EQ SOLVER

HP-71 Equation Solver System

Owner's Manual

Version 1

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1. INTRODUCTION

The HP-71 Equation Solver System introduces a new interactive calculating environment for the handheld computer. The system enables the user to manipulate families of equations and variables in a "what-if" or "let's try this and see what we get" context. The power of the solver system lies in the fact that the relationship between variables in an equation need be expressed only once, so the user does not have to create a separate equation for each variable in a system. Since all variables are global, a variable can be solved for in one equation, and it's newest value can be used in another equation, automatically.

1.1 Methodology

An equation is entered into the HP-71 as a BASIC language expression, from which a program is created. When this program is executed, each variable in the equation appears in the display, centered above an alpha key on the keyboard. A number is stored to a variable by typing the number and pressing the key corresponding to the variable name in the display. By entering the contents of known elements, an equation can be "solved" to provide the value for an unknown quantity. A variable can be "solved" by pressing its corresponding key without a pending numeric entry.

1.2 History

The most well-known "what-if" software products have been spreadsheets, like the original VisiCalc (a product of Visi-Corp), or Lotus, Inc.'s popular product 1-2-3. Spreadsheets are adept at adding up rows and columns of numbers; one can change the contents of a cell and view its impact on a final result. Spreadsheet systems (as a rule) cannot calculate the contents of an input cell based on a varying final result and thus are not terribly friendly when it comes to manipulating sets of equations.

The Equation Solver System extends concepts found in three existing HP calculators to the HP-71. Two of the current calculator products allow the user to solve for any variable in an equation given the contents of the others; the HP 12C is restricted to the built-in financial functions, while the newer HP 18C, and HP 28C can work with user supplied equations. This program for the HP 71 was the original inspiration for the menu system and "SOLVE" functionality on the HP 18C and HP 28C.

1.3 How To Use This Manual

This manual assumes you are familiar with the basic operations of the HP-71, including keyboard, file, and mass storage operations. To become familiar with the Equation Solver System, read the section "Getting Started", and work through the example provided. Once you are familiar with the example equation, the subsequent sections will explain in more detail each of the features in the system.

Throughout this manual, there are three types of key notation. A key denoted as [P] refers to the physical P key. A key denoted as {P} refers to the physical key immediately below a letter **P** in the display. A key denoted as [EDIT] refers to the shifted typing aid obtained by pressing *f* Z.

When letters in the variable menu have a black background they are represented by **bold** characters in this manual.

2. GETTING STARTED

The HP-71 Equation Solver System has been optimized for a portable environment. The *HP 82480A Math Pac* is the only accessory required to run the system, and must be plugged into one of the four ports in the front of the HP-71.

A card reader or HP-IL module and mass storage device are required only to load the programs into memory. Once loaded, these devices are not required, and may be disconnected.

The following files are used in the equation system:

EQUATION SOLVER FILES		
File	**Type**	**Description**
EQ	BASIC	Main program for the equation system.
EQLEX	LEX	Language Extension (LEX) file.
TPKEYS	KEY	Key definitions.
TPFILE	DATA	(Created) Data storage file.

Note: The file *TPFILE* may be created through the use of the system - it is *not* provided in the original product.

Load the files *EQ*, *EQLEX*, and *TPKEYS* into the HP-71.

2.1 Example Problem

To become familiar with the equation solver system, consider the equation of state for an ideal gas,

$$pV=\mu RT$$

where:

- p is the pressure in atmospheres,
- V is the volume in liters,
- μ is the mass of the gas in moles,
- R is the universal gas constant for low densities, 8.314 joule/mole ^{0}K, and
- T is the temperature.

Suppose a cylinder of an "ideal" gas is at a temperature of 290 ^{0}K at a pressure of 15 atm in a volume of 250 liters. Use the equation solver system to calculate the value for μ. Then calculate the final pressure after a piston is lowered into the cylinder, given the new temperature and volume.

2.2 Working The Example

The BASIC program *EQ* is the starting point for all new equations:

Display	Input	Comments
>_	RUN EQ	This is where you enter a new equation.
EQUATION NAME?_	GAS1	Call the equation GAS1.
Enter Equation GAS1}_	P*V=U*8.314*T	Enter the equation. For this example, U will represent μ.
Working..P,V,U,T,		The variables are identified.
VARS?P,V,U,T	[ENDLINE]	Ignore this step - just press the [ENDLINE] key to proceed.
Working...on GAS1		The program GAS1 is constructed from the equation.
P V U T_		The variable menu appears.

Remember: Letters in the variable menu have a black background and are represented by **bold** characters in this manual. A letter in braces, like {P} refers to the physical key below the enclosed letter found in the display. In this example, the letter **P** in the display is above the [E] key, so you would push [E] to enter the value for the variable **P**.

To enter 15 atm for the pressure, enter 15, then press the key immediately below the **P** in the display:

Display	Input	Comments
P V U T_	15 {P}	Enter the pressure.
P=15		The value 15 is stored in P. This message will remain in the display for a moment, then the variable menu will be displayed again.
P V U T_	100 {V}	Enter the volume.
V=100		The value 100 is stored in V.
P V U T_	290 {T}	Enter the temperature.

T=290	The value 290 is stored in T.

Now the known quantities have been entered into P, V, and T. To compute the unknown value for μ, simply press {U}:

Display	Input	Comments
P V U T_	{U}	Solve for μ.
U=		A pause for computation...
U=.622133003741		Et voila! The answer!

The answer will remain in the display until a key is pressed. Press [ENDLINE] to return to the variable menu:

P V U T_

Now the value for μ is known, so the rest of the problem can be worked out. The new values for T and V will be 295 and 80 respectively. Compute the new value for P:

Display	Input	Comments
P V U T_	295 {T}	Enter the new temperature.
T=295		The value 295 is stored in T.
P V U T	80 {V}	Enter the new volume.
V=80		The value 80 is stored in V.
P V U T_	{P}	Calculate the new pressure.
P=19.073275862	[ENDLINE]	Press [ENDLINE] to return to the variable menu.
P V U T_	[ON]	After a key is pressed, the program returns to the variable menu. The program is ended by pressing [ON].
>_		

3. ENTERING EQUATIONS

The program *EQ* is used to enter a new equation into the Equation Solver System. Once the equation has been entered, a separate program is created with the name you provide.

Equations are entered one at a time. A group of equations may be related through a "family name" and a number from 1 to 9, such as GAS1, GAS2, GAS3, etc.

An equation is entered in a manner similar to a BASIC expression, and all variables and functions (including those added by plug-in ROMs) are available for use.

Run the BASIC program *EQ* to enter an equation:

Display	Input	Comments
>_	RUN EQ	This is where you enter a new equation.
EQUATION NAME?_	*name*	Enter the equation name, up to eight characters.
Enter Equation *name*}_	*equation*	Enter the equation. All BASIC functions are available, including any from plug-in ROM's. The equation may use up to 20 variables with names from A to Z9.
Working..*variables*		EQ identifies the variables.
VARS?*variables*	*variables*	This step lets you change the order of the variables as they will appear in the display. By editing the default answer, you change the order of the variables or remove a variable from the list altogether. *You may* **NOT** *rename a variable!*
Working...on *equation*		A new BASIC program is constructed from the equation you entered.

The new program has the name that you entered for the equation name. When the program *EQ* ends, it runs the new program automatically, and you are ready to enter data into the variables.

4. RUNNING THE EQUATION

When the equation's variables are displayed in a *variable menu*. If the equation contains more than five variables, the menu is divided in up to four *windows* of five variables each. The 1, 2, 3, and 4 flag annunciators in the HP-71 display indicate which window is currently being displayed.

A variable name is normally displayed as a white letter on a black background. If the name is displayed as a black letter on a white background, the contents of the variable do not represent a real number. The variable name can be restored to normal by storing a real number into the variable. For more information about number types, see Section 2 of the *HP-71 Owner's Manual*.

When the variable menu is in the display, the following options are available:

- Store a value or the result of an expression into a variable.
- Solve for an unknown variable given the contents of the remaining variables.
- View the current contents of a variable.
- Recall the current contents of a variable for editing.
- Switch between variable windows if there are more than five variables.
- Store and recall values in "permanent" storage registers.
- Edit the equation.
- Switch between equations within a family.
- Straddle a root (specify a range to search for a solution).

The following sections describe each of these options. The equation GAS1 from the *Getting Started* chapter will be used to illustrate the use of some options.

4.1 Storing To A Variable

A new value is stored into a variable by entering a valid mathematical expression and pressing the key associated with that variable.

All HP-71 operators, keywords, and functions are available for use in an expression, including any added to the BASIC language through a LEX file or a plug-in ROM, such as the Math ROM. Variables may also be used in an expression. If the variable is on the top row of the keyboard, such as E, it may be entered by preceding the variable with the blue $\boxed{g}$ shift key.

Example: Enter 2*SIN(E) to variable M.

Display	Input	Comments
E M C T _	2*SIN(e) {M}	The blue shift key causes the variable to be entered in lowercase.

4.2 Solve For An Unknown Variable

Pressing a variable key with no pending expression causes the equation system to try to solve for the correct value based on the contents of the remaining variables.

Example: Solve for V in the "Getting Started" example.

Display	Input	Comments
P V U T_	{V}	Press {V} with no pending expression.
V=135.25	[ENDLINE]	Press [ENDLINE] to return to the variable menu.

4.3 Viewing The Contents Of A Variable

The contents of a variable may be viewed at any time by pressing the gold [f] shift key, then the variable. The contents of the variable will be displayed as long as the key is held down, then the display returns to its former state.

Example: View the contents of variable U from the example.

Display	Input	Comments
P V U T_	*f* {U}	View the contents of variable U.
U=.62213303741	*Hold the key down*	The value is displayed as long as the key is held down.
P V U T_		The variable menu returns.

4.4 Changing Variable Windows

If an equation contains more than five variables, the variables are presented in up to four *windows* of five variables each. To switch between windows, press the Q key. The 1, 2, 3, and 4 annunciators in the HP-71 display indicate which window is in the display. If an equation has less than six variables, no annunciators will be turned on.

When Q is pressed, the next window in numeric order is pressed. Pressing Q while in window 4 wraps you back around to window 1.

Example: An equation has seven variables, from A to G.

Display	Input	Comments
A B C D E_	Q	View the other window.

F G_	Q	Return to the first window.
A B C D E_		The first window returns.

4.5 Using Storage Registers

There are ten storage registers available for temporary or long term storage. The registers are numbered 0-9, and are accessed through the [INPUT] (*f* G) and [FETCH] (*f* B) keystrokes.

Values in the storage registers are actually stored in the data file *TPFILE*, which is created if it does not already exist. Like any other data file, *TPFILE* may be copied to a mass storage device for long term storage.

4.5.1 Storing To A Register

To store a value to a register, enter (or recall) a value or expression, press [INPUT], then 0 - 9 to select the register.

Display	Input	Comments
P V U T_	25*V	Enter an expression.
P V U T 25*V_	[INPUT] 2	Store the result in register 2.
P V U T 2500		The result is still available to be modified or stored in a variable.

4.5.2 Recalling From A Register

A value may be recalled from a register by pressing f-[B] (FETCH) and specifying the desired register.

Display	Input	Comments
P V U T_	[FETCH] 2	Recall the value from register 2.
P V U T 2500		The value is available for use.

4.6 Editing The Equation

The current equation may be modified by pressing [EDIT] (*f* Z). When an equation is recalled, the form may be different from the original entry. The equation entered in the form:

Left = *Right*

will be altered to appear as:

Left - (*Right*)

This is done to facilitate the use of the rootfinding technique of the equation solver.

When an equation is recalled for editing, all the same procedures are used as for the original entry, allowing you to re-order or delete variables.

Display	Input	Comments
P V U T_	[EDIT]	Press f-Z to edit the equation.
GAS1}P*V-(U*8.314*T)		The equation may be edited. When the changes have been made, press [ENDLINE] to store the new equation.

4.7 Switching Equations

A *family* of equation may be related through the use of a common first name followed by a digit from 1 to 9. In the getting started example, the equation named GAS1 might be related to an equation for the volume of a cylinder (V) in an equation V=L*3.14*R^2 named GAS2. The volume of the cylinder can be calculated with the equation GAS2, and the answer for V is available to GAS1.

The [↑] and [↓] keys are available for switching between equations. Pressing [↓] causes the next highest numbered equation to appear, while [↑] causes the next lowest numbered equation to appear. When searching for the next equation, the arrow keys "wrap around" between 1 and 9 until another equation is found or the original equation is re-displayed.

Display	Input	Comments
P V U T_	↓	Press ↓ to get from GAS1 to GAS2.
V L R_	↑	Press ↑ to return to GAS1.
P V U T_		

Up to nine equations can be related through a single family name.

4.8 Specifying a range to search for a solution

Sometimes, when more than one solution is possible, it will become necessary to specify a range that the desired root or solution is to be found. The program usually searches around the current value of a variable in order to find a correct root that satisfies the current equation. If a value is entered followed by a question mark "?", and a solver variable is pressed, the value currently assign to the variable and the value followed by a "?" will be used as the range specifiers. The program will concentrate its search for the solution in this range first. If it can't find an answer, it will look outside of the range.

5. THE TIME VALUE OF MONEY (Financial calculations)

As a bonus, I've provided the TVM equation as an example EQSOLVER application. This seems to be the equation I need to use most often. The finance keys found on the HP12C are what inspired me to develop the interface for any equation. The interface is (in my opinion) the easiest, most effective way of dealing with any equation.

The program "FIN" allows you to input or calculate:

- N -the NUMBER of periods or payments of a loan
- I -the INTEREST (per period) of a loan
- V -the present VALUE of a loan
- P -the PAYMENTS of a loan
- F -the FUTURE value of a loan

You can calculate any one of these variables if all of the others are input. In addition, the timing of the payments can be specified as being either at the END of the compounding period (END MODE) or at the beginning of the compounding period, BEGIN MODE. The default is END MODE.

5.1 Getting Started with FIN

First, copy the file *FIN* into your HP71. Run the file by typing RUN FIN [ENDLINE]. The display should show the variables N, I, V, P and F.

N I V P F_	The financial menu appears.

5.2 Changing to BEGIN MODE

To change the MODE, we need to change the status of flag 15 of the HP71. This can be done before we run the program by typing SFLAG 15 [ENDLINE], to be in BEGIN MODE, or CFLAG 15 [ENDLINE] to be in END MODE. To change the status of the flag while in the equation, type FLAG(15,0) [ENDLINE] for END MODE, or type FLAG(15,1) [ENDLINE] for BEGIN MODE.

5.3 Some financial examples

5.3.1 Financial Example #1

A borrower can afford $600.00 monthly payments. If he gets a 30 year loan at 12% interest, how much can he borrow? For now, assume payments are due at the end of the month (END MODE).

Run the *FIN* program.

Display	Input	Comments
>_	RUN FIN	This assumes FIN is in your HP71.
N I V P F_		The variable menu appears.
N I V P F_	-600 {P}	Money going out is negative.
P=-600.00		A temporary message verifies the input.
N I V P F_	12/12 {I}	The annual rate is divided by the number of payments per year.
N I V P F_	30*12 {N}	Total number of payments (the number of payments per year multiplied by the number of years of the loan).
N I V P F_	0 {F}	After 30 years, the future value is 0.
N I V P F_	{V}	Now we can calculate the present VALUE of the loan.
V=58914.31		This is the present Value of the loan.

5.3.2 Financial Example #2

How much money needs to be set aside in a savings account each quarter in order to accumulate $5000.00 in 3 years? Assume the account earns 9.5% interest, compounded quarterly, and that deposits begin now.

Run the *FIN* program, if it's not already running.

Display	Input	Comments
>_	RUN FIN	This assumes FIN is in your HP71.
N I V P F_		The variable menu appears.
N I V P F_	FLAG(15,1) [ENDLINE]	Get in "BEGIN" mode.

Press [ENDLINE], then [ON] to get the normal variable display back.

Display	Input	Comments
N I V P F_	5000 {F}	Our FUTURE value goal
F=5000.00		A temporary message verifies it.
N I V P F_	9.5/4 {I}	The annual rate is divided by the number of deposits per year.
N I V P F_	4*3 {	Total number of deposits (the number of deposits per year multiplied by the number of years of the loan).
N I V P F_	0 {V}	We start with nothing.
N I V P F_	{P}	Now we can calculate the amount of the deposit, or PAYMENTS.
P=-356.64		This is the quarterly deposit.

Remember; payments that leave you will have a negative sign. The way I remember it, is to think of money coming to me as a POSITIVE experience, and money that I pay is a NEGATIVE experience. Good luck.

If you have a problem running this program, I'm willing to help as long as the problem concerns getting the program to do what the manual says it can do. If you think you found a bug, please write and tell me. I'm a very reasonable guy, and if I think it's a bug I'll attempt to fix it. Im very proud of my programs.

If a bug should happen to be found (heaven forbid), and I can manage a fix, I will attempt to send copies of the fix to ALL PARTIES that have requested to be updated. If you would like to be on the list or have a major problem, please send this page or a copy of it to me with the blanks filled in as best you can.

NAME OF OWNER ____________________

ADDRESS: ____________________

CITY/STATE ____________________

PHONE: ____________________

PLACE OF PURCHASE: ________________

DATE OF PURCHASE: ________________

TYPE OF MEDIA: tape? disk? cards?

I have not and will not give a copy of this program to anyone, because I want Chris Bunsen to profit from writing inexpensive, high-quality software. I understand that this program is copywrited.

signed ________________________

date ____________________

My mailing addess is:

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