

PROGRAM SUBMITTAL

New Program

Revision to Program

Model No.

67

97

41

Program Title

Financial Calculations

No. Lines 176 Bytes 279 Category No. D200
(Primary)

Primary Category Name General Investment Analysis

Abstract-75 Word Maximum This program calculates any of the five standard compound interest variables: number of periods, periodic interest, present value, payment amount and future value. Payments are made at the end of each compounding period. This program is an improved version of the one found in the HP-41C Standard Applications Handbook but has a number of enhancements. Input as well as output values are labeled and optionally printed. Also the keyboard labels can be displayed at any time.

Necessary Accessories: None; Printer optional.

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Company (If Applicable)

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City Fredericksburg

State/Province Virginia

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Country U.S.A.

Hewlett Packard Dealer Educalc

Acceptance Choice: FOUR \$6.00 PROGRAMS ONE POINT CERTIFICATE

Please use the checklist below to insure submittal of all proper program documents

SIGNED PROGRAM
SUBMITTAL PAGE

Program Description II

Program Listing(s)

Registers, Status...

Program Description I

User Instructions

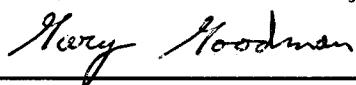
MASS STORAGE
MEDIA mag. cards

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



Date 3/24/85

HP USE ONLY	No. Pages:	Mag Cards Cassette:	Price:
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Program Title: Financial Calculations

Contributor's Name: Gary Goodman

Address: Box 259N Route 4

City: Fredericksburg

State: Virginia

Zip Code: 22405

Program Description:

FINANCE calculates any of the five standard compound interest variables:

N = Number of periods.

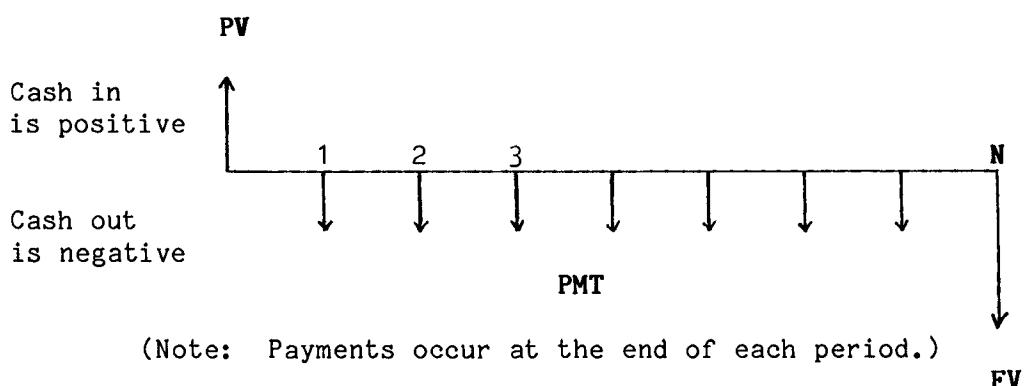
I = Periodic interest.

PV = Present Value: the amount loaned, borrowed, invested, etc.

PMT = Payment amount: the periodic amount paid on a loan or earned on an investment.

FV = Future Value: the amount remaining, accumulated, saved, etc.

The diagram below describes the cash flow in these type of problems.



The diagram shows a standard loan amortization cash flow from the borrower's point of view. From the lender's point of view, all the signs would be reversed. Note that in all real situations, the signs of PV and FV are always opposite. (Cases in which PV and FV have the same sign represent situations in which the account balance changes sign, i.e., money is borrowed and lent at the same rate.)

Necessary Accessories: Printer Optional

Operating Limits and Warnings: $I \neq 0$. Also see discussion on solving for I .

Reference: Financial Calculations in HP-41C Standard Applications Handbook, March 1980, Hewlett-Packard Company.

The initial program display shows the labels **N**, **I**, **PV**, **PMT**, **FV** for the five top-row keys, [A] through [E], which are used to enter or calculate these financial parameters. All variables are initially set to zero. If you enter a number and press one of these keys, you set the value of that variable. Pressing a key without entering a number calculates the corresponding value based on the values of the other four.

The displayed value is also in the X-register. Any of the other values may be recalled by pressing [RCL] followed by the appropriate key. Following any entry or calculation, the keyboard labels may be redisplayed by simply pressing [R/S]. (This also clears flag 22, so a variable may be calculated following any side calculations.) The key sequence [SHIFT] [A] clears all the variables and redispays the keyboard labels.

Printer: The printer should be set to Manual mode. All input and calculated values will be labeled and printed. A blank line will follow a calculated result so as to separate it from subsequent entries.

Equations Used

The general equation is

$$f = PV + \frac{PMT}{i} \left[1 - (1+i)^{-N} \right] + FV(1+i)^{-N} = 0$$

where $i = I/100$.

The solution for each of the variables, except for **I**, can be obtained from various rearrangements of this equation.

Solving for **I**:

When **PMT** = 0, the equation can be solved for **i** directly:

$$i = - \left(\frac{FV}{PV} \right)^{\frac{1}{N}} - 1$$

Else **i** is solved for iteratively using Newton's Method of Approximation.

$$i_{n+1} = i_n - \frac{f(i_n)}{f'(i_n)}$$

where $f'(i)$ is the derivative of f with respect to i , and is shown below

$$f'(i) = \frac{PMT}{i} \left[N \frac{(1+i)^{-N}}{(1+i)} - \frac{1-(1+i)^{-N}}{i} \right] - FV \cdot N \frac{(1+i)^{-N}}{(1+i)}$$

This process converges when an appropriate starting value for **i** is chosen. Experience has shown that $i_0 = -.01$ provides a good starting value for almost all problems of practical interest. (Convergence will not be obtained in some problems in which the interest is less than 1%. In these few cases, the user should try the following key sequence: .1 [CHS] [STO] 09 [XEQ] 06)

Successive **i**'s are generated until

$$\left| \frac{f(i)}{f'(i)} \right| \leq 10^{-7}$$

Sample Problem

- a. A couple purchase a \$80,000 house, borrowing \$70,000 at 12.5% for 30 years. What is their monthly loan payment?
- b. They sell their house 38 months later (after making 38 payments). How much is still owed on the mortgage?
- c. The couple net \$25,000 after the sale. They estimate the rental value of their home at \$600/month. At what interest rate would they have had to invest their original \$10,000 and monthly mortgage payment minus rental value to obtain \$25,000?

SOLUTION:

Keystrokes (SIZE \geq 010)	Display	Comments
Part a.		
[XEQ] "FINANCE"	N, I, PV, PMT,FV	Keyboard labels for keys [A]-[E]
70000 [C]	PV=\$70,000.00	Enter the present value.
12.5 [ENTER] 12 [÷] [B]	I=1.04%	Enter the monthly interest rate.
30 [ENTER] 12 [×] [A]	N=360.00	Enter The number of payments.
[D]	PMT=\$-747.08	Solve for the monthly payment.
Part b.		
[R/S]	N, I, PV, PMT,FV	Forget the keyboard labels?
38 [A]	N=38.00	Enter 38 payment periods.
[E]	FV=\$-69,170.09	Solve for the future value.
Part c.		
10000 [CHS] [C]	PV=\$-10,000.00	Enter the initial investment.
25000 [E]	FV=\$25,000.00	Enter the final return.
[RCL] 04	-747.08	Recall the monthly payment.
600 [+] [C]*	PV=\$-147.08	Add in the rental value of home.
[B]	I=1.49%	Solve for monthly interest rate.
12 [×]	17.90	Compute the annual interest rate

*This works because a numeric entry (600) set flag 22 to signal the computer to enter data rather than to solve for it. If a problem involves just transferring a value from one variable to another, then the dummy numeric entry 0 [+] will accomplish the same thing.

USER INSTRUCTIONS

 SIZE:
(HP-41C) 010

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Load program "FINANCE".		[GTO]..	PACKING
2	Initialize the program (clears all financial registers).		[XEQ] "FINANCE"	N, I, PV, PMT, FV
3	Store inputs as desired:			
	number of periods	n	[A]	N=(n)
	periodic interest rate (%)	i	[B]	I=(i)%
	present value of investment	pv*	[C]	PV=\$(pv)
	periodic payment	pmt*	[D]	PMT=\$(pmt)
	future value of investment	fv*	[E]	FV=\$(fv)
4	Compute desired output:			
	number of periods		[A]	N=(n)
	periodic interest rate (%)		[B]	I=(i)%
	present value of investment		[C]	PV=\$(pv)*
	periodic payment		[D]	PMT=\$(pmt)*
	future value of investment		[E]	FV=\$(fv)*
5	To redisplay the keyboard labels (This may be done at any time.)		[R/S]	N, I, PV, PMT, FV
6	You may return to Step 3 to change any of the values and then proceed to Step 4 to compute a new answer.			
7	To clear all financial registers		[SHIFT] [A]	N, I, PV, PMT, FV

*Positive for cash received; negative for cash paid out.

PROGRAM LISTING

Page 5 of 8

□ 67 □ 97 □ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
01	LBL "FIN ANCE"			47	RCL 05		
02	LBL a		Initialization	48	RCL 08		
03	ADV			49	*		
04	SF 27			50	+		f(i)
05	SF 29			51	RCL 08		
06	ΣREG 01		Clear financial registers.	52	RCL 07		
07	CLE			53	/		
08	FIX 2			54	RCL 01		
09	LBL 15		Keyboard Labels	55	*		
10	"N, I, P V, PMT, F"			56	STO 06		$N \frac{(1+i)}{(1+i)}^{-N}$
11	"FV"			57	1		
12	CF 22			58	RCL 08		
13	PROMPT			59	-		
14	GTO 15			60	RCL 09		
15	LBL B		Interest	61	/		
16	"I="			62	-		
17	STO 02		Store I as a %.	63	RCL 04		
18	1			64	RCL 09		
19	%			65	/		
20	STO 09		Store i=I/100.	66	*		
21	X<>Y			67	RCL 05		
22	FS? 22		If data entry, display I.	68	RCL 06		
23	GTO 03			69	*		
24	RCL 04			70	-		f'(i)
25	X#0?		If PMT≠0, go to Iterative Sol.	71	/		f(i)/f'(i)
26	GTO 01			72	ST- 09		
27	RCL 05			73	ABS		
28	RCL 03			74	1 E-7		
29	/		Compute i by	75	X<=Y?		If $ \Delta i > 10^{-7}$ go to next iteration,
30	CHS			76	GTO 06		else display I.
31	RCL 01			77	RCL 09		Display Routine
32	1/X		$i = - \left(\frac{FV}{PV} \right)^{\frac{1}{N}} - 1$	78	LBL 00		for I
33	Y↑X			79	1 E2		
34	1			80	*		
35	-			81	STO 02		Store I as %.
36	STO 09			82	LBL 03		
37	GTO 00			83	ARCL X		
38	LBL 01		Iterative Solution	84	"F%"		
39	-.01			85	AVIEW		
40	STO 09		$i_0 = -.01$	86	FC?C 22		Advance printer if I is calculated.
41	LBL 06			87	ADV		
42	XEQ 08			88	RTN		
43	RCL 04			89	GTO 15		
44	+						-----
45	RCL 03						
46	+						

PROGRAM LISTING

Page 6 of 8

□ 67 □ 97 ☐ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
90	♦LBL A		Number of Periods	138	*		
91	"N="			139	CHS		
92	STO 01		Store N.	140	STO 04		
93	FS? 22		If data entry, display N.	141	GTO 07		Display PMT. Future Value
94	GTO 07			142	♦LBL E		
95	RCL 04			143	"FV= \$"		
96	RCL 09			144	STO 05		Store FV.
97	/		PMT/i	145	FS? 22		If data entry, display FV.
98	STO 00			146	GTO 07		
99	RCL 05			147	XEQ 08		
100	-			148	RCL 04		
101	RCL 03			149	*		
102	RCL 00			150	RCL 03		
103	+			151	+		
104	/			152	RCL 08		
105	LN			153	/		
106	RCL 09			154	CHS		
107	LN1+X			155	STO 05		
108	/			156	♦LBL 07		Display Routine for N,PV,PMT,& FV
109	STO 01			157	ARCL X		
110	GTO 07			158	AVIEW		
111	♦LBL C		Display N. Present Value	159	FC?C 22		
112	"PV= \$"			160	ADV		
113	STO 03		Store PV.	161	RTN		Advance printer for calculated results.
114	FS? 22		If data entry, display PV.	162	GTO 15		
115	GTO 07			163	♦LBL 08		Subroutine
116	RCL 04			164	1		
117	XEQ 08			165	RCL 09		Calculates:
118	*			166	1		
119	RCL 05			167	+		
120	RCL 08			168	STO 07		(1+i)
121	*			169	RCL 01		
122	+			170	CHS		
123	CHS			171	Y↑X		
124	STO 03			172	STO 08		(1+i) ^{-N}
125	GTO 07			173	-		
126	♦LBL D		Display PV. Periodic Payment	174	RCL 09		$1 - (1+i)^{-N}$ i
127	"PMT= \$"			175	/		
128	STO 04		Store PMT.	176	END		
129	FS? 22		If data entry, display PMT.				
130	GTO 07						
131	XEQ 08						
132	1/X						
133	RCL 03						
134	RCL 05						
135	RCL 08						
136	*						
137	+						

STATUS

SIZE : 010

Program Size : 279 Bytes (40 Registers)

USER Mode : ON, automatically set by program

Display setting : FIX 2, automatically set by program

DATA REGISTERS

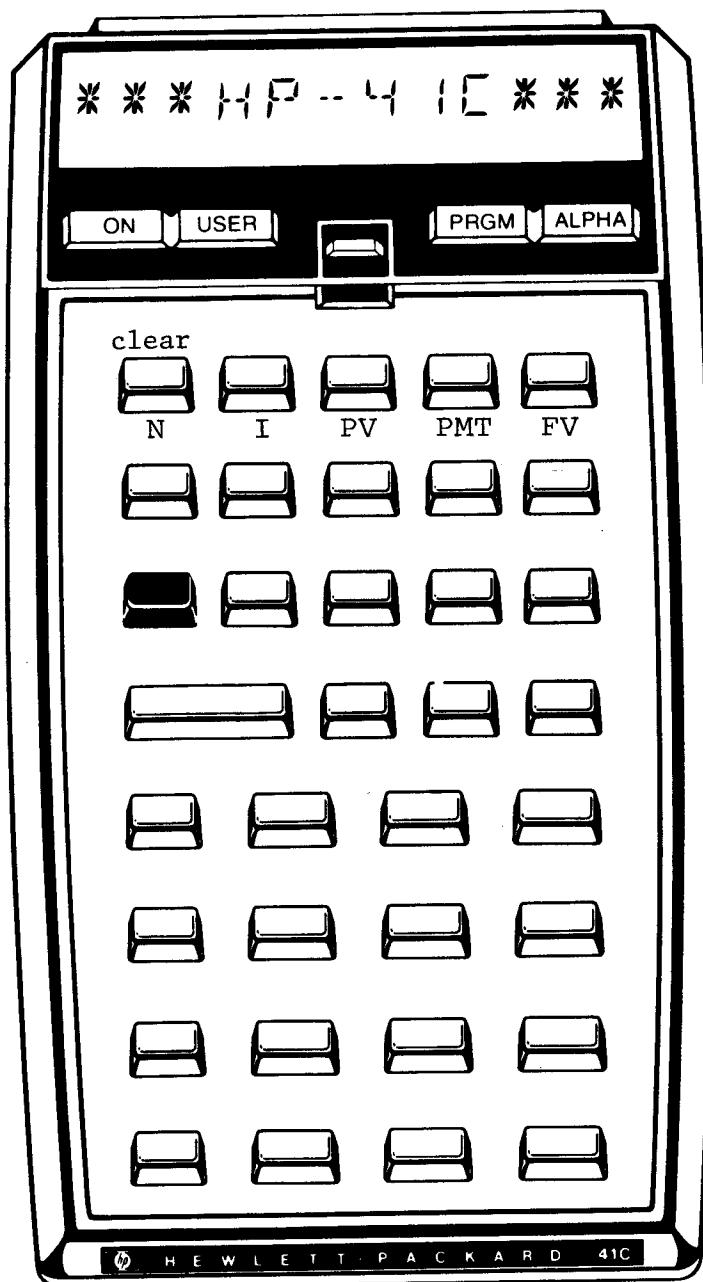
00	PMT/i
01	N, the number of periods
02	I, the periodic interest rate
03	PV, the present value
04	PMT, the periodic payment
05	FV, the future value
06	$N(1+i)^{-(N+1)}$
07	$1+i$
08	$(1+i)^{-N}$
09	$i = I/100$

FLAGS USED

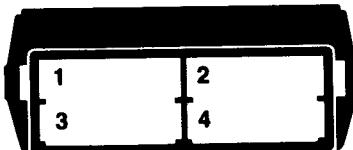
22	Set : A value is being entered by the user. Clear : A value is being calculated.
27	Set : User mode is set on.
29	Set : Numbers are displayed with commas.

KEYBOARD CARD LABELING

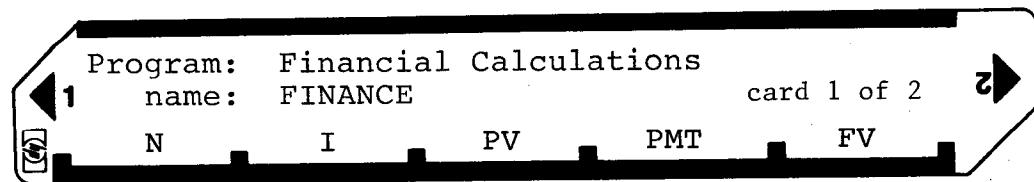
KEYBOARD



SYSTEM CONFIGURATION



CARD



Box 259N Route 4
Fredericksburg, Virginia 22405
March 17, 1985

Hewlett Packard Company
Attention: Users' Library
1000 N.E. Circle Blvd.
Corvallis, Oregon 97330

Dear Sirs:

Enclosed are three programs which I am submitting for inclusion in the HP-41 User's Library. Two of these programs are quite short, and for this reason I am concerned about their marketability. It is easy to conclude that a very short program is either of limited use or is trivial and is not worth buying. I have developed these programs over a number of years, putting innumerable hours of work into making them as compact, versatile, and easy to use as possible. Perhaps you have some suggestions on how we might make these programs more marketable.

The MEMO program has been designed to be as small as possible, so that it can be left in memory almost indefinitely, without reducing the capacity of the HP-41 to contain a user's usual compliment of programs. The data is kept in extended memory for the same reason and also to insulate it from the data of other programs. Of the dozen or so programs which I have submitted to the User's Library, and the two or three dozen which I received from the library, and others which I have written, MEMO is, by far, my most frequently used program -- the one which I use many times every day. I imagine that there are others who would like to keep their notes, appointments, and expenses on their HP-41.

The PHONE program was designed in much the same philosophy. It is small so that it can be kept in memory for long periods, and the data is also kept in extended memory. The PHONE file is protected from accidental change by the user mode functions, Add Name, and Delete. Primary protection is through the use of prompt and verification actions. Additional protection is provided by the user having to manually take the computer out of Alpha mode and to set User mode. I find this program quite useful when I am travelling (I always have my HP-41 with me).

The FINANCE program is yet another version of HP's own Financial Calculations program published in the Standard Applications Manual. The basic design of the original program is excellent. However, while using the program without the manual, I often forgot which key to press. This led to the creation of the present version which has the following enhancements.

1. Input values are echoed to the display with their labels.
2. Keyboard labels may be displayed at any time without affecting the calculation, by simply pressing [R/S].
3. Flag 22 is cleared whenever the keyboard labels are displayed. This permits the user to do side calculations before computing a result.
4. Printer output contains input values as well as the result and all lines are properly labelled. A result is separated from following input by a blank line to distinguish it from the next calculation.

While examining the code in the published version, I was puzzled by not being able to understand the logic behind the initial guess for i (lines 50 - 73). I have now come to the conclusion that this code is wrong, and that the only reason the program works is because the algorithm is relatively insensitive to the starting value. It appears to me that the author wanted to choose a starting value for i close to 0 but haveing the proper sign. The program steps shown on the bottom of the page perform this correctly. However, in reality, they are not needed. I have investigated the problem of choosing a good initial value by checking for convergence and timing the solutions for many examples, covering every reasonable case (and a few unreasonable cases) I could think of. My findings are that the algorithm converges very well towards increasing i but occasionally has difficulty when the true value of i is less than the initial guess. This problem becomes critical for large N . Thus an initial value of $i = -0.01$ (-1%) was chosen. This value converges for more cases than the value chosen in the original program. The only problems I have found occur when $i < -1\%$ AND N is quite large. Considering that most people do not keep investments having a negative return for long periods of time, I don't believe that this will be a problem for real situations.

Sincerely yours,

Gary Goodman

Gary Goodman

Code to compute initial guess for i with correct sign (replaces steps 50 - 73)

```
50 RCL 05
51 RCL 03
52 +
53 RCL 04
54 RCL 01
55 *
56 +
57 RCL 05
58 RCL 03
59 -
60 *
61 SIGN
62 1 E-9
63 *
```

Review Date 9/15/85

AUTHOR Gary Goodman
TITLE Financial Calculations
LOG # 09685 PROGRAM # REVIEWER P. Niskanen
NEW XXX RESUBMITAL REVISION

Thank you for sending your enclosed program submittal to the Users' Library. Before we can accept it, however, we must ask that you review the comments below and adjust your program accordingly.

Your program submittal duplicates others already in existence in the Users' Library. Please review your current Users' Library Software Catalog listing to insure your submittal represents a unique contribution to the Library. If you have any questions regarding program development, contact the Library for assistance.

TO CORRECT AND RESUBMIT YOUR PROGRAM:

1. If part of your documentation package was omitted:
 - a. Insert the form and/or magnetic card(s) needed.
 - b. Re-number the documentation pages accordingly.
The "Program Submittal" page is not numbered.
2. If a correction must be made to your existing documentation:
 - a. Re-do only the form affected by the change. Use the blank forms enclosed for this purpose. Please use the same ink or type used for the rest of your documentation.
 - b. Replace the erroneous form with the corrected form. Do not return the erroneous form to the Library.
3. Re-do the "Program Submittal" form *only if the information given on it is affected by the changes being resubmitted.*
4. When resubmitting your program, please be sure you return this review sheet with your *completely revised package, including your magnetic card(s).*

The Users' Library was established to provide readily available and useful programs for all users. Since good programs like yours are necessary to ensure its success, we hope you will resubmit your corrected program at your earliest convenience. Thank you for your cooperation.

Colleen R. Johnson

Colleen R. Johnson

Hewlett-Packard Company
Users' Library