or deletion.

Drag	over cells
or	
Click	on first cell in the range
Shift-Click	on last cell in the range.

CALCULATOR

The calculator can be opened by selection from the EDIT menu;
pressing the F9 key;
clicking on the Calculator icon.

The calculator screen holds the current cell contents when it is opened.

The value on the calculator screen is copied to the Clipboard when the COPY button is clicked. Use Ctrl-V to paste the value in the Clipboard to a selected spreadsheet cell.

Calculator keys can be used by clicking on the calculator or by pressing the corresponding keys on the computer's keyboard.

Click on PASTE to transfer a value from Clipboard to Calculator.

Close the calculator by clicking its CLOSE button.

INPUT FILE FORMATS

All files can be thought of as cells arranged in rows and columns. There are small files and large files. Large files are those that have more than 255 columns and/or more than 8192 rows. Such files are discussed in a separate chapter.

The arrangement of rows and columns differs between input and output files. Input or data file formats are set and differ between LP, assignment and transport problems.

Input files are stored in ways peculiar to LP FOR WINDOWS but can also be stored in ways compatible with other micro-computer software.

These various aspects of file formats will be discussed by example using sample files.

FILES FOR INPUT TO REVISED SIMPLEX PROBLEMS

Table 1 shows the data for R.G.D. Allen's example in the way in which they appear in the LP SPREADSHEET or on an EXCEL screen.

Table 1: Data filed in LP_ALL3.WK1.

	Hogs	Corn	Person 1	Person 2	Resources
Labor ≤	50.0	25.0			50.0
Land ≤	5.0	50.0			52.5
Corn =	0.5	-1.0	1.0	2.0	
Hogs =	-1.0		1.0	0.5	
MAX Utility			1.0	1.0	

The rules for creating such a table are:

0. Rows and columns are counted from base 0.
1. Activities are in the columns starting in column 1 (B in EXCEL).
2. The RH constants in the constraints are in the last column.
3. Right-hand constants must be non-negative.

4. Constraints are in rows, starting with row 1.
5. Constraints are ordered:
   First all ≤ constraints;
   Then all equality constraints;
   Finally all ≥ constraints.
6. Only non-zero coefficients and headings need to be filed.
7. Objective function coefficients go into the last row.
8. The last cell is always empty.
9. Column headings are required and must be in row 0.
10. Row stubs are required and must be in column 0 (A in EXCEL).
11. Non-numeric values outside row 0 and column 0 are ignored.
12. Zeros need not be filed. Any cell can be blank.

FILES FOR INPUT TO ASSIGNMENT PROBLEMS

Table 2 shows the data filed in ASSIGN.WK1. The same rules apply as in the case of the Simplex problem with the following exceptions:

Table 2: Data filed in ASSIGN.WK1.

	Mowing	Weed-ing	Pruning	Water-ing	Raking	Baling	Feed-ing	Fertili-zing
Abbott	93	93	91	94	99	99	90	92
Brown	96	93	90	94	98	96	97	91
Carter	96	90	91	90	92	90	93	96
Clark	93	94	95	96	97	10	92	93
Davis	94	93	95	91	90	97	96	92
Moore	94	93	96	90	93	89	88	91
Pascoe	94	96	91	90	95	93	92	94
Smith	93	94	6	95	91	99	91	96

1. There are no right-hand constants.
2. There are no objective function coefficients.
3. No numeric cell should have a zero or negative value.

INPUT FILE FORMATS . . .

FILES FOR INPUT TO TRANSPORT PROBLEMS

Table 3 shows the data in the sample, balanced transportation problem.

Table 3: Data filed in TRNSPRTB.WK1.

	Atlanta	Chicago	Dallas	New York	Seattle	Supplies
Chicago	1		3	2	4	15
Houston	4	8	1	3	4	20
Omaha	5	1	2	3	3	25
Demands	20	12	5	15	8	

The rules are:

1. Sinks are named in the column headings.
2. Sources are named in the row stubs.
3. Supplies from each source are in the last column.
4. Demands at each sink are in the last row.
5. Transport costs from source to sink are non-negative.
6. Transport costs are filed above demands and to the left of supplies.
7. All supplies and demands are greater than zero.

FILE COMPATIBILITY

The most universally compatible file format is the *data interchange format* DIF. *.WK1 files created with the LP SPREADSHEET can be read by older versions of EXCEL, and *Quattro Pro*. Such files can also be imported by most word-processing programs.

A file created in the LP SPREADSHEET and saved as a WK1 file may have to be read into a spreadsheet program and saved again before it will be capable of being imported into a word-processor file.

INPUT OF ASCII FILES

Data files can also be created by any ASCII editor. A word-processor can also be used to record data and save them in DOS ASCII text format. Table 4 shows how such a file may appear in the text editor.

Table 4: Data filed in LP_ALL3.TXT

```
0,1,Hogs
0,2,Corn
0,3,Person 1
0,4,Person 2
0,5,Resources
1,0,Labor
2,0,Land
3,0,Corn
4,0,Hogs
5,0,Utility
1,1,50
1,2,25
1,5,50
2,1,5
2,2,50
2,5,52.5
3,1,0.5
3,2,-1
3,3,1
3,4,2
4,1,-1
4,3,1
4,4,0.5
5,3,1
5,4,1
```

The above text file is a comma-delimited file. The commas separate row, column, value.

OUTPUT FILES

Output files can be in DOS ASCII text format with and without comma delimiters. Those without commas are suitable for insertion in word processor files. Those with commas can be inserted in spreadsheets, including the LP SPREADSHEET.

Both file types, print and text, can be check-marked before clicking the GO button. LP will then file results in two files but only the text file will be displayed in the RESULTS window and available for immediate printing.

Text files without commas are best printed in a fixed, non-proportional font such as courier. In that way they retain the appearance shown on the LP results window with neatly spaced columns and aligned decimal points. LP uses a fixed font when the user clicks the PRINT button on the results window. See that window to view the output files.

Print files with commas should not have more than 8,192 lines, because that is the maximum number of rows allowed by spreadsheet software intended for importing and processing these files.

Output files have at least as many lines (rows) are there are variables and constraints. A few additional lines are used for titles and footnotes. The solution to an LP problem that has 1,000 variables subject to 1,000 constraints will take up about 32 printed pages.

Excessively large output files cannot be viewed in the RESULTS Window. Use other software to browse through and process the output files.

LARGE FILES

Large files are those too large for spreadsheet programs by having either too many rows or too many columns. There are two ways to handle large files.

1. Cut the file into sets of columns. Up to four sets can be used.

2. Translate the file to a comma-delimited ASCII format such as that shown in T. 4.

The first approach is useful when using EXCEL files saved in DIF format but it can also be used to cut large text files. Allen's data are reproduced as three files in Tables 5 and 6.

Table 5: LP data stored in three text files.

LP_ONE.TXT	LP_TWO.TXT	LP_THREE.TXT
1,0,Labor <	1,0,Labor <	1,0,Labor <
2,0,Land <	2,0,Land <	2,0,Land <
3,0,Corn =	3,0,Corn =	3,0,Corn =
4,0,Hogs =	4,0,Hogs =	4,0,Hogs =
5,0,MAX Utility	5,0,MAX Utility	5,0,MAX Utility
0,1,Hogs	0,1,Corn	0,1,Person 2
1,1,50	1,1,25	3,1,2
2,1,5	2,1,50	4,1,0.5
3,1,0.5	3,1,-1	5,1,1
4,1,-1	0,2,Person 1	0,2,Resources
	3,2,1	1,2,50
	4,2,1	2,2,52.5
	5,2,1	

The data cells in text files are indexed by their absolute position: column 1 is in file LP_ONE.TXT, columns 2 and 3 are in file LP_TWO.TXT, and columns 4 and 5 are in file LP_THREE.TXT. The three files can be read in sequence to fill a five-column matrix. Table 6 shows more clearly that all files meant to be merged into one LP data set must have identical numbers of rows and that the column of row stubs must be repeated in every file.

Table 6: LP data stored in three WK1 or EXCEL *.DIF files.

LP_ONE.WK1		LP_TWO.WK1			LP_THREE.WK1		
	Hogs		Corn	Person 1		Person 2	Re-sources
Labor <	50	Labor <	25		Labor <		50
Land <	5	Land <	50		Land <		52.5
Corn =	0.5	Corn =	-1	1	Corn =	2	
Hogs =	-1	Hogs =		1	Hogs =	0.5	
MAX		MAX		1	MAX	1	

MULTIPLE FILE INPUT

Up to four files can be read at one time. The file paths and names can be typed into the four text boxes in the INPUT FILENAME(S) frame. Alternatively, click the BROWSE button and select files from the FILES dialog box. Use Click and Shift-Click to select a range of files. Use Click and Ctrl-Click to select individual files. Click on the OK button to confirm the multiple file selection. File names are then transferred to the text boxes in INPUT FILENAME(S) frame. The filenames are inserted in alphabetical order. Their alphabetical order may be inappropriate. Any two file names can be swapped by dragging the number at the left of a text box. Drag the 2 over the 3, or drag the 3 over the 2, and the contents of text boxes 2 and 3 will be exchanged. Continue reordering file names until they are in the same order as the blocks of columns.

In most cases, the order of columns will not matter. There is only one case where the order always matters. That is the case of right-hand constants that must always appear in the last column. For example, if

one clicked on LP_ONE, LP_TWO, and LP_THREE, Windows gathers them from disk in the order of LP_ONE, LP_THREE and LP_TWO. LP then puts LP_THREE in text box 2 although LP_THREE contains the right-hand constants. Order is then restored by dragging the 2 over the 3.

FILE TRANSLATION

Files can be converted from ASCII to WK1 and from WK1 to ASCII format using the FILE TRANSLATION option in the FILE menu. Up to 4 WK1 files can be converted to a single, large ASCII file. One very large ASCII file can be converted into 9 WK1 files. Such files will all have the same 7-character name with an 8th character indicating their position in the grand file. That last character can be 1, 2, ..., 9. File output is truncated if a tenth or more files were needed.

WHICH IS THE MOST CONVENIENT FILE FORMAT?

The WK1 format is transportable to older LOTUS, EXCEL, *QuattroPro*, and word processors. However, these spreadsheet programs allow only 255 columns. Thus a large file has to be cut into 2 to four sets of columns with at most 1016 columns of numerical data. The ASCII text format is therefore more convenient for very large files, for files with more than 1016 columns.

Small files of less than 1024 rows can be dealt with in the LP SPREADSHEET and saved as WK1 if they have fewer than 255 columns. Otherwise they are saved as TXT.

RESULTS

Computed results appear in a window. The volume of results usually exceeds the size of the window. To view all results, scroll the text in the window using the keyboard or the scroll bars. Keyboard uses are:

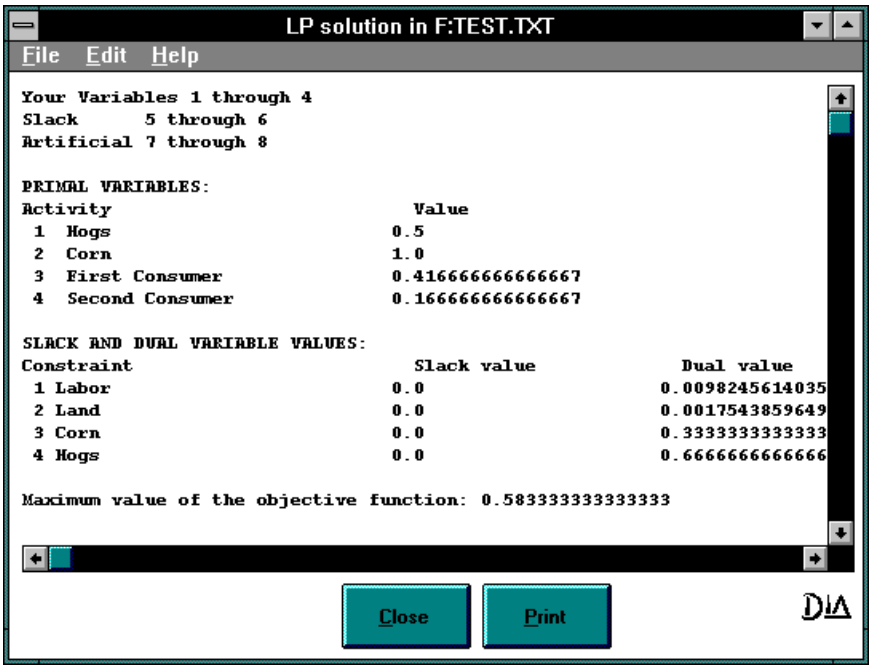
End	Show the end of the line
Ctrl-End	Show the end of the text
Home	Show the beginning of the line
Ctrl-Home	Show the beginning of the text
PageUp	Show lines above
PageDown	Show lines below

The results text cannot be edited to change words and numbers but it can be cut, copied to the Windows Clipboard, and pasted with text in the Clipboard. Text cut or copied to the Clipboard can be transferred from there to other Windows applications.

The results text can be printed. To print the text, click on the PRINT button or press the Ctrl-P keys. The printed text is that in the results file, not the edited text shown in the window.

The volume of results may exceed that which can be held in the results window. The displayed results are truncated in that case. Other software must be applied to view and process all results.

RESULTS . . .



CYCLING

Cycling is the LP analogue to ill-conditioning in matrix algebra. The LP disk includes a sample file with data for Beale's example of cycling. See Table 7. Minimize a function of four variables subject to three "less than or equal to" constraints. Find $w = 1$, $y = 1$, *Slack* 1 = 0.75, and *Min* = –1.25.

Table 7: Data for an example of cycling in CYCLE_LP.WK1.

	W	X	Y	Z	Constant
Row 1 ≤	0.25000	-8.00000	-1.00000	9.00000	
Row 2 ≤	0.50000	-12.00000	-0.50000	3.00000	
Row 3 ≤			1.00000		1.00000
Min	-0.75000	20.00000	-0.50000	6.00000	

UNBALANCED TRANSPORT PROBLEMS

The LP disk includes two sample files with data for unbalanced transport problems. The data are shown in tables 8 and 9.

Table 8: Data in TRNSPRTS.WK1 for problem with excess demand.

	Atlanta	Chicago	Dallas	New York	Seattle	Supplies
Chicago	1		3	2	4	15
Houston	4	8	1	3	4	20
Omaha	5	1	2	3	3	25
Demands	20	12	5	15	18	

Table 9: Data in TRNSPRTU.WK1 for a problem with surplus supplies.

	Store A	Store B	Store C	Store D	Supplies
Warehouse A	2	2	2	4	15
Warehouse B	3	1	1	3	25
Port	3	6	3	4	20
Demands	20	12	5	9	

The solutions to these problems identify the sink where the shortage will be felt and the source where the surplus will accumulate. Such are the results of transport cost minimizations without regard for the supply price at the source and the demand price at the sink.

ALGORITHMS

LP

Linear programming problems are solved by the Revised Simplex method of Dantzig and Orchard-Hays with Beale's correction for cycling.

G. B. Dantzig and W. Orchard-Hays, *Alternative Algorithm for the Revised Simplex Method Using Product Form for the Inverse*, **Rand Corp. Rept.**, R.M-1268, 1953.

E. M. L. Beale, *Cycling in the Dual Simplex Algorithm*, **Nav. Res. Logistics Quart.** , 2, 269-76, 1955.

ASSIGNMENT

Assignment problems are solved by Mack's Bradford method.

C. Mack, *The Bradford Method for the Assignment Problem*, **The New Journal of Statistics and Operations Research**, 1 (1969) Part I, 17-29.

TRANSPORT

Transport problems are solved by Hitchcock's stepping stones algorithm.

F. L. Hitchcock, *The Distribution of a Product from Several Sources to Numerous Localities*, **Journal of Mathematical Physics**, 20 (1941), 224-30.

ERROR TOLERANCE

The value of the error tolerance defines the concept of near zero used in the Revised Simplex algorithm.

There usually is no need to change the error tolerance except when constraints have no feasible solution, in which case a solution might still be found after increasing the value of the error tolerance.

ERROR MESSAGES

Access to file *FileName* denied

The file has the *Read Only* attribute or it is a *locked* network file. Determine the reasons for denied access before attempting to correct the problem.

Can not mix input files of *.WK1 *.DIF and *.TXT types

Cannot find file LP.HLP in *folder path*

Find the current location of the file and copy it to the LP folder, or decompress LP.HL_ on the release disk.

Choose output file type: Check-mark an output-file type.

Could not open DIACALC.EXE

Find the current location of the file and copy it to the LP folder, or decompress DIACALC.EX_ on the release CD.

Data are inconsistent with the indicated number of assignments
or with the indicated number of sinks
or with the indicated number of constraint rows
or with the indicated variable number

Ensure that the correct number appears in the corresponding text box. Click on the GO button or press ENTER again.

Enter an output-file name

Enter input-file name(s)

Fault 1 : The transportation problem may not have a solution. Abort.

File *FileName* is not a Lotus v. 1.0 or 2.2 file

Switch to LOTUS or other spreadsheet program, open the file and save it again as a WK1 file. Switch back to LP and try again.

File *FileName* does not exist.

Inadmissible negative restriction in constraint *name or number*
Edit the input file and try again.

Inadmissible, non-positive demand at sink *name or number*
or supply at source *name or number*
Edit the input file and try again.

Indicate the type and number of constraints

Matrix size error
The matrix is too large for the Spreadsheet program.
The maximum numbers of rows and columns are 1024.

The problem is too large for the available memory
Close unnecessary spreadsheets, unload unnecessary programs from *Windows*, install more memory. LP can access up to 64 mega-bytes.

The assignment data matrix is not square
Edit the input file and try again.

The name of *FileName* is invalid
Valid characters are A to Z; 0, 1, ..., 9; ! # $ ^ % ( ) - _ { }~`
Invalid name extensions are: BAT COM DLL EXE SYS

The path *folder pathname* is invalid
Valid characters are A to Z; 0, 1, ..., 9; ! # $ ^ % ( ) - _ { }~ : /

Too many constraints
The sum of the numbers of constraints, variables, and “greater than” constraints must be less than 32767.

Variable *VarName* is unbounded : Re-formulate the LP problem.

You have not chosen an input-file.

You have not chosen an output-file.

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