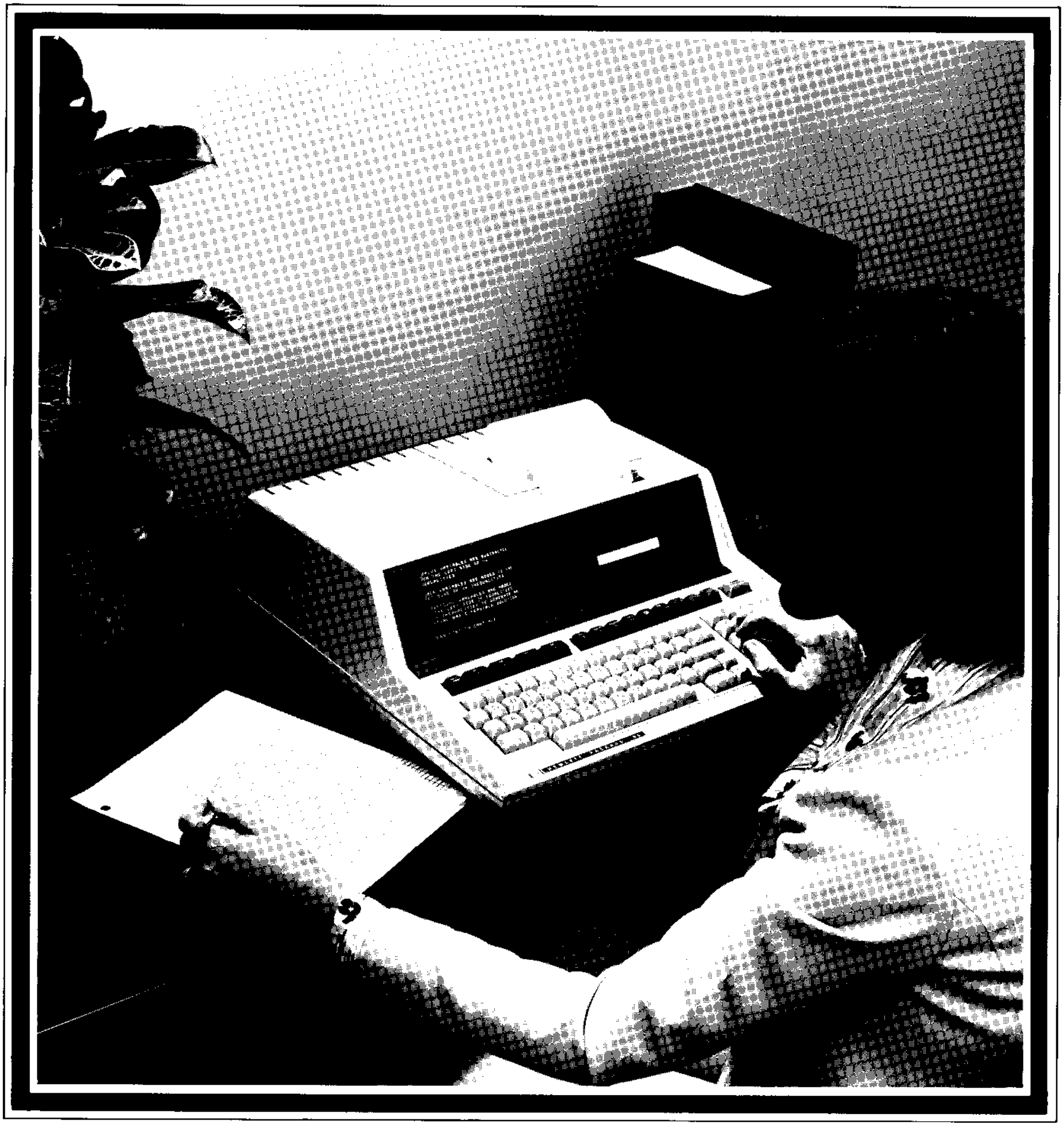
A Hewlett-Packard Software Summary
for the HP-85 Personal Computer

HP-85
Linear Programming



Optimize the allocation of your resources . . . automatically.

Fast Solutions for Linear Programming

Linear programming is used extensively in such industries as manufacturing, transportation, agriculture, and chemicals for applications in production scheduling, profit optimization, blending, assignment problems, and nutrition. It is a mathematical method for optimizing a linear function of a number of variables. The variables, representing resources, are subject to constraints, expressed as linear inequalities. Now Hewlett-Packard provides a simple and convenient means of optimizing linear programming models in the HP-85: the HP-85 Linear Programming Pac.

A General Purpose Software Package

The HP-85 Linear Programming Pac has been designed for use in many different industries. Since the format of the input and output has not been tailored or structured for any particular application, it can be used for many diverse applications requiring LP capability.

Problem Dimensions

The maximum problem size you can handle with the HP-85 Linear Programming Pac depends on how much read/write memory (random access memory or RAM) is available. Two versions of the program are recorded on the tape cartridge. The first requires 16K bytes of RAM; the second, 32K bytes. Figure 1 gives the problem size restrictions for each version.

Solving a Linear Programming Problem

The first step in solving an LP problem is to set up your input in the format used by the HP-85. The worksheet included in the instruction manual will assist you in formatting the input.

From the worksheet you enter:

- Problem name
- Maximize or minimize
- Number of constraints
- Number of variables
- Names of the constraints
- Names of the variables
- Objective function coefficients
- Upper bounds on the variables
- Lower bounds on the variables
- Variable coefficients for constraints
- Constraint values

Figure 2 shows a sample worksheet for a typical problem of trying to determine the lowest cost for a feed mix.

		16K	32K
Tableau Matrix	A (O,P)	(18,47)	(30,85)
Variables	N	1 to 40	1 to 78
Constraints	M	1 to 13	1 to 25
)=Constraints	G	0 to 13	0 to 25
	N+M+G	2 to 41	2 to 79

For each constraint (M) and each)= constraint (G), the maximum number of variables (N) is reduced by one. Some extreme examples are:

Memory	(N)	(M)	(G)	N+M+G
16K	40	1	0	41
16K	15	13	13	41
32K	78	1	0	79
32K	29	25	25	79

Figure 1. *These tables indicate the size of problems that can be handled with the different memory configurations.*

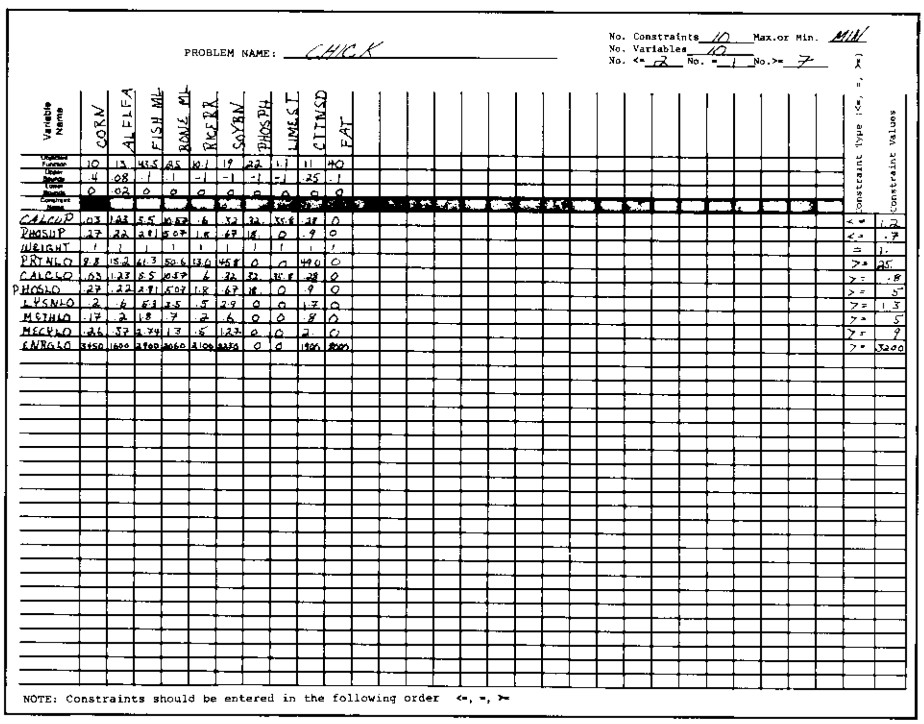


Figure 2. *An example worksheet for a typical linear programming problem of mixing feed and trying to determine the lowest cost. A sample worksheet is also provided in the instruction manual.*

Check Input on the CRT Display

The print section of the program allows you to print the data on the HP-85's printer. The printout (see Figure 3) can be used as a check on the data entered or just to provide a hardcopy record of the problem. If any errors have been made during entry of the problem, the modify routine provides a simple way to make corrections. The routine also allows the user to create essentially new problems by just adding or deleting constraints from a previously created problem.

Problem Storage

After a problem is entered, it can be stored on a tape cartridge under the problem name given at the start of the data entry.

You then have the opportunity to enter another problem, to print, modify, or solve the problem just entered, or to solve any previously entered problem.

Solutions

The solve routine performs the optimization using a modified simplex method, then prints the solution and, if desired, a sensitivity analysis. The tableau, which is used to provide a beginning solution in optimizing the problem, will show not only the variables which have been entered, but also the slack, surplus, and artificial variables. The system automatically computes these variables in order to convert the inequalities to equalities. Printing the tableau is an option that you may specify either before or after optimization. (See Figures 4 and 5.)

After the optimization, the system will automatically print out the basis and solution variables, including the dual variables, and indicate both the value of the objective function and the number of iterations required (as shown in Figure 6). If you wish to see a final tableau, the system will print one out at this point.

Finally, the LP system will provide a sensitivity analysis to determine the range for variables to stay in or out of the basis. The system also provides the critical level of the constraint values. These portions of the program are important tools for analyzing the results of LP and for looking at various alternatives. The sensitivity analysis for the sample problem is shown in Figure 7.

```
                 CHICK
VARIABLE     #   1 = CORN
VARIABLE     #   2 = ALFLFA
VARIABLE     #   3 = FISHML
VARIABLE     #   4 = BONEML
VARIABLE     #   5 = RICEBR
VARIABLE     #   6 = SOYBN
VARIABLE     #   7 = PHOSPH
VARIABLE     #   8 = LIMEST
VARIABLE     #   9 = CTTNSD
VARIABLE     #  10 = FAT

CONSTRAINT #   1 = CALCUP
CONSTRAINT #   2 = PHOSUP
CONSTRAINT #   3 = WEIGHT
CONSTRAINT #   4 = PRTNLO
CONSTRAINT #   5 = CALCLO
CONSTRAINT #   6 = PHOSLO
CONSTRAINT #   7 = LYSNLO
CONSTRAINT #   8 = METHLO
CONSTRAINT #   9 = MECYLO
CONSTRAINT #  10 = ENRGLO

CONSTRAINT CALCUP
     +.03 CORN       +1.23 ALFLFA
    +5.50 FISHML    +10.57 BONEML
     +.60 RICEBR      +.32 SOYBN
   +32.00 PHOSPH    +35.80 LIMEST
     +.28 CTTNSD <=         1.20

OBJECTIVE FUNCTION
MINIMIZE
   +10.00 CORN      +13.00 ALFLFA
   +43.50 FISHML    +25.00 BONEML
   +10.10 RICEBR    +19.00 SOYBN
   +22.00 PHOSPH     +1.10 LIMEST
   +11.00 CTTNSD    +40.00 FAT

VARIABLE LIMITS
     0.00 <=  CORN     <=      .40
      .02 <=  ALFLFA   <=      .09
     0.00 <=  FISHML   <=      .10
     0.00 <=  BONEML   <=      .10
     0.00 <=  CTTNSD   <=      .25
     0.00 <=  FAT      <=      .10
```

Figure 3. *Printout of the data for the sample feed mix problem.*

```
                 CHICK
VARIABLES            FROM   THROUGH
PROBLEM                1       10
SURPLUS               11       17
SLACK                 18       19
ARTIFICIAL            20       27
TABLEAU AFTER    0 ITERATIONS
           .03       1.23       5 50
         10.57        .60        .32
         32.00      35.80        .28
          0.00       0.00       0.00
          0.00       0.00       0.00
          0 00       0.00       1.00
          0.00       0.00       0.00
          0.00       0.00       0.00
          0.00       0.00       0.00
          1.18
```

Figure 4. *Initial tableau for the sample problem before solution. Note that surplus, slack, and artificial variables are automatically calculated and entered into the tableau.*

```
TABLEAU AFTER    22 ITERATIONS
          0.00       0.00       0.00
          0.00       0.00       0.00
          0.00       0.00       0.00
          0.00       0.00       1.00
          0.00       0.00       0.00
          0.00       0.00       1.00
          0.00       0.00       0.00
         -1.00       0.00       0.00
          0.00       0.00       0.00
            40

          -.30        .36       0.00
          -.60       0.00       0.00
         -2.30       0.00        .42
          0 00       0.00        .02
          0.00       0.00      -1.57
          1.00        .00       0.00
          -.13        .59       0.00
          -.02       0 00       0.00
          1.57      -1.00       -.00
           .11
```

Figure 5. *Final tableau for the sample problem showing the number of iterations before a solution is reached.*

```
     ANSWER TO PROBLEM CHICK

 BASIS AFTER   22 ITERATIONS

VARIABLE                  VALUE
SLACK     1                .400
SURPLUS   9                .108
SURPLUS   7                .025
SURPLUS   4               2.125
LIMEST                     .005
SOYBN                      .123
FAT                        .093
RICEBR                     .027
FISHML                     .083
SURPLUS   6                .200
CORN   AT UPR BND          .400
CTTNSD AT UPR BND          .250
ALFLFA AT LWR BND          .020

OBJ FUNC VALUE =         16.922

        DUAL VARIABLES

COLUMN     CONSTRAINT     VALUE
  11         PRTNLO       0.000
  12         CALCLO        .136
  13         PHOSLO       0.000
  14         LYSNLO       0.000
  15         METHLO      18.192
  16         MECYLO       0.000
  17         ENRGLO        .005
  18         CALCUP       0.000
  19         PHOSUP        .744
  20         WEIGHT       3.771
```

Figure 6. *Printout of the basis and solution variables, including dual variables, the value of the objective function, and the number of iterations required for optimization.*

```
        SENSITIVITY ANALYSIS

   CONSTRAINT RHS VALUE RANGING

  CON     LOWER      RHS     UPPER
          LIMIT     VALUE    LIMIT
CALCUP      .80      1.20    UNBND
PHOSUP      .65       .70       73
WEIGHT      .98      1.00    UNBND
PRTNLO    UNBND     25.00    27 13
CALCLO      .60       .80     1.20
PHOSLO    UNBND       .50      .70
LYSNLO    UNBND      1.30     1.33
METHLO      .49       .50      .53
MECYLO    UNBND       .90     1.01
ENRGLO    UNBND   3200.00  3245.84

      OBJ FUNC COEFF RANGING
         BASIS VARIABLES

  VAR     LOWER    OBJ FNC   UPPER
          LIMIT     VALUE    LIMIT
LIMEST    UNBND      1.10    54.05
SOYBN     17.89     19.00    21.52
FAT       27.42     40.00   159.14
RICEBR    UNBND     10.10    11.45
FISHML    36.37     43.50    48.08

      OBJ FUNC COEFF RANGING
       NON-BASIS VARIABLES

  VAR     LOWER    OBJ FNC   UPPER
          LIMIT     VALUE    LIMIT
CORN       2.00     10.00    UNBND
ALFLFA     8.63     13.00    UNBND
BONEML    17.57     25.00    UNBND
PHOSPH    UNBND     22.00    UNBND
CTTNSD     1.45     11.00    UNBND
```

Figure 7. *This sensitivity analysis allows you to evaluate the effects of various constraints on the basis and indicates the range of variables to stay in or out of that basis.*

Ordering Information

The complete HP-85 Linear Programming Pac is contained in a convenient molded binder and includes:

- A prerecorded cartridge containing the LP programs.
- An instruction manual that describes the programs and gives detailed instructions and examples.

To order the Linear Programming Pac, specify Part No. 00085-13011. For further information on the HP-85 Personal Computer or the Linear Programming Pac, contact your nearest Hewlett-Packard Sales Office or authorized HP-85 dealer. To locate the sales office or dealer nearest you, please call 800/648-4711, ext 1000 (Alaska and Hawaii excluded). In Nevada call 800/992-5710.

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