2730 High Ridge Road
Stamford, Conn. 06903
February 2, 1982

Hewlett Packard Users Library
1000 N.E. Circle Boulevard
Corvallis, Oregon 97330

Dear Sirs:

I am submitting this program as a revision to the one with the same name found in the Real Estate applications booklet. The present program is essentially the same, but it has a number of modifications which I believe, are useful improvements.

1. The CLRG function has been eliminated.

2. The prompt for INV. comes first, which is in its natural order.

3. Input is echoed on the printer, and the result is printed. However, use of the printer is optional.

4. Label A is used to initialize the program. Label B is used to backup a step in cashflow entry. This last feature is useful for correction of mistakes and to allow one the easy option of comparing selling "now" or at a later date.

5. The output has the % sign appended, and the user is notified with a "beep".

Whoever wrote the original program did a fine job with the iterative solution. He had good control of the stack. I did not attempt to improve on it.

Sincerely yours

Gary Goodman

Gary Goodman

01630 C

DEAR AUTHOR:

Your program has been accepted into the Users' Library; but our engineer has suggested that I forward these comments to you for your future reference.

Sandy Canning
Users' Library

Size should be 5 + #CF because the last prompt stores whatever is in the X register when R/S with no data input is executed. (These changes have been made in your program documentation).

User mode can be set programmatically via flag 27.

# PROGRAM SUBMITTAL

☐ New Program ☒ Revision to Program 0 1 6 3 0 C

Model No. ☐ 67 ☐ 97 ☒ 41C

Program Title I N T E R N A L R A T E O F R E T U R N

No. of Steps/Lines 7 4 Category No. 0 0 4 and 0 0 3

Category Name REAL ESTATE and GENERAL INVESMENT ANALYSIS

Abstract — 50 Word Maximum This program calculates the Internal Rate of Return (Discount Rate of Return or Yield) for up to 40 cash flows on the basic HP-41C. Each additional memory module adds 64 more cash flows.

This program is an improved version of 00194C both in printed output and in the ability to back up and change previous entries.

Necessary Accessories: none, printer optional

Name Gary Goodman

Company Wellington Systems, Inc.

Address 2730 High Ridge Road

City Stamford State/Country Connecticut Zip Code 06903

Phone Number ( 203 ) 322-5277

If my program is accepted, my bonus choice is: ( Please select two programs if your program is a revision. )

Acceptance Choice: ☐ FOUR PROGRAMS, ☐ CREDIT FOR FOUR PROGRAMS*, OR TWO PROGRAMS AND 10 BLANK CARDS.

☐☐☐☐☐ ☐☐☐☐☐ ☐☐☐☐☐ ☐☐☐☐☐

* No partial credit will be given. Select all four programs at the same time.

Submittal Checklist: Please use the checklist below to insure submittal of all proper program documentation.

☒ Program Submittal ☐ Program Description II ☐ Program Listing(s) ☐ Registers, Status ...

☐ Program Description I ☐ User Instructions ☐ Magnetic Card(s) ☐ Keyboard, Card Labeling (optional)

ACKNOWLEDGMENT AND AGREEMENT

To the best of my knowledge, I have the right to contribute this program material without breaching any obligation concerning nondisclosure of proprietary or confidential information of other persons or organizations. I am contributing this program material on a nonconfidential nonobligatory basis to Hewlett-Packard Company ("HP") for inclusion in its program library, and I agree that HP may use, duplicate, modify, publish, and sell the program material, and authorize others to do so without obligation or liability of any kind. HP may publish my name and address, as the contributor, to facilitate user inquiries pertaining to this program material.

Signature Gary Goodman Date 7/26/82

PROGRAM DESCRIPTIONS I AND II

# INTERNAL RATE OF RETURN

The interest rate that equates the present value of all future cash flows with the original investment is known as the internal rate of return (IRR, also called discounted rate of return or yield). Given a non-zero initial investment and up to 41 cash flows with no Memory Module (64 more for each additional Memory Module), this program calculates the periodic IRR.

The answer produced is the periodic rate of return. If the cash flow periods are other than annual (monthly, quarterly) the answer should be multiplied by the number of periods per year to determine the annual internal rate of return.

The program solves the following equation iteratively for IRR:

$$INV = \sum_{j=1}^{n} \frac{CF_j}{(1+IRR)^j}$$

where $n$ = the number of cash flows and

$CF_j$ = the jth cash flow.

Note: When the sign of the cash flows is reversed more than once, more than one interest rate is considered correct in the mathematical sense. While this program may find one of the answers, it has no way of finding or indicating other possibilities. Problems which involve a large number of cash flows will have long execution times.

Example: Income property requiring a $250,000 equity investment is to be sold in ten years and is expected to generate the "after tax" cash flows shown below. What is the expected yield or IRR?

| End of Year | Cash Flow | End of Year | Cash Flow |
|---|---|---|---|
| 1 | $46,423 | 6 | $ 23,199 |
| 2 | 40,710 | 7 | 21,612 |
| 3 | 36,638 | 8 | 20,037 |
| 4 | 34,097 | 9 | 18,460 |
| 5 | 32,485 | 10 | 311,406 (property sold) |

| Keystrokes: | Display: |
|---|---|
| [USER] | (set USER mode) |
| [XEQ] [ALPHA] SIZE [ALPHA] 014 | |
| [XEQ] [ALPHA] IRR [ALPHA] | INV. ? |
| 250000 [R/S] | CF,1 ? |
| 46423 [R/S] | CF,2 ? |
| 40710 [R/S] | CF,3 ? |
| . . . | |
| 311406 [R/S] | CF,10 ? |
| [R/S] | CF,11 ? |
| | IRR = 13.98% |

# USER INSTRUCTIONS



| | | | | SIZE: (HP-41C) 5 +#CF's |
|---|---|---|---|---|
| STEP | INSTRUCTIONS | INPUT | FUNCTION | DISPLAY |
| 1 | Load the program and set USER mode | | [USER] | |
| 2 | Initialize the program | | [XEQ] "IRR or [A] | INV. ? |
| 3 | Input the initial investment. | INV | [R/S] | CF,1 ? |
| 4 | Input the cash flows for each consecutive period. Enter zero for periods of no cash flow, positive values for cash received, and negative values for cash paid out. | $CF_j$ | [R/S] | $CF,_{j+1}$ ? |
| 5 | The last cash flow should be the cash flow from disposal of the investment. | $CF_{last}$ | [R/S] | $CF_{last+1}$ ? |
| 6 | Compute Internal Rate of Return | | [R/S] | IRR = xx.xx% |
| 7 | You can back up and delete preceeding cash flow entries by repeatedly executing this step. Then continue with step 4. This is particularly useful when one wants to compare the IRR for a number of possible disposal periods. | | [B] | $CF,_{j-1}$ ? |

# PROGRAM LISTING



☒ 41C

| STEP/ LINE | KEY ENTRY | KEY CODE (67/97 only) | COMMENTS |
|---|---|---|---|
| | 01◆LBL "IRR | | |
| | 02◆LBL A | | Initialize |
| | 03 CF 29 | | |
| | 04 1 | | |
| | 05 STO 00 | | |
| | 06◆LBL B | | Backstep cashflow # |
| | 07 FIX 0 | | |
| | 08 DSE 00 | | |
| | 09◆LBL 01 | | |
| | 10 "CF," | | |
| | 11 RCL 00 | | |
| | 12 ARCL X | | |
| | 13 X=0? | | |
| | 14 "INV." | | |
| | 15 "⊢ ? " | | |
| | 16 3 | | |
| | 17 + | | |
| | 18 STO 01 | | temporary, j+3 |
| | 19 PROMPT | | Prompt and store |
| | 20 STO IND | | cash flows |
| 01 | | | |
| | 21 1 | | Initial value for 1+IRR |
| | 22 STO Z | | |
| | 23 FC?C 22 | | If no more input, |
| | 24 GTO 02 | | compute IRR |
| | 25 ARCL Y | | |
| | 26 FS? 55 | | Echo input |
| | 27 PRA | | on printer |
| | 28 ST+ 00 | | increment j |
| | 29 GTO 01 | | |
| | 30◆LBL 02 | | Compute IRR |
| | 31 FIX 2 | | |
| | 32 RCL 00 | | |
| | 33 STO 01 | | |
| | 34 DSE 01 | | |
| | 35 R↑ | | |
| | 36 0 | | |
| | 37 STO 02 | | Initialize f(i) |
| | 38◆LBL 03 | | Loop to compute f(i) |
| | 39 3 | | |
| | 40 RCL 01 | | j goes from n to 1 |
| | 41 + | | |
| | 42 X<> L | | |
| | 43 RCL IND | | $CF_j$ |
| L | | | |
| | 44 ST+ 02 | | |
| | 45 * | | $j*CF_j$ |
| | 46 + | | |
| | 47 X<>Y | | (1+i) |
| | 48 ST/ 02 | | |
| | 49 / | | |
| | 50 DSE 01 | | |
| | 51 GTO 03 | | |
| | 52 RCL 02 | | f(i) |
| | 53 RCL 03 | | INV |
| | 54 − | | |
| | 55 X<>Y | | -(1+i)f'(i) |
| | 56 / | | |
| | 57 * | | Δi = [INV-f(i)]/f'(i) |
| | 58 + | | |
| | 59 LASTX | | Δi |
| | 60 ABS | | |
| | 61 1 E-6 | | |
| | 62 X<=Y? | | |
| | 63 GTO 02 | | |
| | 64 RCL Z | | 1 + IRR |
| | 65 1 E2 | | |
| | 66 ST* Y | | |
| | 67 − | | 100*IRR |
| | 68 "IRR = " | | |
| | 69 ARCL X | | |
| | 70 "⊢%" | | |
| | 71 AVIEW | | |
| | 72 ADV | | |
| | 73 BEEP | | |
| | 74 .END. | | |

$$f(i) = \sum_{j=1}^{n} \frac{CF_j}{(1+i)^j} j \text{ , where i is an approximation to IRR.}$$

**Note:** Refer to "HP-41C OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for specific information on keystrokes. The Function Index is found at the very back of the Handbook.

# REGISTERS, STATUS, FLAGS, ASSIGNMENTS

## DATA REGISTERS

| | |
|---|---|
| 00 | number of CF's |
| 01 | used |
| 02 | f(i) |
| 03 | INV |
| 04 | $CF_1$ |
| 05 | $CF_2$ |
| | . |
| | . |

## STATUS

SIZE 5+#CF's TOT. REG. 19+size USER MODE

ENG FIX SCI ON X OFF

DEG RAD GRAD

## FLAGS

| # | INIT S/C | SET INDICATES | CLEAR INDICATES |
|---|---|---|---|
| 22 | | next CF entered | no more CF's |
| 29 | | | suppress dec. pt. |
| 55 | | printer connected | no printer |

## ASSIGNMENTS

| FUNCTION | KEY | FUNCTION | KEY |
|---|---|---|---|