hp calculators

HP 30b Programming examples and using HP Solve in algebraic mode

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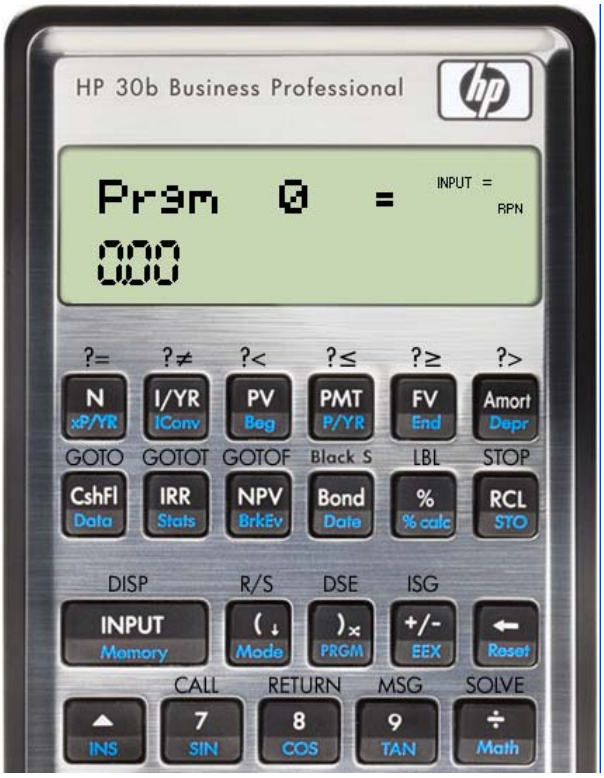
Programming on the HP 30b

The HP 30b Business Professional calculator includes a programming capability designed to help automate repetitive calculations and extend the usefulness of the built-in function set of the calculator. The capability includes the creation of up to 10 separate programs using up to 290 bytes of memory among them.

Programs record keystrokes, with each keystroke using one byte of memory, although some commands use more than one byte. In addition, many program-only functions are provided for conditional tests, “gotos”, looping, displaying intermediate results and even calling other programs as subroutines.

This learning module will show how to program the HP 30b in algebraic mode using several example programs and HP Solve. These programs are just a couple of possible ways in which the HP 30b can be extended by writing short programs.

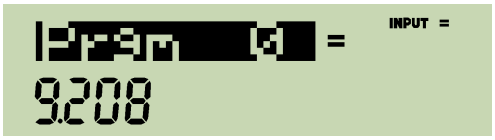


As shown in the picture at right, the HP 30b has additional functions assigned to the keys that are program-only functions. Other than the Black-Scholes function (shown as Black S), which is not a program function but a financial function, these functions are not printed or labeled on the actual HP 30b itself. However, an overlay is provided that lays over the top rows of keys that helps indicate how these functions are mapped to the keys.

Each of these functions is inserted into a program by pressing the shift key and holding it down while pressing the key under which the program function is displayed. For example, to insert a LBL (label) command, press [shift] and, while holding it down, press [%]. In these learning modules describing programming, this will be shown as [shift] + [%]. Pressing that key combination will insert a LBL instruction into a program in program edit mode. Pressing that key combination in calculation mode will do nothing.

There are 10 numbered slots available for programs, numbered from 0 to 9. These are displayed in the program catalog which is viewed by pressing [shift] [)] PRGM. In the image above, the program catalog is displayed, showing Prgm 0 or program 0. Pressing the [▲] or [▼] keys will scroll through the list of 10 programs. Pressing [INPUT] will enter the selected program, allowing you to view the program steps stored in that program slot or to change the program steps. To exit this program editing mode and return to the program catalog, press [shift] [)] PRGM. To exit the program catalog and return to calculation mode, press [ON/CE].

When a program is displayed, a number will be shown below it indicating how many bytes are used and a checksum, to help ensure the program has been entered correctly. If the program name is shown in reverse video, then the program has been assigned to a key and can be executed by pressing the appropriate key combination, even when in calculation mode. This is shown in the image at right. When viewing a program in the program catalog, pressing [shift] [Reset] [INPUT] will delete the presently displayed program and return you to the calculation environment. To delete all programs, press [shift] [Reset] [▲] [▲] [INPUT] [INPUT] while in calculation mode.



HP 30b Programming examples and using HP Solve in algebraic mode

At different places within a program, you can insert a Label (LBL) command. A label defines a location to which program control may be transferred. The HP 30b can handle up to 100 labels within the entire program memory. These labels are a two-digit numeric value from 00 to 99. No label can be used more than once, which makes each label a "global" label and defined only once within the global program memory space. If you attempt to enter a label that has already been used, a message saying "Exists!" will be briefly displayed with no change made to the program.

HP Solve

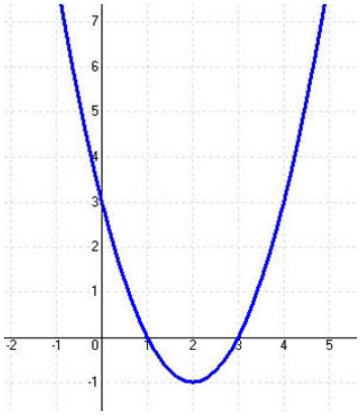
The HP 30b contains the incredibly powerful HP Solve feature. No competing business calculator contains such power accessible to the user. HP Solve allows you to key in a program that evaluates a function so that the result is equal to zero and then finds a value for a variable within the function that makes the result equal to zero, called a root. For a very simple example, if you have X = 5, this can be rewritten in the form X – 5 = 0. Obviously, the value of X that makes this result equal to zero is 5 and HP Solve will find that answer.

The way you use HP Solve on the HP 30b is to write a program that evaluates a function so that the function is equal to zero using the memory registers for the variables. Then you use the SOLVE function and specify the memory register for which you wish to solve.

In this case, the program using memory register 1 for X would be: RCL 1 then 5 then – then STOP. If you then performed a SOLVE 1, the HP 30b would find the root for this function: 5.

In this learning module, we will work through several examples using HP Solve writing the programs in algebraic mode. Since not every function has a root, and since some functions have special conditions, the examples may not always find a root.

Example 1: Find the root of $Y=(X-2)^2-1$. Use memory register 9 for X. End the program with a STOP command. Use algebraic mode. To set algebraic mode, press: [▬] [Mode] [▼] [▼] [▼] [▼] [▼]. If the display does not show algebraic, press [INPUT] until it does. Then press [ON/CE]. Algebraic mode can also be set by pressing [2] [0] [3] [▬] [STO] [▬] [Mode]. This will also set FIX 3 display mode.



If this function is graphed, we can tell that HP Solve should find two roots, as shown at right, at approximately 1 and 3. HP Solve uses a value stored in the memory register being used to evaluate the function as a starting point, or "guess" value for a root. Try guesses of 2 and -3. See what roots HP Solve finds.

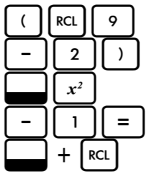
To enter this function into the HP 30b as a program, you would press the following keys:

[▬] [PRGM]

Enters program mode and displays the last program previously viewed in the program catalog. If you wish to enter your program into a different program number in the catalog, press [▲] or [▼] until the program number you wish to use is displayed. In this example, let's use Prgm 0. To erase Prgm 0, press [▬] [Reset] [INPUT]. Since this erases Prgm 0 and exits the program catalog, press [▬] [PRGM] to re-enter the program catalog. Then press:

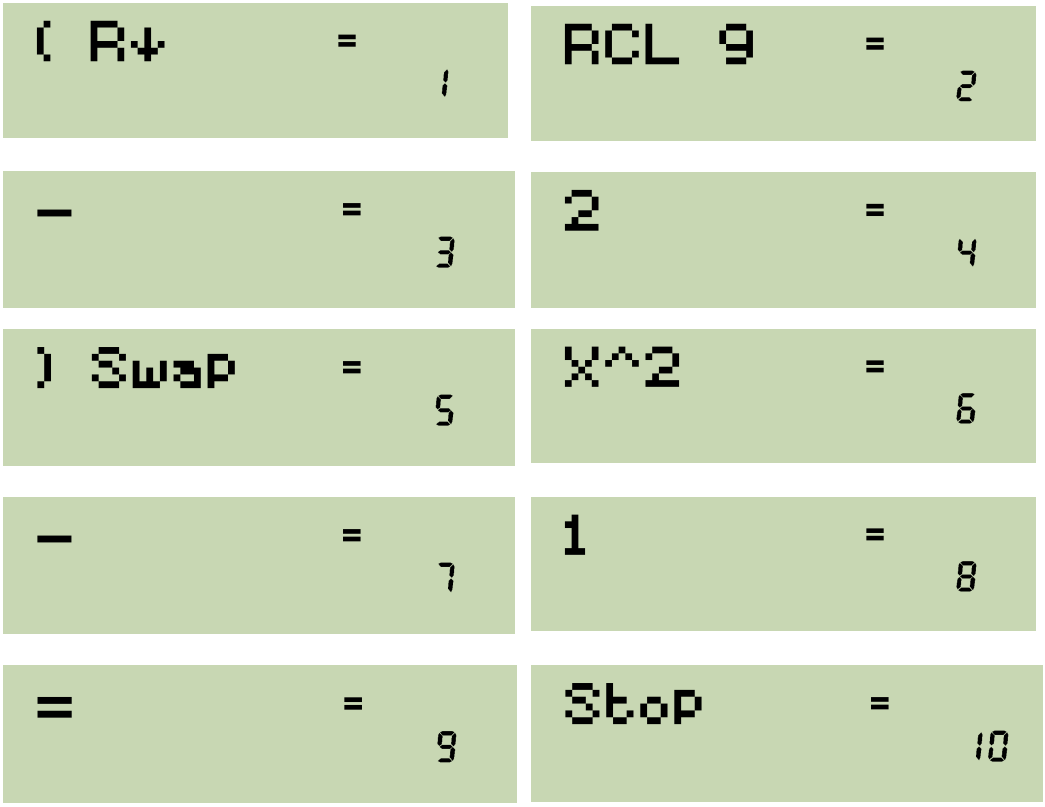
[INPUT]

Enters program edit mode and displays the first line of the program, which will be blank as shown at right if this is a new program.



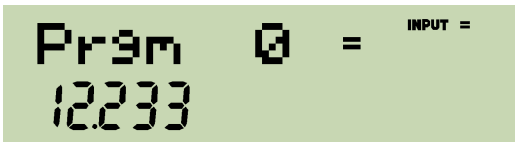
These key presses evaluate the function. In this example, memory register 9 will be used by the SOLVE command to evaluate the function. When the SOLVE command running, memory 9 will hold the last value used for the the variable. This last key press enters the STOP command using the shift-hold method. Blank step 11 is displayed.

The full program should appear as shown below. Note that the open and close parentheses symbols also show the function they perform in RPN mode.

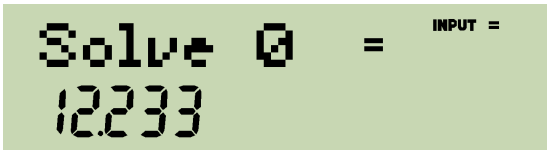


The final STOP command is required. All programs used with HP Solve must end with a STOP command.

To use HP Solve to try to find a root for this function (and from the graph we already know there should be two), press . This returns the HP 30b to the program catalog and now displays Prgm 0 (or whatever program slot in the program catalog into which you just entered this program). The number of bytes used by Prgm 0 is shown below it in the display. This function program uses 12 bytes of memory and should have a checksum of 233, as shown below.



Store the first guess to be used into memory 9 by pressing [2] [▬] [STO] [9]. Now we can use HP Solve to find a root by pressing [▬] + [÷]. The screen will appear as shown below. Note that the SOLVE command prompts with a 0 for the memory register to use.



The program just entered used memory 9 for the variable, so press [9] to begin the hunt for the root of this function. Note that if the solver is taking a while to find the solution, the screen may show ON->Stop, indicating that you can abort the execution by pressing the [ON/CE] key.

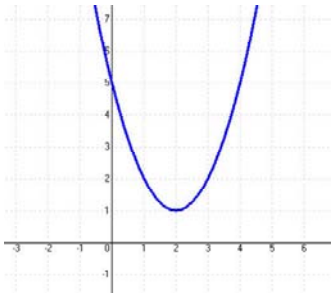
HP Solve has found a root at X=3 for this function.

To try again with a different guess, enter a new guess by pressing press [3] [+/-] [▬] [STO] [9] from the calculation environment. Then press [▬] [PRGM] and navigate to the same program entry in the program catalog as before (the program being used in this learning module is Prgm 0). Start HP Solve to find a root by pressing [▬] + [÷] [9].

HP Solve has found a root at X=1 for this function. The two roots found are at 1 and 3.

Note that if you execute SOLVE from the calculation environment, it solves for the specified memory register value in the most recently viewed program.

Example 2: Find the root of $Y=(X-2)^2+1$. Use memory register 1 for X. End the program with a STOP command. Use algebraic mode. To set algebraic mode, press: [▬] [Mode] [▼] [▼] [▼] [▼] [▼]. If the display does not show algebraic, press [INPUT] until it does. Then press [ON/CE]. Algebraic mode can also be set by pressing [2] [0] [3] [▬] [STO] [▬] [Mode]. This will also set FIX 3 display mode.



If this function is graphed, we can tell that HP Solve should not find a root, as shown at right, since the graph never crosses the X-axis.

To enter this function into the HP 30b as a program, you would press the following keys:

[▼] [PRGM]

Enters program mode and displays the last program previously viewed in the program catalog. If you wish to enter your program into a different program number in the catalog, press [▲] or [▼] until the program number you wish to use is displayed. Let's reuse Prgm 0. To erase Prgm 0, press [Reset] [INPUT]. Since this erases Prgm 0 and exits the program catalog, press [PRGM] to re-enter the program catalog. Then press:

[INPUT]

Enters program edit mode and displays the first line of the program, which will be blank as shown at right if this is a new program.

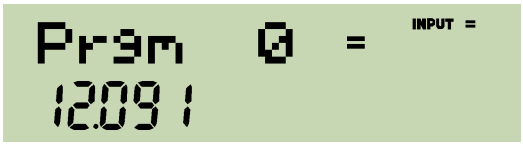
[(] [RCL] [1] [−] [2] [)] [x²] [+] [1] [=] [▼] + [RCL]

These key presses evaluate the function. In this example, memory register 1 will be used by the SOLVE command to evaluate the function. When the SOLVE command stops running, memory 1 will hold the last value used for the variable. This last key press enters the STOP command using the shift-hold method. Blank step 11 is displayed.

The full program should appear as shown below.

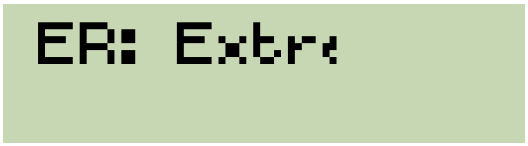
The final STOP command is required. All programs used with HP Solve must end with a STOP command.

To use HP Solve to try to find a root for this function (and from the graph we already know there should not be one), press [↓] [PRGM]. This returns the HP 30b to the program catalog and now displays Prgm 0 (or whatever program slot in the program catalog you just entered this program into). The number of bytes used by Prgm 0 is shown below it in the display. This function program uses 12 bytes of memory and has a checksum of 091.



Now we can use HP Solve to find a root by pressing [↓] + [÷]. The screen will appear as shown below. Note that the SOLVE command prompts with a 0 for the memory register to use.

The program just entered used memory 1 for the variable, so press [1] to begin the search for the root of this function.



The HP 30b displays “ER: Extremum Found”, which indicates that no root was found, but that a maximum or minimum value for the function was found. That appears evident from viewing the graph above. After HP Solve runs, the value found for the “root” is left in the memory register used, in this case memory register 1. To see what this maximum or minimum value was for this function, press [RCL] [1].

The value of 2.000 agrees with the minimum value from the graph. So, HP Solve has indicated that no root exists, but that the minimum value is approximately 2.

Example 3: Use HP Solve to work with the relationship indicated by the equation Profit = Sales – Costs. Use algebraic mode. Of course, this relationship can also be solved using the HP 30b Breakeven menu, but for this example, use HP Solve. Use algebraic mode. To set algebraic mode, press: [↓] [Mode] [▼] [▼] [▼] [▼] [▼]. If the display does not show algebraic, press [INPUT] until it does. Then press [ON/CE]. Algebraic mode can also be set by pressing [2] [0] [3] [↓] [STO] [↓] [Mode]. This will also set FIX 3 display mode.

First, translate the words in the equations to memory registers. Use memory 0 for profit, memory 1 for sales and memory 2 for costs. The new equation would be Memory 0 = Memory 1 – Memory 2. Now rewrite this equation so that it is equal to zero. The new form to program and use for HP Solve would be: Memory 1 – Memory 2 – Memory 0 = 0.

To enter this function into the HP 30b as a program, you would press the following keys:

[shift] [PRGM]	Enters program mode and displays the last program previously viewed in the program catalog. If you wish to enter your program into a different program number in the catalog, press [▲] or [▼] until the program number you wish to use is displayed. Assume Prgm 0 is empty. If it is not empty, refer back to example 2 and erase the program. Then press:	
[INPUT]	Enters program edit mode and displays the first line of the program, which will be blank as shown at right if this is a new program.	
[RCL] [1] [−] [RCL] [2] [−] [RCL] [0] [=]	These key presses evaluate the function using the memory registers as indicated above.	
[shift] + [RCL]	This last key press enters the STOP command.	

Press [shift] [PRGM] to return to the program catalog. The program uses 11 bytes and has a checksum of 148.

Use HP Solve to find profits if sales are 1500 and costs are 900. Since memory 1 represents sales, press [1] [5] [0] [0] [shift] [STO] [1] to store the sales value. Since memory 2 represents costs, press [9] [0] [0] [shift] [STO] [2] to store the cost value. Since memory 0 represents profits press [shift] + [÷] [0] to find the profits.

Profits are 600 when sales are 1500 and costs are 900.

Use HP Solve to find costs if sales are 1500 and profits are 300.

Since memory 1 represents sales, press [1] [5] [0] [0] [shift] [STO] [1] to store the sales value. Since memory 0 represents profits, press [3] [0] [0] [shift] [STO] [0] to store the profit value. Since memory 2 represents costs, press [shift] + [÷] [2] to find the costs.

Costs are 1200 when sales are 1500 and profits are 300.

Example 4: Generalized odd-days loan solver program

The formula presented below shows the time value of money relationship for a first period with an odd number of days. In this formula, PV is the original present value of the loan, I/YR is the annual interest rate, P/YR is the number of periods per year, DAYS is the number of days in the odd-day first period, PMT is the periodic payment, FV is the future value (which would be zero or a balloon payment). Two additional functions are present in this formula. FP stands for fractional part, and will return the decimal value that is computed when DAYS are divided by 30. IF is a logical test such that if the value of DAYS is less than 30, PMT will be multiplied by the value of I/YR divided by P/YR plus 1, but if the value of DAYS is not less than 30, PMT will simply be multiplied by 1. FP will be implemented using the FP function from the MATH menu, while the IF will be implemented using a conditional test.

$$PV\times\left(\frac{I/YR}{P/YR}\times FP\left(\frac{DAYS}{30}\right)+1\right)+\left(PMT\times IF\left(DAYS<30,\left(1+\frac{I/YR}{P/YR}\right),1\right)\times\frac{\left(1-\left(1+\frac{I/YR}{P/YR}\right)^{-N}\right)}{\left(\frac{I/YR}{P/YR}\right)}\right)+\frac{FV}{\left(1+\frac{I/YR}{P/YR}\right)^{N}}=0$$

The program presented below allows for the solution to the number of odd days, the payment, the present value, the number of periods, the future value and the interest rate using the formula presented above. In this example, the following registers will be used for the components of the formula:

Register 0 for the number of odd days in the first period.
Register 1 for the value of N.
Register 2 for the value of I/YR. If solving for I/YR, be sure to store an initial guess.
Register 3 for the value of PV.
Register 4 for the value of PMT.
Register 5 for the value of FV.

Note that if you wish to use values from the time value of money registers in this solve program, they will have to be recalled from the time value of money register and manually stored into the memory registers above before using HP Solve. To enter this equation into the HP 30b as a program, you would press the following keys:

Keys Pressed	Explanation
[PRGM]	Enters program mode and displays the last program previously viewed in the program catalog. If you wish to enter your program into a different program number in the catalog, press [▲] or [▼] until the program number you wish to use is displayed. Use Prgm location 3 which is assumed to be empty. Then press:
[INPUT]	Enters program edit mode and displays the first line of the program
[RCL] [2] [÷] [RCL] [P/YR] [÷] [1] [0] [0] [=]	Recall the interest rate per year and divide by the number of periods per year and then divide by 100.
[STO] [9]	Save I/YR divided by P/YR in memory 9 for later use. This is line 9 of the program.
[RCL] [0] [+] [PV] [3] [0]	Recall the number of odd days. Insert ?< comparison test. 30 is the comparison point.

Keys Pressed	Explanation
=	The equal sign is required to perform the comparison. Note: Any pending operations are evaluated when an equal sign is encountered.
[ ] + [IRR] [0] [3]	If true, goto label 03.
[1]	Enter a 1 onto the stack
[ ] + [CshFl] [0] [4]	Unconditional go to label 04.
[ ] + [%] [0] [3]	Label 03. This is line 18 of the program.
[RCL] [9]	Recall I/YR divided by P/YR.
[+] [1]	Add 1 to compute (1 plus I/YR divided by P/YR)
=	
[ ] + [%] [0] [4]	Label 04. This is line 23 of the program.
[÷]	
[RCL] [9]	Recall I/YR divided by P/YR.
[×]	
[(] [1] [−]	
[(] [1] [+]	
[RCL] [9]	Recall I/YR divided by P/YR. This is line 33 of the program.
[)]	
[ ] [y^x]	Raise (1 plus I/YR divided by P/YR) to the negative N power.
[RCL] [1]	Recall N, the total number of periods.
[+/-]	Change the sign of N.
[)]	
[×]	
[RCL] [4]	Recall PMT.
=	Compute the present value of the payments. This is line 41 of the program.
[+]	
[(] [RCL] [5]	Recall FV
[÷]	
[(] [1] [+]	
[RCL] [9]	Recall I/YR divided by P/YR.
[)]	Add 1.
[ ] [y^x]	Raise (1 plus I/YR divided by P/YR) to the N power
[RCL] [1]	Recall N, the total number of periods.
[)]	
=	Computes the present value of the future value. This is line 54 of the program.
[+]	Add to previous result.
[(] [RCL] [9]	Recall I/YR divided by P/YR.
[×]	
[(]	
[RCL] [0]	Recall the number of odd days.
[÷]	
[3] [0]	Divide by 30.
[)]	

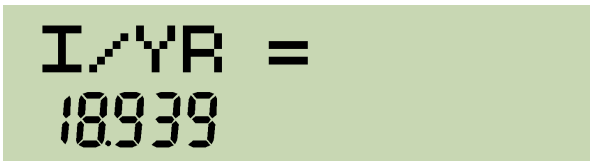
Keys Pressed	Explanation
[Math]	Perform the FP function from the MATH menu.
[+] [▲]	Displayed as "Math Up Input" and discards integer
[INPUT]	portion of previous result. FP is evaluated when [INPUT] is pressed.
[+] [1]	Add 1 to result.
[)]	
[×]	
[RCL] [3]	Recall PV and multiply by previous result. This is line 72 of the program.
[=]	
[+] [RCL]	This last key press enters the STOP command. This is line 74 of the program.

Now press [+] [PRGM] to exit program edit mode and return to the program catalog. If you have entered this program correctly, you should see that program 3 uses 94 bytes and has a checksum of 231.

Question 1: A 24 month loan for 10,000 has a monthly payment of 400 and a balloon payment required at the end of the loan of 3,000. What interest rate, compounded monthly is being charged if there are no odd days in the first period? What is the interest rate if there are 8 days until the first payment?

First solve the time value of money problem.

[2] [4] [N]
[1] [2] [+] [P/YR]
[1] [0] [0] [0] [0] [PV]
[3] [0] [0] [0] [+/-] [FV]
[4] [0] [0] [+/-] [PMT]
[I/YR]



The interest rate is 18.939%, compounded monthly. This is the interest rate being charged, assuming there are no odd days in the first period and the first payment is due in 30 days.

Now store the actual number of odd days in the first period into memory 0 by pressing [8] [+] [STO] [0]. Transfer the time value of money entries to the appropriate registers by pressing:

[RCL] [N] [+] [STO] [1]
[RCL] [PV] [+] [STO] [3]
[RCL] [PMT] [+] [STO] [4]
[RCL] [FV] [+] [STO] [5]

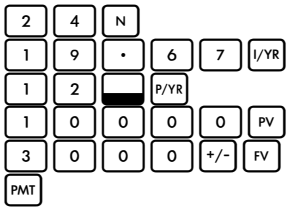
Store a guess of 2 (most any guess will do – a guess of 55 results in the same answer shown below) into the interest rate register by pressing [2] [+] [STO] [2].

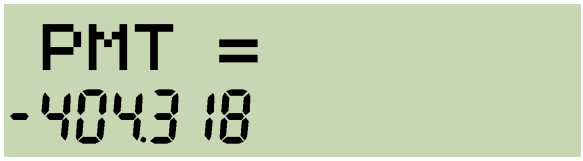
Since the last program viewed was the one we wish to run, the interest rate being charged for 8 odd days in the first period can be found in calculation mode at this point by pressing [+] [÷] [2].

HP Solve indicates that if there only 8 days until the first payment, then the loan is being assessed interest at 19.674%, compounded monthly.

Question 2: A 24 month loan for 10,000 at 19.67%, compounded monthly with a balloon payment required at the end of the loan of 4,000. What is the size of the monthly payment if there are no odd days in the first period? What is the monthly payment if there are only 8 days until the first payment?

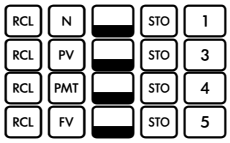
First solve the time value of money problem.





The monthly payment is 404.32. This is the monthly payment assuming there are no odd days in the first period.

Now store the number of odd days in the first period into memory 0 by pressing 8 − STO 0. Transfer the time value of money entries to the appropriate registers by pressing:

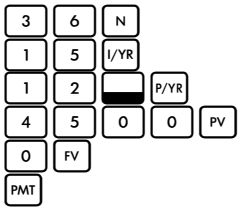


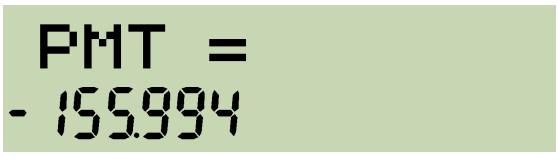
Since the last program viewed was the one we wish to run, the monthly payment with the new value for odd days in the first period can be found in calculation mode at this point by pressing − + ÷ 4.

HP Solve indicates that if there are only 8 days until the first payment, the monthly payment will be 399.98 per month. Because there are now less than 30 days until the first payment, the monthly payment required to pay off the loan has decreased slightly.

Question 3: A 36-month loan for 4,500 has an annual interest rate of 15%, compounded monthly. What is the monthly payment if there are no odd days? If the first payment is due in 46 days, what is the monthly payment?

First solve the time value of money problem.





The monthly payment is 155.99. This is the monthly payment assuming there are no odd days in the first period.

Now store the number of odd days in the first period into memory 0 by pressing 4 6 − STO 0. Transfer the time value of money entries to the appropriate registers by pressing:

RCL N − STO 1
RCL PV − STO 3
RCL PMT − STO 4
RCL FV − STO 5

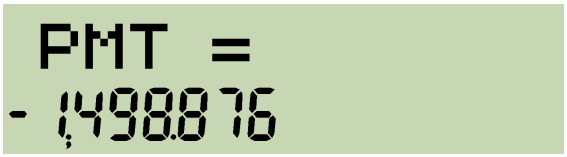
Since the last program viewed was the one we wish to run, the monthly payment with the new value for odd days in the first period can be found in calculation mode at this point by pressing − + ÷ 4.

HP Solve indicates that if there are 46 days until the first payment, the monthly payment will be 157.03 per month. Because there are now more than 30 days until the first payment, the monthly payment required to pay off the loan has increased slightly.

Question 4: A 30 year loan for 250,000 has an annual interest rate of 6%, compounded monthly. What is the monthly payment if there are no odd days? If the first payment is due in 45 days, what is the monthly payment?

First solve the time value of money problem.

3 6 0 N
6 I/YR
1 2 − P/YR
2 5 0 0 0 0 PV
0 FV
PMT



The monthly payment is 1498.88. This is the monthly payment assuming there are no odd days in the first period.

Now store the number of odd days in the first period into memory 0 by pressing 4 5 − STO 0. Transfer the time value of money entries to the appropriate registers by pressing:

RCL N − STO 1
RCL PV − STO 3
RCL PMT − STO 4
RCL FV − STO 5

Since the last program viewed was the one we wish to run, the monthly payment with the new value for odd days in the first period can be found in calculation mode at this point by pressing − + ÷ 4.

HP Solve indicates that if there are 45 days until the first payment, the monthly payment will be 1502.62 per month.