The HP Business Consultant HP–18C

Training Guide

A GRAPEVINE PUBLICATION

THE HP BUSINESS CONSULTANT TRAINING GUIDE

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We extend our thanks and congratulations to Hewlett-Packard Company's calculator division for continuing its tradition of producing top-quality products and documentation.

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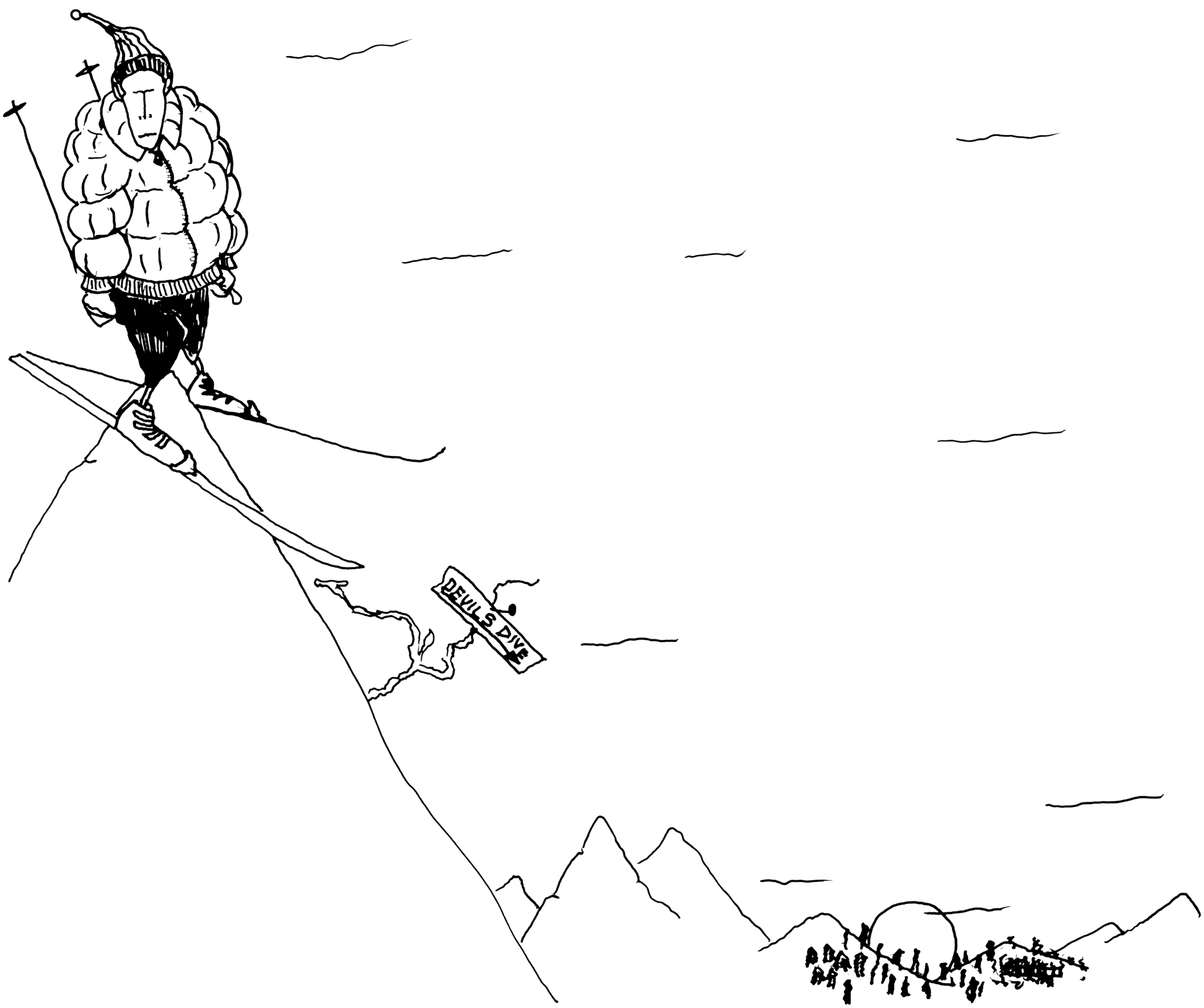
Chapter 1.

...LET'S ROLL...

BEGIN HERE

This is it — the upper left-hand corner. It's all downhill from here.



The hardest thing about learning something new is simply getting started.

(You realize, of course, that this means you've already finished the toughest part of this book.)

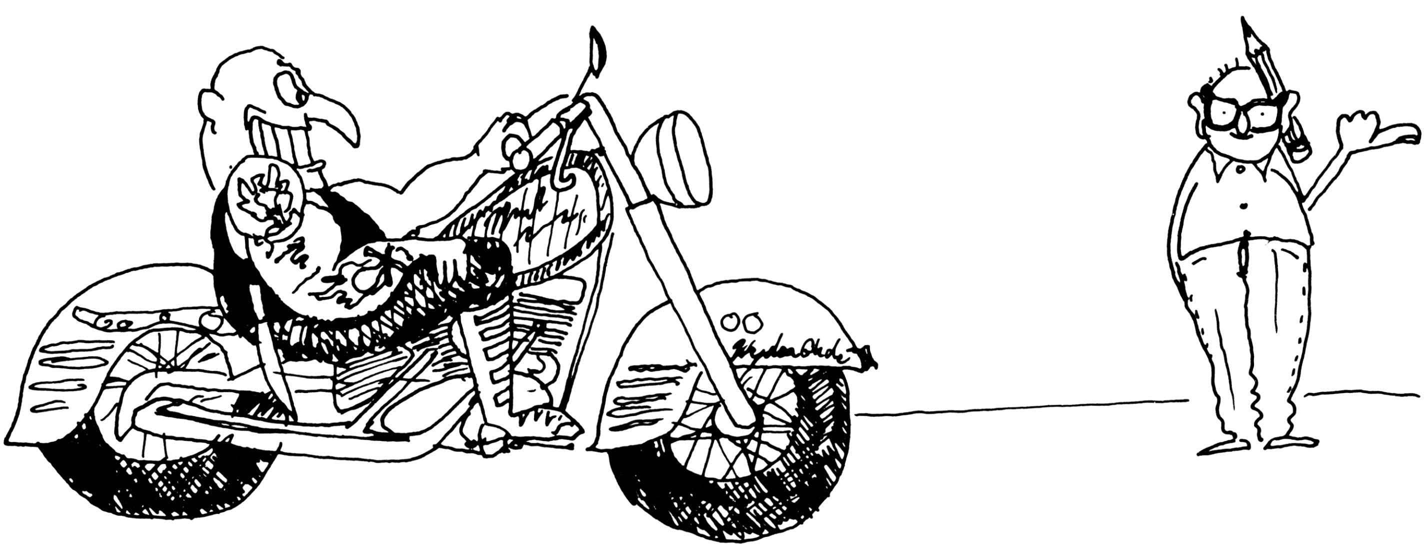
This book is really a classroom-style course (operating under cover). Its mission is clear: to give you a guided tour of the HP-18C — and the practice you'll need to use it with confidence. Our book has gone through rigorous preparation for its job; it's been specially trained to let you simply follow your nose, reading straight through, from the point that says "BEGIN HERE" (see above) to the very end, giving you good pictures and memorable lessons in a friendly fashion.

Of course, while you're working through this book, you may find topics that you already understand (or you don't really want to know any more about). So to help keep things moving for you, there will be places in the text that allow you to detour around certain sections, bypassing them or saving them for later, as you wish.

Also, if you don't understand some idea after the first pass through it, there will be points in the text that tell you to go back for another look.

Finally, remember: This course is designed so that you can go at YOUR speed, so don't feel rushed by anything. Take your time; allow yourself at least an hour for the first session. You will also find designated "rest areas" in the course, during which you can stretch your legs, and step out for doughnuts and coffee (or carrot sticks and yogurt), etc.

All aboard....



LOOKING UNDER THE HOOD

Beneath the dashing good looks and the overall high quality of the HP Business Consultant Calculator (HP-18C for short) lies a loyal and friendly calculator. It's a new generation of calculator, with more power — that's easier to use — than ever before. It can do everything from remembering your appointments to analyzing your investments.

When you open up your HP-18C, a few things are very noticeable. On the left side, there's a set of keys with letters on them, and on the right side are more keys with numbers, mathematical symbols, and strange abbreviations.

The alphabetical keys are used to type messages or name lists, and to type in useful equations for your daily calculations. But those keys on the right side are the ones that you'll use the most. They're used mainly for keying in and working with numbers.

Look at the display. It seems bigger than most calculator displays, and there's a good reason for this: This display shows you a lot more than just a single number. It tries to give you the best possible picture of what's going on in your Business Consultant. Of course, it never shows you a complete picture (it's not THAT big), but it does show you a much bigger picture than most other calculators ever could. And that's very handy, as you'll soon see.

Next, look at the first row of keys below the display. They're blank.

These keys are blank because their meanings change. And how do you know what these keys mean at any given time? You simply look at the signs directly above them in the display. These signs form a set called a menu.

(If you know all about menus — and how to set the time on the clock in your HP-18C — turn to page 16. Otherwise, turn your machine on (press [ON]) and continue.)

[ON]

With the display "lit up," you'll notice that in the lower part of the display, there are some boxes filled with words or abbreviations — to tell you just what those top-row blank keys mean at the moment. They're much like road signs that tell which exit to choose to reach your destination.

To begin with, press the gold key in the second row and then press the [EXIT] key.

THE GOLD [ ] KEY

The gold [ ] key acts like a "shift" key on a typewriter (except you don't hold it down). When you press the gold key, the keys that have gold meanings written above them take on those meanings; thus the [EXIT] key becomes the [MAIN] key. And notice that when you have pressed the [ ] key, a little _↑ appears in the top of the display to tell you that some of the keys have taken on their gold or "shifted" meanings.

Thus, [ ] [MAIN] takes you to the MAIN menu, the menu that would be like the first set of signs you'll encounter along a freeway, allowing you to choose among several possible exits.

The boxes in the display now look like this:

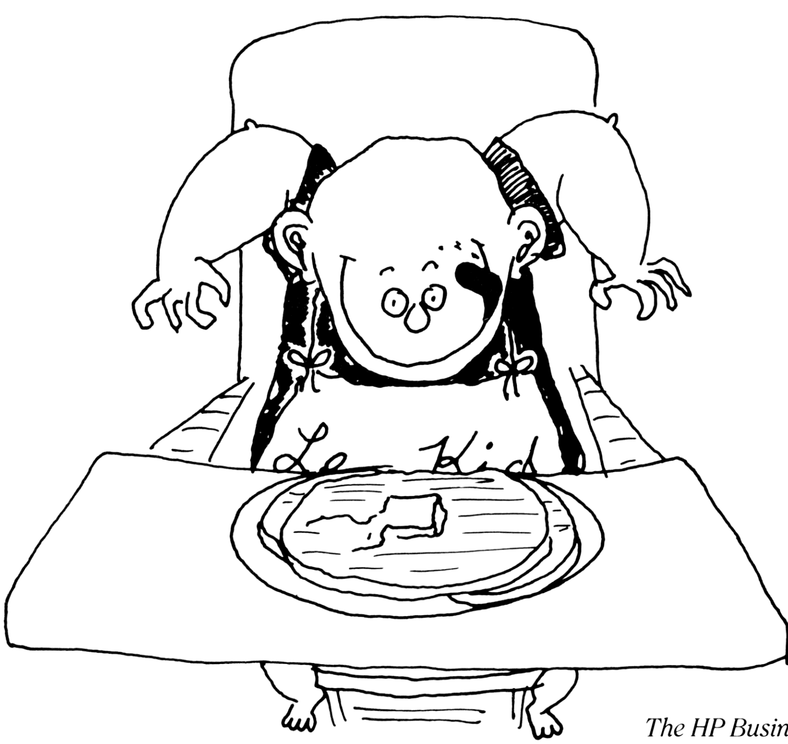
FIN BUS SUM TIME SOLVE MATH

MENUS

This picture shows you the “MAIN menu.” The calculator is offering you six possible routes to take. Notice that you can ALWAYS arrive at this menu — from wherever else you may happen to be — by pressing [ ] [MAIN] .

If you press the key under the box that says “TIME,” you’ve chosen to go from the “MAIN freeway” onto the “TIME highway,” so to speak. From here you may have other off-ramps to choose from — ramps that take you from the TIME highway onto various side roads — as the bottom line in the display now shows you.

As you can already tell, using the HP-18C is really just a matter of reading and obeying the road signs properly, so get used to the idea of menus as choices of “off-ramps” to other areas of the calculator. Then it’s only a matter of knowing where you are and where you want to go. And if you make a mistake, who cares? The machine might beep harmlessly to you to tell you it didn’t understand what you were asking it to do — but nobody else will know. So relax — even if you’re a “student driver” here, you won’t hurt anything or anybody if you make mistakes. And that’s how we all learn, don’t we — by making mistakes?



SETTING THE TIME AND DATE

Exercise:	To get used to working with menus — and with those blank menu selection keys — try setting the time and date on your calculator.
Solution:	Press [TIME] [SET] , key in the correct date and press [DATE] ; then key in the correct time and press [TIME] .

(If you had no problems doing this, press [ ] [MAIN] and turn to page 16.)

(If you attempted the above solution and the calculator beeped at you, press [ ] [CLEAR] [ ] [MAIN] and read this explanation.)

Explanation: This exercise is related to time, right? So your selection from the main menu would be [TIME] . Press the key right under that box.

Now look at the boxes. You're on the TIME highway (sounds sort of cosmic), but what road or street do you really want? Your destination isn't on the highway; it's on some street somewhere, and you must continue to choose among options to narrow them down to your actual destination.

CALC **APPT** **ADJST** **SET**

You want to set the time and date, so the best of the above choices seems to be [SET] . Press the key below that box.

Again, the calculator presents you with a whole new set of options, of which the first two are [DATE] and [TIME]. To set the date, you key in the correct date and press the key right below [DATE].

Exercise:	Give it a try: set the date.
Solution:	Again, read below if you don't already know how to do this.

(Too trivial? Turn to page 16.)

Explanation: In order to set the date, you need to be able to key in one number that represents the current date. For the date June 17, 1988, the month is number 6, the day is 17, and the year is 1988. You have to combine these digits into a single number that the calculator will recognize as a date.

For June 17, 1988, you key in either 6.171988 or 17.061988, depending on which date format the calculator is expecting. And you can always tell which format that is:

In Europe and most other parts of the world, the usual abreviation for the date is DD.MM.YYYY, with the Day before the Month and with periods (. .) or dashes (- -) used as the separators. By contrast, in the U.S. and Canada, the usual abreviation for the date is MM/DD/YYYY. That is, the Month comes before the Day, and slashes are used as separators (/ /).

Well, which format is the calculator now using in the date on the upper left? Then that's the format it expects you to use, too. But you can switch from one format to the other by using the [M/D] key on this menu. Try it!

So with the slashes in the displayed date, key in 6.171988 (or whatever the correct date is in MM.DDYYYY format), then press [DATE] . The calculator should display the correct date (6/17/1988) and, right below the date, the correct day (FRIDAY for June 17, 1988). Once you've set the correct date, you may never have to set it again, because the machine will keep time — even when it's turned off!

Exercise:	Now set the clock to the correct time.
Solution:	The procedure is below.

(Thoroughly bored? Then go ahead to page 16.)

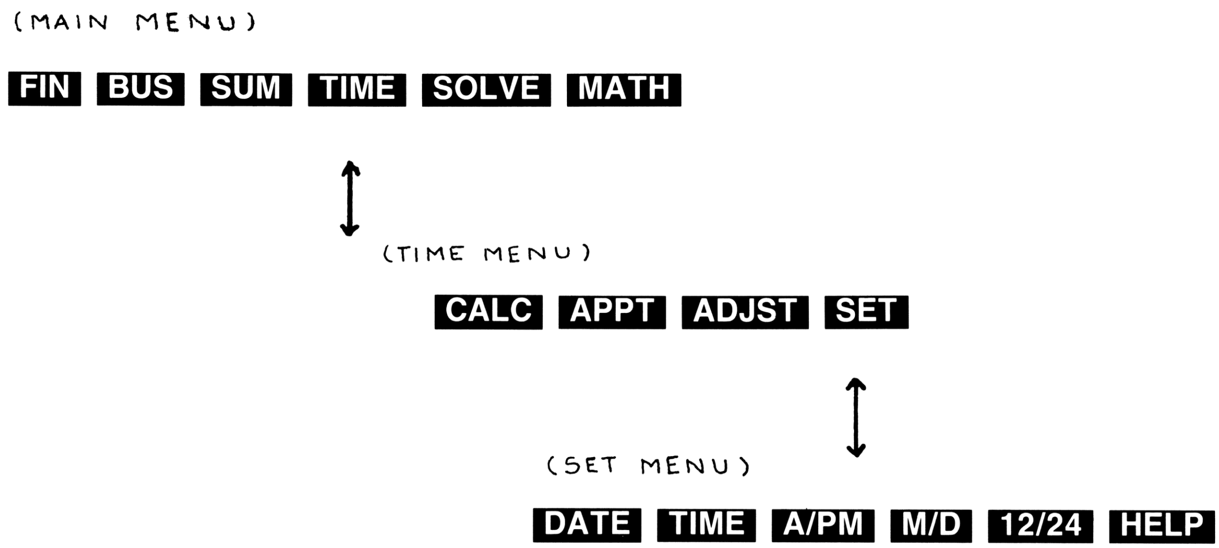
Explanation: Again there is a format question: What number do you use to represent the correct time?

Well, if it's 4:30 A.M., press 4.3 [TIME] (and then go back to bed).

The calculator is expecting the hours on the left side of the decimal place and the minutes and seconds on the right side (two decimal places each). Some would call this HH.MMSS format, which makes sense. And since the [A/PM] button switches from AM to PM and vice versa, you don't have to worry about using the 24-hour clock.

If it's 1:00 PM, key in 1 [TIME] [A/PM] . If it's 3:28:56 PM key in 3.2856 [TIME] [A/PM] . And if it's 10:05 AM, key in 10.05 [TIME] . Get the picture? OK...now set your calculator to the correct time.

Is your calculator displaying the correct time and date? The main reason for this time and date exercise was to get you accustomed to using the top row of keys (the blank "menu" keys) to move from menu to menu until you eventually reach your destination (i.e. what you really wanted to do in the first place).



This diagram shows you a "map" of the route you just took through the menus. It's important to have a good understanding of these "exits" and how to reach them. You already know that you can get back to the MAIN menu at any time by pressing [ ] [MAIN] (the shifted [EXIT] key).

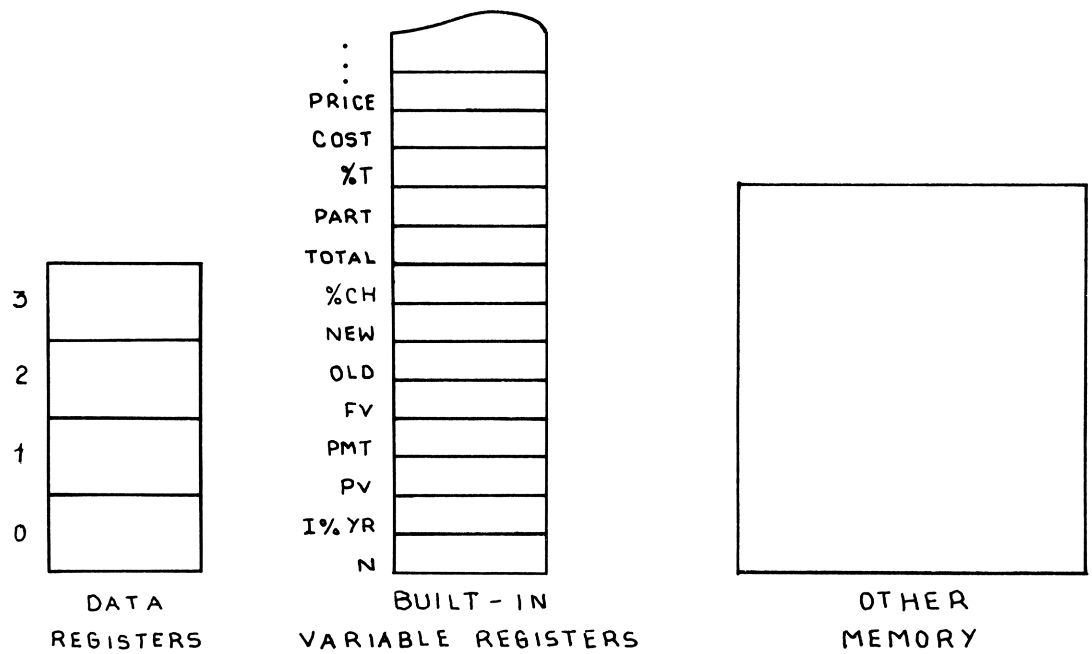
But what if you want to retrace your steps? What if you want to find your way back from a side road to a main road, then to a highway, and finally to the MAIN freeway again? You need to remember all the exits you took, right?

Just use the [EXIT] key.

The [EXIT] key will route you back to your most recent exit, thus letting you retrace your steps. Try it now: Press [EXIT] repeatedly and watch the display send you back from the SET menu to the TIME menu, then to the MAIN menu. It's that simple!

DATA REGISTERS

A calculator is, after all, a machine to store and combine numbers. So after knowing how to work with the menus of your HP-18C, the next step is to learn how it stores and manipulates numbers for you. Look at this picture:



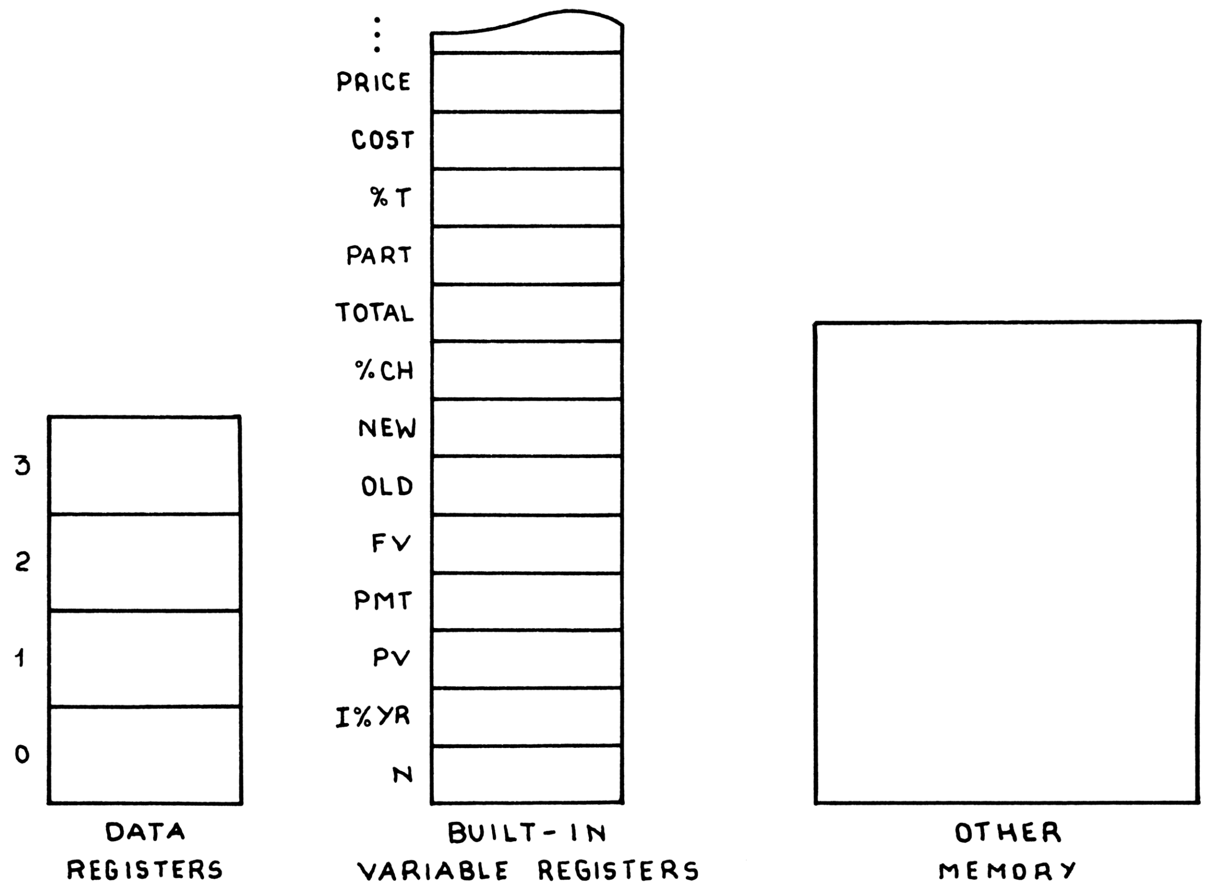
(If you know all about data registers and other memory, and if using [STO] and [RCL] is really old-hat for you, turn to page 20.)

Each of these boxes represents a "storage bin" in your HP-18C. The official term for these bins is "data registers," but all you need to picture is a set of cubby-holes (each with its own unique name) somewhere inside the calculator. Each of these data registers is a place where you can store one (and only one) number at a time.

When you want to change the number stored in any register, you simply store a new number there; this erases and writes over the old one.

Once you store a number in a register, it will usually stay there until you change it! That's what the "C" in "HP-18C" means — Continuous Memory, even when you turn the machine off.

Now look at the numbered data registers (0, 1, 2, and 3). These numbers are the unique names of those registers. When you want to store or recall a number from one of these registers, you use these number names.



Also in this picture, there is a block of data registers named N, I%YR, PV, etc., and OLD, NEW, %CH, TOTAL, etc. These registers are very similar to the numbered data registers — and they're just as easy to use.

But before you get into the details of using these registers, you probably ought to get "warmed up" a bit with the numbered registers....

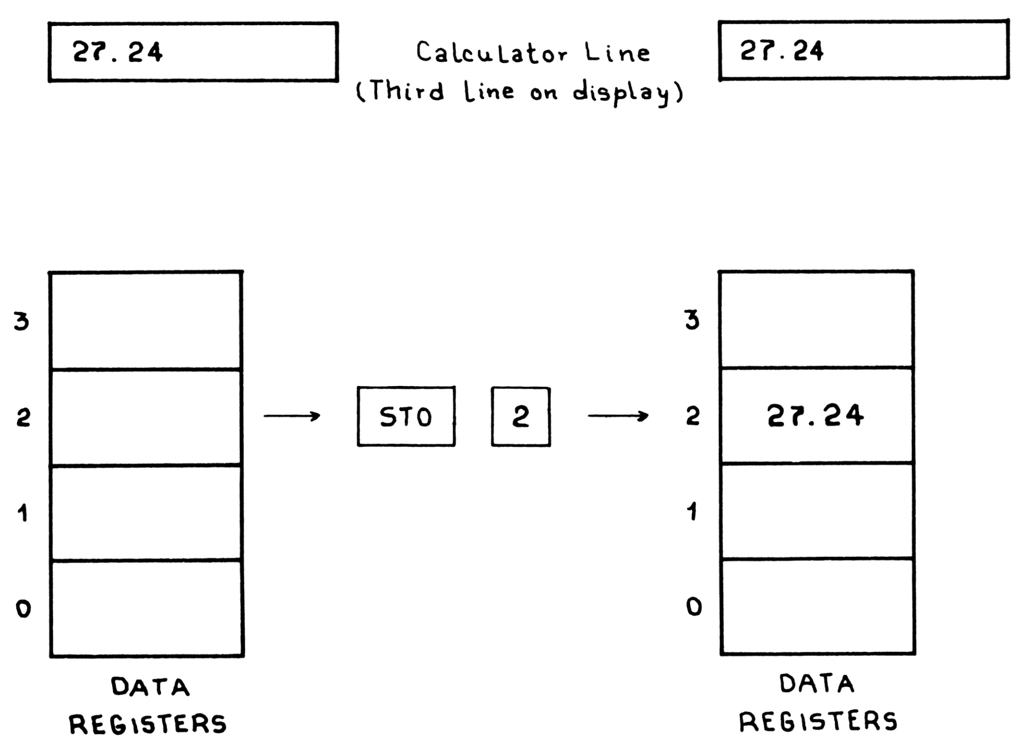
[STO] AND [RCL]

Exercise:	Store the number 27.24 in register 2.
Solution:	27.24 [STO] 2

(If you're already comfortable storing and recalling from the numbered data registers, you may now go on to page 20.)

Explanation: Whenever you key in a number, it goes on what's called the "calculator line" (the third line from the top in the display). To store the number you've just keyed in, just press [STO] and then name the register where you want to store it. A COPY of the number is stored in that register, erasing what was there before.

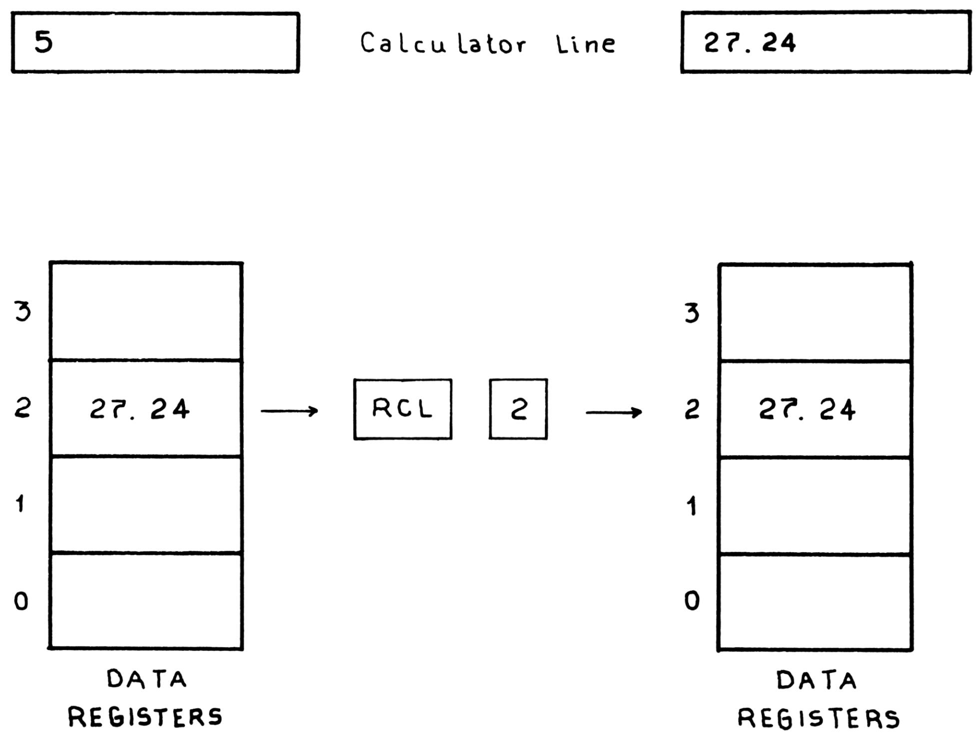
So after you key in the solution to the above exercise, the number 27.24 is stored on the calculator line AND in register 2, right?



Exercise: Key in a five, and then recall the contents of register 2.

Solution: 5 [RCL] 2

Explanation: When you press [RCL] 2, the 5 is bumped up in the display (and you'll soon see why), and the number in register 2 is copied to the calculator line.



Getting a fairly clear idea of how to store and recall numbers from registers? Remember that storing and recalling is a copying process — not a transferring process! After you press [RCL] 2, that number 27.24 is on the calculator line, but it's also still in register 2, where it will stay until you change it.

ARITHMETIC AND WORKING WITH NUMBERS

Of course, you can't store any important numbers until you learn how to calculate them, right? It's arithmetic time....

The display of the HP-18C removes all the mystery in calculator arithmetic. It's impossible to forget which keys you've pressed — because the display spells them out as you press them! And you can even recover results you got "several calculations ago" — without having [STO]red them — because they will probably still be in the display! You certainly won't find these conveniences in the displays of most calculators. But on the HP-18C...

IF ALL ELSE FAILS, LOOK AT THE DISPLAY

Now let's take a look at some ordinary arithmetic problems and at the list of results (or "history" list).

Arithmetic can be performed at almost any time, under almost any menu. For example, if you're in the middle of setting the time on your calculator and you need to know what 1.75 × 12 equals, just key it in: 1.75 [×] 12 [=]. You won't lose anything; you won't mess up the time menu; you can clear the result away or store it and continue with what you were doing.

> Exercise: What is 7.9 × 16.4?
>
> Solution: 7.9 [×] 16.4 [=]

No problem, right? You solve this by keying in exactly what you are saying to yourself: "Seven-point-nine [times] sixteen-point-four [equals] ..." and bingo! There's the answer: 129.56.

CHANGING THE DISPLAYED DECIMAL PLACES: [DISP]

Does the answer you have on your calculator line look exactly like 129.56? Are there zeros following it (for example, 129.5600)? How do you change the number of displayed decimal places?

Exercise:	Set the calculator to display 4 decimal places.
Solution:	[DISP] [FIX] 4 [INPUT]

(No problems? If you understand the whole DISPlay menu, move on to page 24.)

Voila! When you press the [DISP] key (in the second row of keys beneath the display), you are telling the calculator that you want to change something about the way it is displaying numbers. The menu that it offers you (like a trip down a side road) is this:

FIX ALL . ,

When you press the [FIX] key, you are telling the calculator to show you a fixed number of decimal places — always. It then tells you to type in the number of digits you want to see following the decimal point (0-11) and press [INPUT] . In the above example, you press 4 [INPUT] , and thus you see 4 decimal places (129.5600). Pretty straightforward, no?

But, besides [FIX], you have some other options! For example, what does [ALL] mean in the DISPlay menu? And what do [.] and [,] mean?

Well, [.] and [,] let you choose your decimal point to be either a comma or a period. People in Europe, Africa, and almost everywhere else in the world like to see the number "one million" displayed as:

1.000.000,00

(where the decimal point is a comma). But a small fraction of the world's arithmetickers (mostly in the U.S.) would prefer this:

1,000,000.00.

So choose whichever decimal point (radix) you prefer.

Now what does the choice [ALL] do? Well, it tells the calculator you want it to display ALL possible digits of every result — except for trailing zeros.

For example, the number on the "calculator line" at this time should be 129.5600. The number that the calculator is actually storing is 129.560000000 (always twelve digits). So if you choose the ALL option, the calculator will display 129.56. Notice how it chops off the irrelevant trailing zeros.

You'll be playing around with this more as you go along, but there is one very important point that you MUST understand:

The HP-18C ALWAYS stores AND calculates with 12-DIGIT NUMBERS.

The only rounding that's done is done IN THE DISPLAY — as you direct it to — but the display is an EDITED COPY of what's really in the calculator — like a window that may be open or partially shut — letting you view only a certain portion of what's inside.

Exercise: Now set the calculator to display 0 decimal places after the decimal point.

Solution: [DISP] [FIX] 0 [INPUT]

Notice that the number 129.56 has been rounded to 130. As you know, this rounding takes place ONLY in the display. In the calculator's internal register, you still have 129.560000000.

Exercise: Set the calculator to display 2 decimal places.

Solution: [DISP] [FIX] 2 [INPUT]

Now you see 129.56. The rounding that the calculator did in the display did not affect the number it's storing, right?

OK, enough of this fooling around and getting sidetracked here with the [DISP] menu.... Back to the arithmetic (...goody goody!):

Exercise: Increase 129.56 by 17%.

Solution: [+] 17 [%] [=]

Easy, right? The answer is 151.59.

Explanation: As usual, you key in arithmetic problems just as you would say them out loud. So far you have said: "Seven-point-nine [times] sixteen-point-four [equals] (129.56), [plus] seventeen [percent] [equals] (151.59)."

And again, that's exactly how you keyed it in! Notice that when you press the [%] key, the calculator immediately computes 17% of 129.56. The calculator does this whenever you're adding or subtracting percentages.

Exercise: (29 + 7) × (85 − 16) = ? Solution: 2,484.00

Explanation: You can key in the above problem just as it's written, OR you can take some shortcuts.

To key it in as it is written, press the keys [(] 29 [+] 7 [)] [×] [(] 85 [−] 16 [)] [=]. You literally type in all the symbols and numbers in the order that they're written.

The other way (the shortcut way) lets you save a few keystrokes by taking advantage of the fact that the HP-18C "crunches" things down as soon as it can and that it will close parentheses for you. The minimum keystrokes you can use are: 29 [+] 7 [×] [(] 85 [−] 16 [=].

(When you press [=], the calculator closes any open parentheses. [=]

THE HISTORY STACK

Whenever you are doing a lot of calculations in a row — without changing menus — the calculator automatically stores a list of the four most recent results (only three are shown in the display).

When you start a new calculation, the result from the previous calculation is stored in the display right above the new calculation. This four-number stack is the "history list" or "history stack" because it represents a (recent) history of your calculations.

You can use the numbers in your history list later in your calculations. Take a look at how this works:

First, if you aren't at the MAIN menu already, press: [ ] [MAIN] .

Exercise: Fill up your history list by doing the following calculations:

a. 9 × 16

b. 21.7 ÷ 12.4

c. 23.68 + 91.43

d. 67 − (29 ÷ 13)

Solution: a. 9 [×] 16 [=]

b. 21.7 [÷] 12.4 [=]

c. 23.68 [+] 91.43 [=]

d. 67 [−] [(] 29 [÷] 13 [)] [=] .

THE [←] AND [ ] [CLEAR] KEYS

If you make a mistake in performing any arithmetic, you can use the [←] key to "back out" of the error, or you can use the [ ] [CLEAR] combination to set the entire calculator line to zero — and start the calculation all over again.

If you've just successfully completed the last example, your history stack should now look like this (though only the bottom three numbers will be visible in your display):

144.00

1.75

115.11

64.77

THE [↓] AND [↑] KEYS

You can use the [↑] and [↓] keys to roll the numbers in the history stack up or down.

Exercise:	Add 4.75 to the 1.75 in the history stack.
Solution:	[↓] [↓] [+] 4.75 [=] (Answer: 6.50)

NOTICE that in order to do any type of calculation with a number in the history stack, you must FIRST move that number to the calculator line (Remember which line this is in the display? It's described on page 18.). So in this last example, you use the [↓] key to roll the numbers down until the 1.75 is on the calculator line. THEN you add 4.75, by pressing [+] 4.75 [=]. It's that simple!

THE [ ] [LAST] KEY

The [ ] [LAST] key is used to copy the number right above the calculator line down to the calculator line. So using the [ ] [LAST] key you can either: begin a new calculation with the result from your previous one; or you can use that result in your current calculation.

Exercise:	Divide the 144.00 in the history stack by the 64.77 that is right above it.
Solution:	[↓] [÷] [ ] [LAST] [=] (answer: 2.22)

Explanation: You can see what a powerful tool the history stack can be. You have four numbers that you can "roll" around, adding, multiplying, or doing whatever you wish to minimize your keystrokes and maximize your calculating enjoyment.

Practice some of your own exercises in the history list. One good exercise may be to store the whole stack in registers 0, 1, 2, and 3, and then recall them. Or use these numbered registers to reverse the order of the numbers in the history stack. The possibilities are endless.

One thing to remember is this:

THE HISTORY STACK IS NOT SACRED.

If you do so much as change menus the top three numbers will vanish, leaving only the number on the calculator line. So, if you want to preserve the numbers in the history stack while changing menus, you'll have to store them in the numbered data registers first. (Storing numbers is covered on page 18.)

We've covered quite a bit in these 27 pages. This may be a good point to take a break. Go get yourself a snack and, while you're eating, ponder the implications of moving around the HP-18C via menus. Sit back and picture in your mind the memory of the HP-18C, think about storing and recalling numbers from data registers, and think about the history stack. Have there been times in the past when you could have used a history stack? How are you going to make good use of it in the future?

When you get back, start out by working all the questions in this quiz. Some of the problems in the quiz deal with the MATH menu, which we have not addressed, but it works just like the other menus in the Business Consultant. So, don't hesitate to look at a solution first if you have no clue as to where you should start.

NOTES

QUIZ

(Work all of these problems. Don't hesitate to look at the answers.)

1. $-12 \times 65 \times (19 + 73) = ?$
2. $340 \div \text{LOG}(71{,}760.00) = ?$
3. $\text{PI} \times 75^2 = ?$
4. $(1 - \text{EXP}(-1.25))$
5. What's 25% of 77,653? Store the answer in register 3.
6. Decrease 77,653 by 25%. Add the answer to the number in register 3 without using the [RCL] or [LAST] keys. (If you don't already know about register arithmetic, look at the solution.)
7. Recall the number in register 3.
8. What's the cube root of 343?

SOLUTIONS

1. 12 [+/–] [×] 65 [×] [(] 19 [+] 73 [)] [=] (Answer: –71,760.00).

   Notice that the [+/–] key is used to change the sign of the most recent entry to the calculator line. It will change a number from a positive to a negative and vice versa.

2. 340 [÷] [ ] [LAST] [+/–] [MATH] [LOG] [=] (Answer: 70.02).

   By using the keys [ ] [LAST] [+/–] we're assuming that you had just worked problem 1 and that –71,760 is in your history stack. Also, on the main menu, there is a selection, [MATH], that offers you some common math operations. One of these operations is [LOG]. These operations act on the most recent number to appear on the calculator line. In this case, [LOG] takes the logarithm (base 10) of 71,760. Don't worry about what LOG means — this is just to let you know that the [MATH] menu exists.

3. [PI] [×] 75 [ ] [x^2] [=] (Answer: 17,671.46).

   [PI] is a key under the [MATH] selection from the MAIN menu. All it does is bring the number 3.14159...(pi) onto the calculator line. [x^2] is the shifted version of the [+] key. When you press [ ] [x^2] you square the most recent number to appear on the calculator line.

4. 1 [–] 1.25 [+/–] [EXP] [=] (Answer: 0.71).

   Again, the [EXP] key is a choice from the MATH menu.

5. 25 [%] [×] 77,653 [=] [STO] 3 (Answer: 19,413.25).

6. 77,653 [−] 25 [%] [=] [STO] [+] 3 (Answer: 58,239.75).

   Yes, you can add a number to another number in any register by pressing [STO] [+] and the register name. This is called register arithmetic. You can also use [STO] [−], [STO] [×], and [STO] [÷].

7. [RCL] 3 (Answer: 77,653.00)

8. 343 [ ] [∧] 3 [ ] [1/x] [=] (Answer: 7.00).

   Finding the third root of a number is the same as raising that number to the one-third power. The [∧] key is used to raise a number to some power.

LISTS, EQUATIONS, AND A LIST OF EQUATIONS.

The history stack is one example of a list in your HP-18C. The HP-18C is partial to lists; it likes to use them for storage purposes, so you should get used to working with them. In fact, you have already had a little practice — when you were dealing with the history stack back on page 24. Remember? You used the [↑] and [↓] keys to "move around" in the list and to bring a given number to the calculator line. Remember how these keys work, because you'll also be using them to "move around" in the other types of lists.

[SUM]

One of the options offered to you at the main menu is [SUM] . By choosing this option, you are telling the calculator that you have a list of numbers you want to store (a list of check amounts, sales figures, etc.). As you store this list, the calculator gives you a running total of the numbers in the list. Once the list is stored, you can have the calculator run statistical calculations on the numbers in the list (average, range, etc.), or you can save that list and key in another list of numbers.

All of the HP-18C's "statistical computing power" is in the SUM menu.

Exercise: Key in this list of numbers:

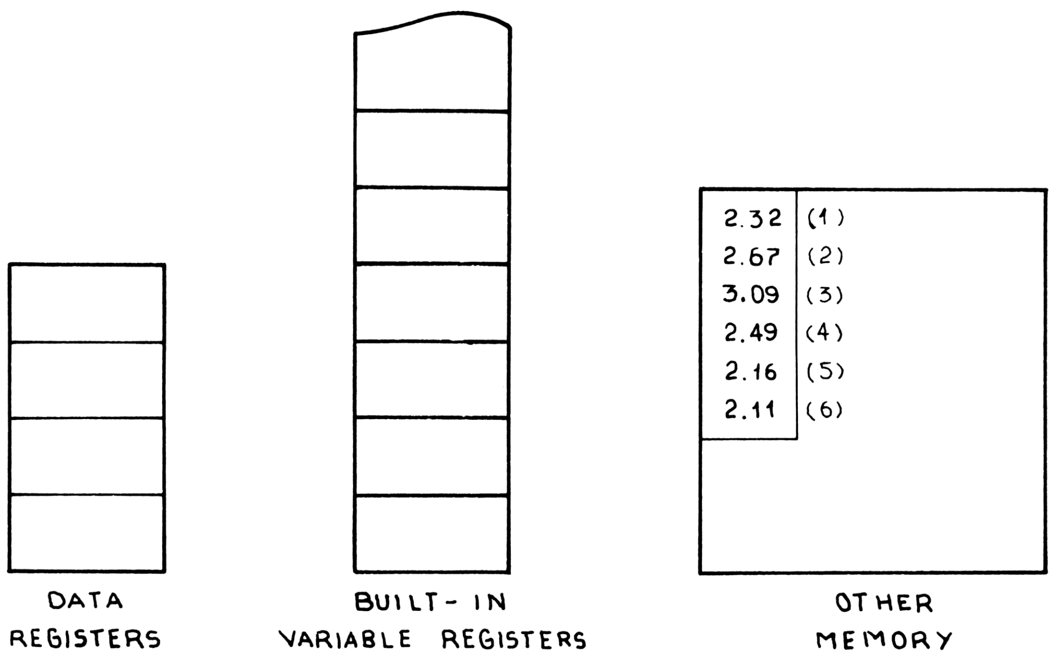
2.32	2.67
3.09	2.49
2.16	(7 ÷ 3.31)

Solution: From the main menu, press [SUM] ([GET] [*NEW])
2.32 [INPUT] 2.67 [INPUT] 3.09 [INPUT] 2.49 [INPUT] 2.16 [INPUT] 7 [÷] 3.31 [INPUT]

The keystrokes [GET] [*NEW] aren't necessary if you've never keyed in a number list. If, when you press [GET] [*NEW], the calculator beeps and says "CURRENT LIST UNNAMED, NAME OR CLEAR THE LIST," press [ ] [CLEAR ALL] [YES]. Then key in the above list.

Notice that when you key in the last entry, pressing [INPUT] completes your calculation.

When you complete the above keystrokes, you have a list of six numbers (ITEM (1) through ITEM (6) stored in your calculator. In the memory of your calculator, this is what this list looks like:



What you see in the display is the bottom of the list as it is stored in your machine. There is a little pointer (>) in the display positioned at ITEM (7), anxiously awaiting your next input. For some reason, this pointer (>) is called the "list pointer." If you were to key in a number now and press [INPUT], that number would go on the bottom of the list as ITEM (7).

On the calculator line of the display, the HP-18C keeps you informed as to the sum of all the values in the list (TOTAL = 14.84). Pretty slick, right?

Exercise: Change ITEM (2) from 2.67 to 2.64.

Solution: [↑] [↑] [↑] [↑] [↑] 2.64 [INPUT]

Simple, right? You just need to position the list pointer to ITEM (2), key in the new value, and press [INPUT]. The new value writes over the old value, the pointer hops to the next entry, and the calculator displays the new TOTAL (TOTAL = 14.81). You use the [↑] key to do the positioning.

If you want, you could take advantage of the fact that the keystrokes [ ] [↑] take you to the top of the list. By doing this you shorten the above solution to [ ] [↑] [↓] 2.64 [INPUT].

Exercise: Copy ITEM(3) to the bottom of the list.

Solution: [RCL] [INPUT] [ ] [↓] [INPUT]

Explanation: To recall an item from a list, just position the list pointer to that item and press [RCL] [INPUT]. Remember that when you press the gold [ ] key before you press one of the arrow keys, it means "go all the way" in that direction.

NAMING A NUMBER LIST

Exercise: Give this list a name. "TEST" would be a fine name.

Solution: [NAME] T E S T [INPUT]

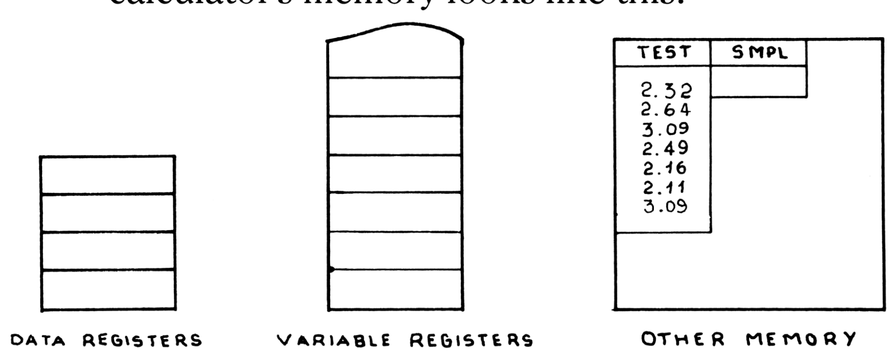
Notice, as you're working through the above solution, that the HP-18C tells you what you need to do next. It's actually quite hard to get lost when you're using this calculator.

Once you have given a list of numbers a name, it can be stored away permanently in memory until you decide to clear it. You can store several of these named lists in your calculator, updating them daily or weekly, doing statistical operations on them, etc.

Exercise. Create a new list and call it "SMPL".

Solution: [GET] [*NEW] [NAME] S M P L [INPUT]

Upon completing the above keystrokes, your calculator's memory looks like this:



You have just created a new list called "SMPL," but you haven't entered any data into it. The list pointer is sitting at ITEM (1), anxiously awaiting your first input.

Exercise: Key in the following list:

10.79

11.12

16.88

23.00

25.70

Solution: 10.79 [INPUT] 11.12 [INPUT] 16.88 [INPUT] 23.00 [INPUT] 25.70 [INPUT]

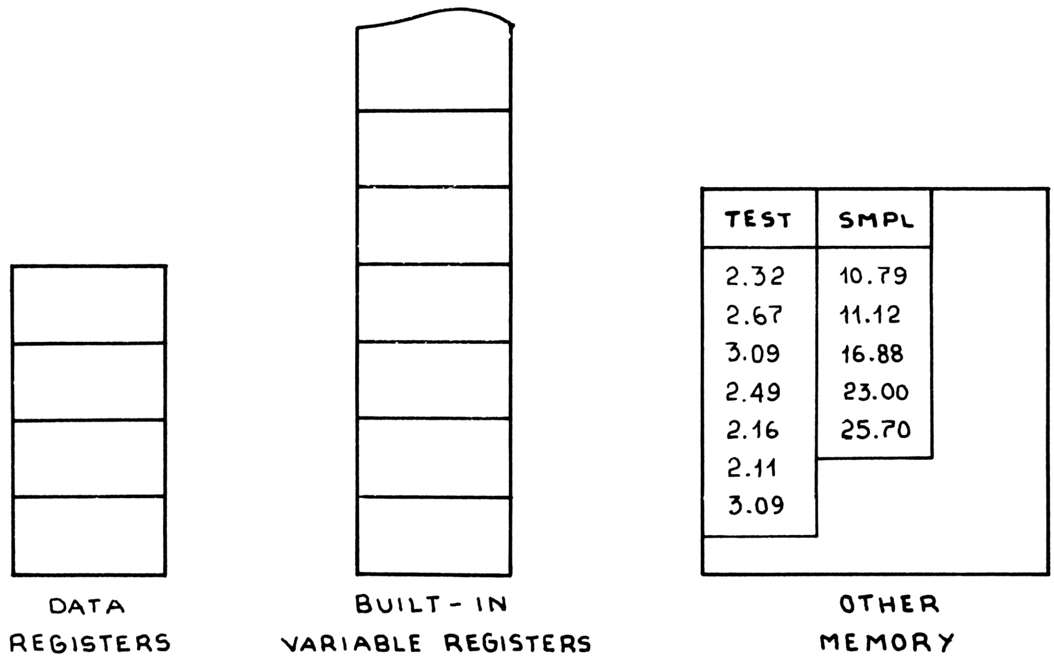
Exercise: Now, calculate the MEAN of the list called "TEST."

Solution: [GET] [TEST] [CALC] [MEAN] (answer: 2.56)

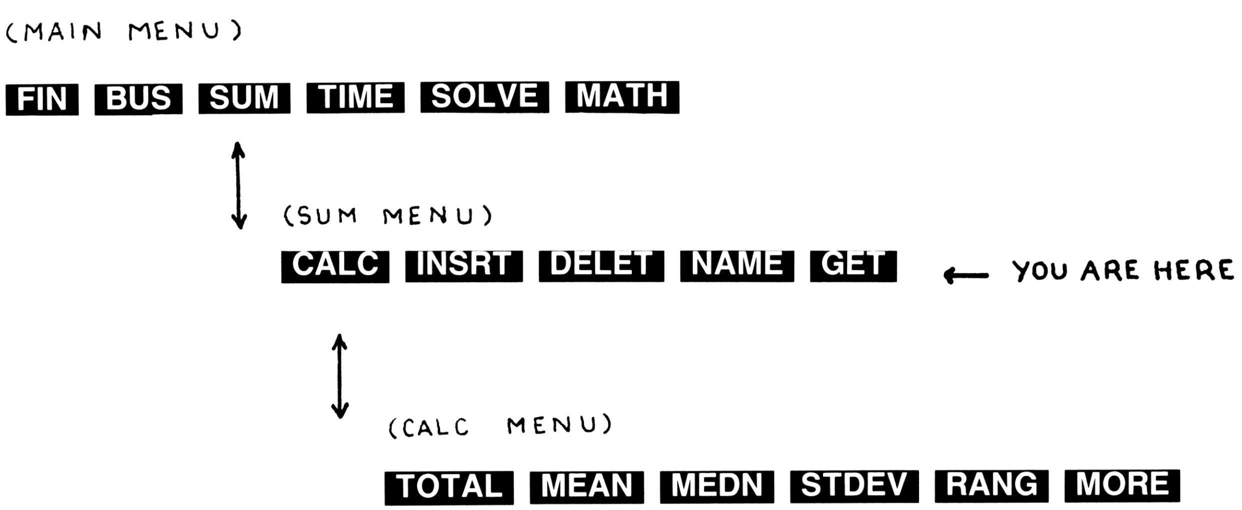
The calculator put the list "TEST" into storage when you created the new list "SMPL." In order to do any calculating with "TEST," you first have to tell the calculator to bring it out of storage. When you press [GET], the calculator displays all the SUM lists that you have stored by assigning them to keys in the top row. Both [SMPL] and [TEST] are on keys in the top row. When you press [TEST], the calculator tucks the current list ("SMPL") into storage and brings out the list "TEST."

Now the HP-18C is ready to do some calculations on "TEST." You press [CALC] and then choose which calculation to perform — in this case, [MEAN]. The calculator sums all the items in "TEST," divides by the number of items, and there's the answer (2.56).

Here's how the memory looks at the moment:



Press the [EXIT] key as needed to jump back to the SUM menu:

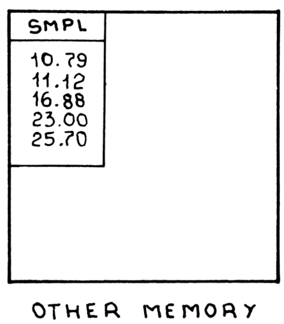


As you saw in this last exercise, the [CALC] option on this menu offers you a choice of calculations that you can perform on a list of numbers. Look at the other options on this menu. The only ones you haven't seen yet are [INSRT] and [DELET].

Practice inserting and deleting numbers from the "TEST" list at your own leisure, using the [INSRT] and [DELET] functions. Notice where the inserting takes place (BEFORE the item to which the list pointer is positioned).

Exercise: Clear the "TEST" list.

Solution: [ ] [CLEAR ALL] [YES] [YES]



Exercise. Clear the "SMPL" list.

Solution: [GET] [SMPL] [ ] [CLEAR ALL] [YES] [YES]

So you can kiss good-bye those two lists you created during the last few exercises; they're gone.

The purpose of these exercises was to get you more comfortable with the concept of having a list stored in your calculator. The lists you created were lists of numbers, and you created them under the [SUM] option from the Main menu. Now go back to the Main menu and look at one other type of list that you can store in the calculator (this, friends, is exciting — and remember, you heard it here first)!

A LIST OF EQUATIONS

Besides the history list and number lists, the HP-18C will store a personal equation list for you. This list is made up of the common equations that you use in your everyday calculations. First, try some exercises to understand some of the basics of using your personal equation list.

(If you already know how to manage your personal equation list AND how to use the SOLVE option from the MAIN menu, then you've ruined all the fun of telling you about it, so go ahead to the quiz on page 44.)

If you own a car, you may know how to calculate the amount of miles your car goes on a gallon of gas (your mileage). This is a common calculation, but even the EPA has difficulty doing it correctly. With the HP-18C, all you have to know is how to key in (once) an equation for mileage, and the calculator will be able to do that calculation for you repeatedly — whenever you pull into a gas station!

This equation isn't difficult to write down. Say you've just pulled into a gas station and filled your tank. To calculate your car's mileage, you need to know: how many miles you traveled since you last filled your tank; and how many gallons it just took to fill it. Your car's mileage is the miles traveled divided by the gallons used:

MILEAGE = MILES TRAVELED ON FILL UP ÷ GALLONS TO FILL UP

Look familiar? OK, now abbreviate and write it like this:

MILEAGE EQUATION: MPG = MILES ÷ GALLONS

If you have this equation in your personal equation list, then when you pull into a station, you just need to key in the miles you've traveled since your last fill-up and the amount of gas it just took to fill up; the calculator will then tell you your mileage.

Exercise:	Store this mileage equation in your calculator.
Solution:	[SOLVE] MPG [=] MILES [÷] GALLONS [INPUT]

(OK? Move ahead to the next exercise.)

To store your personal equation list, you need to take the [SOLVE] exit from the MAIN menu freeway (because eventually, you are going to ask the calculator to solve this equation). When you press [SOLVE], the calculator either displays your equation list or, if you have an empty equation list, it asks you to key in an equation. For this exercise, key in the equation as you see it on the last page, (using the alphabetical keyboard, too). Then press [INPUT].

If you make a spelling mistake, you can use the [←] key on the right side of the keyboard or the [←] and [→] keys on the alphabetical keyboard to help you correct that error before you press [INPUT].

When you press [INPUT] the calculator temporarily displays "VERIFYING FORMULA" and then stops with the formula on the calculator line. After you have gone through the above keystrokes, you have the formula (MPG = MILES ÷ GALLONS) stored in your HP-18C — simple!

Another petrol-related formula you will want in your personal equation list is the equation for converting liters to gallons. In the United States, when the price of gasoline went over $1 per gallon, a few dealers started selling gas by the liter (some type of psychological advantage, perhaps). So occasionally, in order to calculate mileage (in miles per gallon), you need to convert liters to gallons. And since most of us can't remember how many liters are in a gallon, just store this equation in the HP-18C (and let the calculator do the remembering for you):

GALLONS = LITERS ÷ 3.785

(This is the U.S. Customary gallon; the British Imperial gallon is 4.546 liters. The U.S. should switch to the metric system anyway. It's much easier in the long run — which is what we're all here for — an editorial message brought to you by the authors as a public service..and a private beef.)

Exercise:	Key in the above equation for converting liters to gallons.
Solution:	GALLONS [=] LITERS [÷] 3.785 [INPUT]

Notice that when you key in this equation, the previous equation is bumped up in the display. You're building your personal equation list! Once these equations have been keyed in and [INPUT], they will stay in your HP-18C until you purposely clear them. In the next chapter, you'll be learning to use these equations to make life simpler (at least the part of life where you calculate mileage). But first, try a few more exercises in editing this list of equations.

Exercise:	Change the word GALLONS in both equations to the abbreviation, GAL.
Solution:	[↑] [EDIT] [ ] [→] [←] [←] [←] [←] [INPUT] [↓] [EDIT] [→] [→] [→] [DEL] [DEL] [DEL] [DEL] [INPUT]

Explanation: There are two [←] keys on the keyboard, and they have different meanings: The one to use here is on the keyboard below the display. This key moves the cursor back AND erases at the same time. The [←] key on the alpha keyboard (left side, bottom row of keys) moves the cursor back WITHOUT erasing.

As you see from doing this exercise, in order to work with one of the equations in your personal equation list, you have to move it to the calculator line. You use the [↑] and [↓] keys to move up and down the equation list just as you used them to move up and down the number lists back on page 35.

Once an equation is on the calculator line, you can choose the [EDIT] option from the SOLVE menu, to make changes in that equation. When you press the [EDIT] key, the cursor appears at the first character of the equation on the calculator line. You can insert characters [INS], delete characters [DEL], and make other changes using the [←] and [→] keys to move through the equation. When you've finished making your changes, just press [INPUT], and the calculator stores the revised equation (erasing the original)!

One more thing to notice: When you press [ ] before any of the "moving around" keys ([ ] [→], [ ] [←], [ ] [↑], and [ ] [↓]), it means "go all the way." That is, [ ] [→] means "go all the way to the right," [ ] [↑] means "go all the way to the top," etc. In the above solution, after you press [EDIT] for the first time, the [ ] [→] sequence takes you all the way to the right of the equation. OK?

Now, go back to the Main menu (press [ ] [MAIN]). The equations will stay in the calculator, and you will be using them in the next chapter, but before you go on, try this quiz:

QUIZ

1. The last time you balanced your checkbook, the balance was $925.48. Since then, you have written seven checks:

26.46	97.25	7.42	11.93	47.12	51.95	63.68

   and made one deposit of (275.00). What is the new balance (use the [SUM] menu)?

2. Oops...you misread one of those check amounts. Suppose that 47.12 was actually 97.72. What is your REAL checking account balance? (The One Eternal Question everyone must ask)

3. At the middle of each month, your company has to deposit payroll taxes. Those deposits for the last seven months have been as follows:

1,173.27	1,425.91
1,044.13	1,207.70
1,348.46	1,194.50
1,093.06	

   So that you can predict your mid-month cash needs, calculate the average tax deposit.

4. Your actual tax deposit in the previous problem was 1317.62. The following month you want to do the same calculation (based on the previous seven months). So you need to add the 1317.62 to the bottom of the list, delete the 1173.27 from the top of the list, and recalculate the mean. What is this new ("moving") average?

SOLUTIONS

1. [ ] [MAIN] [SUM] [ ] [CLEAR ALL] [YES] 925.48 [INPUT] 26.46 [+/–] [INPUT] 97.25 [+/–] [INPUT] 7.42 [+/–] [INPUT] 11.93 [+/–] [INPUT] 47.12 [+/–] [INPUT] 51.95 [+/–] [INPUT] 63.68 [+/–] [INPUT] 275 [INPUT]

   (Answer: Total = 894.67).

2. From the last problem, key in [↑] [↑] [↑] [↑] 97.72 [+/–] [INPUT]

   (Answer: Total = 844.07).

3. From the last problem, press [ ] [CLEAR ALL] [YES] 1173.27 [INPUT] 1425.91 [INPUT] 1044.13 [INPUT] 1207.70 [INPUT] 1348.46 [INPUT] 1194.50 [INPUT] 1093.06 [INPUT] [CALC] [MEAN]

   (Answer: MEAN = 1,212.43).

4. From problem 3, press [EXIT] [ ] [↑] [DELET] [ ] [↓] 1317.62 [INPUT] [CALC] [MEAN]

   (Answer: MEAN = 1,233.05).

If you're having problems with deleting and inserting numbers in number lists, take some time now to practice on your own. Move up and down this list, and use the [INSRT] and [DELET] keys to insert and delete numbers as you wish.

SO...How do you feel about this machine of yours? Hopefully, it's starting to look like a very useful friend to you. After all, look at all the things you know how to do now:

- You know how to turn on your HP-18C. You may know that it turns itself off after a few minutes of sitting idle — to conserve batteries. But because it's Continuous Memory, you won't lose anything when this happens. And you know that the "C" in HP-18C means "Continuous Memory."

- You know how to picture the numbered data registers, and you have a rough idea of how to picture the rest of your calculator's memory. You know what the [STO] and [RCL] keys do. You know how to copy numbers to and from the calculator line and into data registers 0, 1, 2, and 3 (page 16).

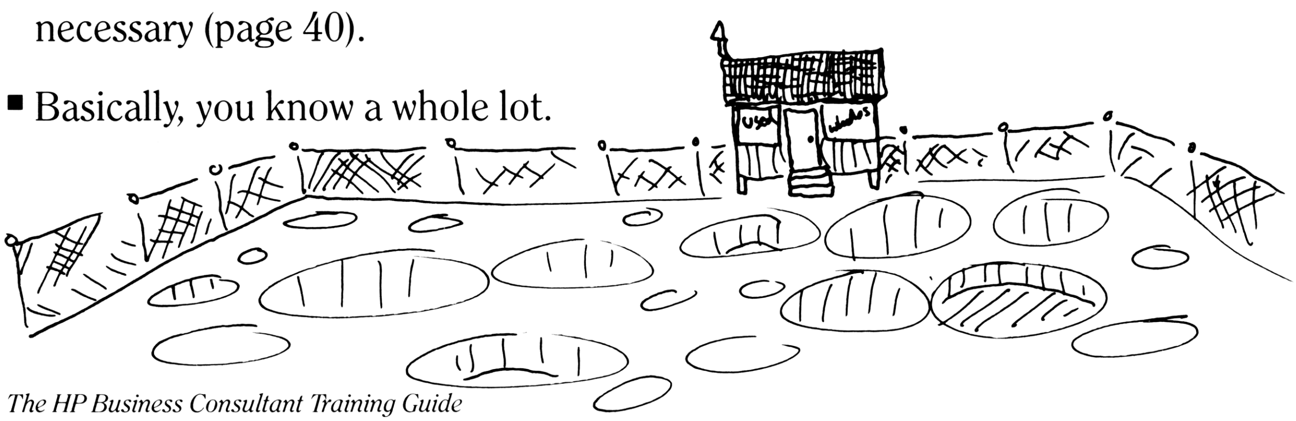
- You know how to do arithmetic. You know that you key in arithmetic problems in basically the same way that you say them out loud (page 20).

- You know how to key in one or more lists of numbers under the [SUM] option from the main menu. You know how to store and retrieve these named number lists. And you know that the [SUM] menu is where you'll find your statistics calculations (page 33).

- You know how to change numbers in a list and how to move through any list, using the [↑] and [↓] characters (page 35).

- You know how to key in a simple equation under the [SOLVE] option from the main menu. You know about the existence of your personal equation list, and you know how to move around in this list and how to change things when necessary (page 40).

- Basically, you know a whole lot.



NOTES

Chapter 2.

SOLVE! SOLVE! SOLVE!

A new chapter...a new session of learning (ah, the joy of discovery, etc., etc.)....

What does It all Mean?

Well, for one thing, it means the rest of the book will be even easier — now that you have the fundamentals down so well. And as you've noticed, everything about using the HP-18C IS truly easy to understand. In fact, with the exception of a few more details, you've learned just about all you need to know to work with your HP-18C.

Now, as you'll recall, just before you finished the last chapter, you stored two formulas into your calculator's memory — into your "personal formula list." So your list is now made up of two equations: one for calculating your car's mileage and one for converting liters to gallons. To get warmed up again here, try this:

Exercise:	You pull into a gas station to fill-up your car. You've gone 326 miles since you last filled your tank, and it takes 9.73 gallons to fill it this time. What mileage are you getting?
Solution:	[ ] [MAIN] [SOLVE] [↑] [CALC] 326 [MILE] 9.73 [GAL] [MPG]
	(Answer: MPG = 33.50)

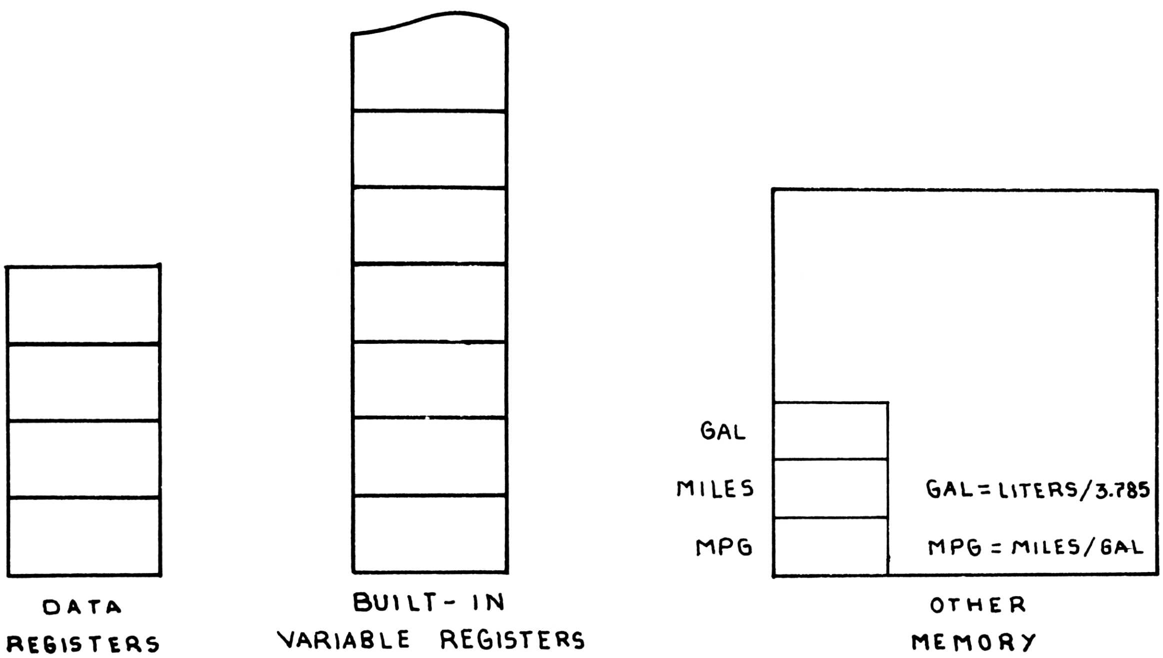
If this was truly trivial for you, and if you understand everything about variable registers and about calculating with your equation list, then skip ahead to page 56.

Otherwise, read on....

Explanation: First of all, remember when you keyed in the gas mileage formula (back on page 41) and then pressed [INPUT] to store it in your formula list? The calculator then verified that the formula was correct; it wouldn't have let you store it if it wasn't a valid formula (and you'll soon learn what a "valid formula" is).

Once your calculator has accepted your formulas as valid — and stored them for you, they're ready to use. Then, whenever you press [SOLVE] (from the main menu) and then [CALC] to use one of these formulas, certain things happen in the machine (do that now):

When you press [CALC] to work with this MPG equation, for example, the first thing the calculator does is to CREATE some new data registers in its memory, naming these registers MPG, MILES and GAL. These new registers take up space in that block of memory called "other memory."

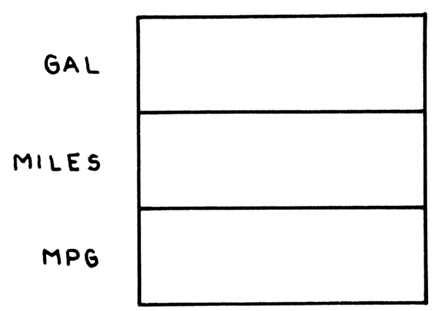


After creating these new variable registers, the HP-18C uses their names to build a custom menu. This means that the names of the variables in the equation are assigned to the top-row of blank keys, and you use this "custom menu" to store and calculate the numbers in these variable registers — just as you're used to doing in any of the other menus. These menu keys are now "variable" keys.

VARIABLE REGISTERS (VARS)

These new registers: MPG, MILES, and GAL are very similar to the numbered registers (0, 1, 2, and 3) that you've come to know and love already. To store a number in register MPG, you can press [STO] [MPG]. To recall a number from register GAL, just press [RCL] [GAL]. All the rules that apply to numbered registers also apply to these new registers. So any register that's not a numbered register is a variable register, agreed?

Most variable registers are ones that you give names to — when you write and store your personal formulas — names such as the three above (MILES, MPG, and GAL).



But these new registers are different from the numbered registers in two important ways:

The first difference is in the way you can store numbers into them. For example, to store 326 in the MILE register, you can press 326 [STO] [MILE] (which is the same way you might have pressed, say, [STO] 1);

OR you can just press 326 [MILE]. That is, you can skip the [STO] altogether!

The second difference is this: "Variable registers" are so named because they hold values in an equation — values that will vary because the machine will automatically recalculate them for you. (By contrast, any number that's sitting around in a numbered register WON'T change in any way until you store something new in that register.)

But how do you ask the machine to do this recalculating for you? It's simple — you just press the key of the variable you want to recalculate!

Hmmm....Something should be bothering you right about now: It seems as if you do the same thing either to store a number in a variable register or to calculate that number. Either way, you're just pressing the appropriate key on the variable menu, right?

Well, yes and no....

Here are the two rules for storing or calculating using variable registers:

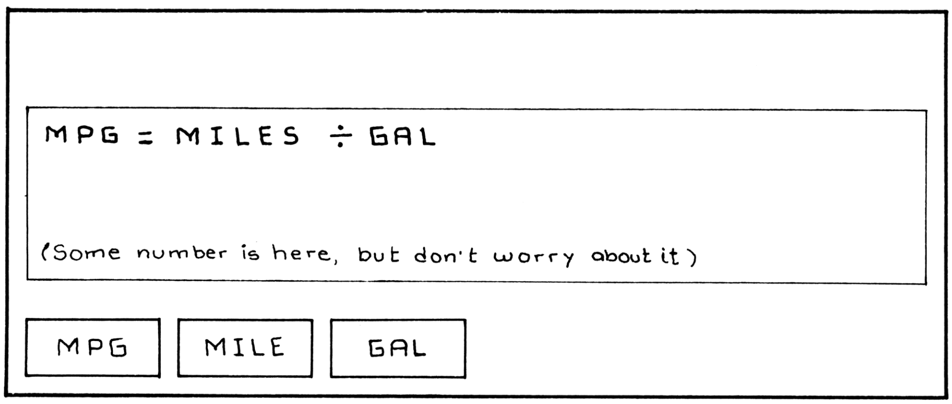
1. STORING A VARIABLE: If the LAST thing you did on the calculator was KEY IN a number, RECALL a number from a NUMBERED data register, or perform some ARITHMETIC, then pressing a key on the variable menu will STORE into that variable register.
2. CALCULATING A VARIABLE: If the last thing you did on the calculator was STORE a number into — or RECALL a number from — a VARIABLE register, or CALCULATE a variable, then pressing a key below a variable name in the display tells the HP-18C to CALCULATE that value.

Now that seems like a rather complicated little pair of rules to remember, but after a little practice, you won't even have to think much about it — like shifting gears on a car. So...time to practice:

Exercise: Store 326 in register MILES.

Solution: 326 [STO] [MILE] or 326 [MILE]

Before you start this exercise, your display should look like the picture below. If it doesn't, press [ ] [MAIN] [SOLVE] [↑] [CALC] (and notice that if you have other formulas in your list — besides the two that you stored there during chapter 1 — then you may have to use the [↑] [↓] keys more than once to get the pointer to the MPG formula on the calculator line; THEN press [CALC]).

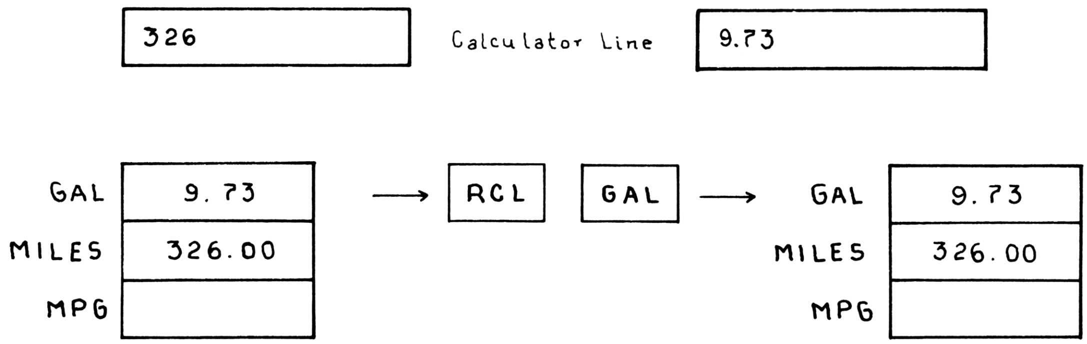


Explanation: When you store 326 in MILES, the calculator displays MILES = 326.00. This tells you that the calculator has 326 stored in the variable register MILES.

Interesting Note: If the calculator line shows an incomplete calculation (for example "26 + 300") then using the storage shortcut (leaving out the [STO] key) tells the calculator to complete the calculation (326) BEFORE storing the number. BUT, if you use the [STO] key, then the calculator will store only the most recent number that appeared on the calculator line (300). Try this: Key in 26 [+] 300 [STO] [MPG] ; then key in [ ] [CLEAR] 26 [+] 300 [MPG] . See the difference?

Exercise: Recall the number from [GAL] to the calculator line.

Solution: [RCL] [GAL]



Exercise: Store 9.73 in GAL. Then calculate MPG.

Solution: 9.73 [GAL] [MPG] (Answer: MPG = 33.5)

Explanation: Keying in 9.73 and pressing [GAL] tells the calculator that you want to store 9.73 in the variable register [GAL] (see rule #1, p. 52). Then, since you just stored in a variable register (see rule #2), pressing [MPG] tells the HP-18C to calculate MPG using the equation:

$$MPG = MILES \div GAL$$

with MILES = 326.000000000

and GAL = 9.73000000000

NOTICE that when it finishes calculating MPG, it stores a copy of the result in the MPG variable register, AND it displays the result on the calculator line.

Now, here's where the real fun begins — where you can really start to appreciate the power of working with formulas on your HP-18C:

Exercise:	How many gallons would it have taken to fill the tank had your car been getting 40 miles per gallon?
Solution:	40 [MPG] [GAL] (Answer: GAL = 8.15)

Exercise:	If you were getting 40 miles to the gallon, and it took 10.17 gallons to fill your tank, how far have you traveled since the last fill-up?
Solution:	10.17 [GAL] [MILE] (Answer: MILE = 406.80)

Explanation: The truly amazing thing about this SOLVE feature is that your calculator will solve for ANY variable that you want. Just supply it with values for all the other variables (according to rule #1 for storing in variable registers); and ask it to solve for the variable that you don't know (according to rule #2 for calculating variables). To solve, it uses the formula that ties ALL the variables together.

You may or may not be realizing the implications of what you have just seen. Though you have been applying this SOLVE concept to a fairly simple example, the possibilities are endless. If you own an HP-18C, all you have to know is how to correctly key in equations.

You don't even need to know how to rearrange equations, because THE CALCULATOR REARRANGES THEM FOR YOU, letting you play "WHAT-IF" by changing one variable at a time and seeing how that affects the value of any other.

It's revolutionary, really.

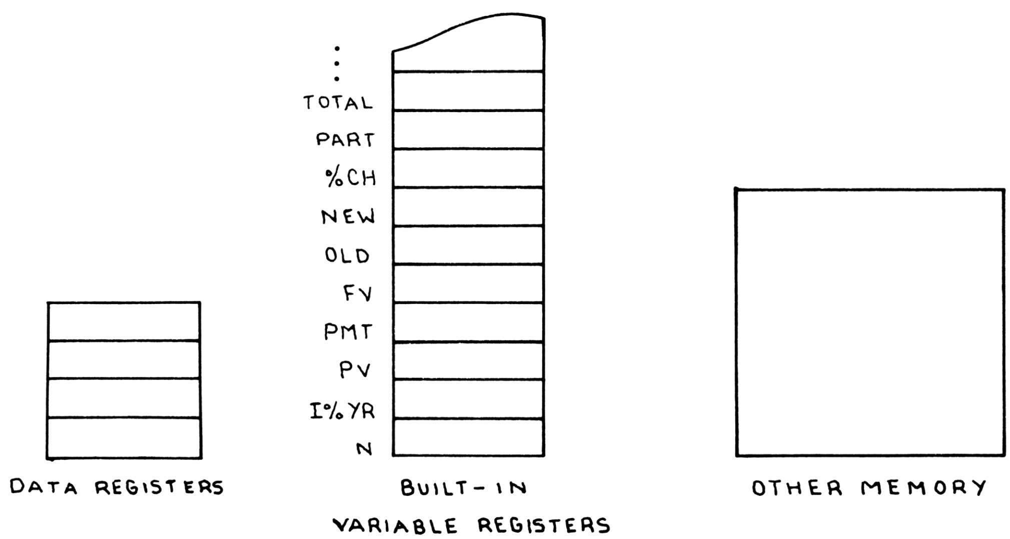
USING THE BUILT-IN EQUATIONS

For some more practice in this game of "What-If" before building up your formula list any further, take a look at how you can use the formulas that are already built into your calculator.

The HP-18C has several built-in formulas. In order to use these formulas, you have to go back to the MAIN menu (do this now: [ ] [MAIN]), and then choose either the [FIN] or [BUS] option.

These formulas are truly built-in; that is, you can't look at them in a formula list, nor can you change them in any way. But they work in much the same way as any calculation that you do under [SOLVE] . You don't need to know what the formulas are to work with them, just as you didn't need to remember the formula for calculating mileage once you had it keyed in. You just need to know how to get the calculator postitioned to that formula and what the variable names mean, right?

Furthermore, the variable data registers used by the preprogrammed formulas don't take up any of that "other memory." There is memory permanently set aside for these registers, as you may remember in this picture:



For some practice in working with formulas that use variable data registers, you're going to do some exercises using the preprogrammed formulas under the BUS option on the MAIN menu. The formulas under this option are fairly simple to explain and are good to use for practice. The formulas under the [FIN] option, however, require a chapter of their own (chapter 3).

Exercise: Go from the MAIN menu to the BUS (business) menu.

Solution: ([ ] [MAIN]) [BUS]

If this exercise gave you any problems, you may want to go back to the point that says LET'S ROLL and review. By pressing the [BUS] key, we simply took an "exit" from the "main menu freeway" onto the "BUS route" (Business route) to do some "business oriented" calculations.

%CHG **%TOTAL** **MU%C** **MU%P**

The calculator is offering you a choice. You can choose one of four formulas to work with. Your choices are [%CHG] (percent change), [%TOTAL] (percent of total), [MU%C] (mark up as a percent of cost), and [MU%P] (mark up as a percent of price).

Exercise: Last week in the grocery store, you noticed that the price of bananas was 34 cents a pound. This week the price has gone up to 39 cents a pound. What percent has the price of bananas increased in one week?

Solution: [%CHG] 34 [OLD] 39 [NEW] [%CH] (Answer: 14.71%)

No problems? Go to the next exercise.

Explanation: Because you're looking for the percent of change in the price of bananas, you choose to work with the [%CHG] formula. When you choose this equation, you are shown the following menu:

OLD **NEW** **%CH**

These are names of three variable registers that you've seen before in our memory picture (see page 16). You know that 34 cents was the OLD price for a pound of bananas, and 39 cents is the NEW price. So store these numbers in their respective registers, following rule #1 on storing in variable registers (34 [OLD] 39 [NEW]).

Then, to calculate the percent the price changed, press [%CH] . It's that easy!

Exercise:	The next week, banana prices go to 42 cents a pound. (A) What is the percent change from 34 cents? (B) What is the percent change from 39 cents?
Solution:	(A) 42 [NEW] [%CH] (Answer: 23.53% up from 34 cents) (B) 39 [OLD] [%CH] (Answer: 7.69% up from 39 cents)

(Again, if this is all fairly easy for you, skip to page 60.)

When you start this exercise, the OLD, NEW, and %CH registers look like this:

%CH	14.71
NEW	39.00
OLD	34.00

Explanation: The first thing you want to do is store 42 as the variable NEW. Just press 42 [NEW] . Because you're keying in a number right before pressing the [NEW] key, the calculator assumes you want to store (this is rule #1 from page 52). Now these registers look like this:

%CH	14.71
NEW	42.00
OLD	34.00

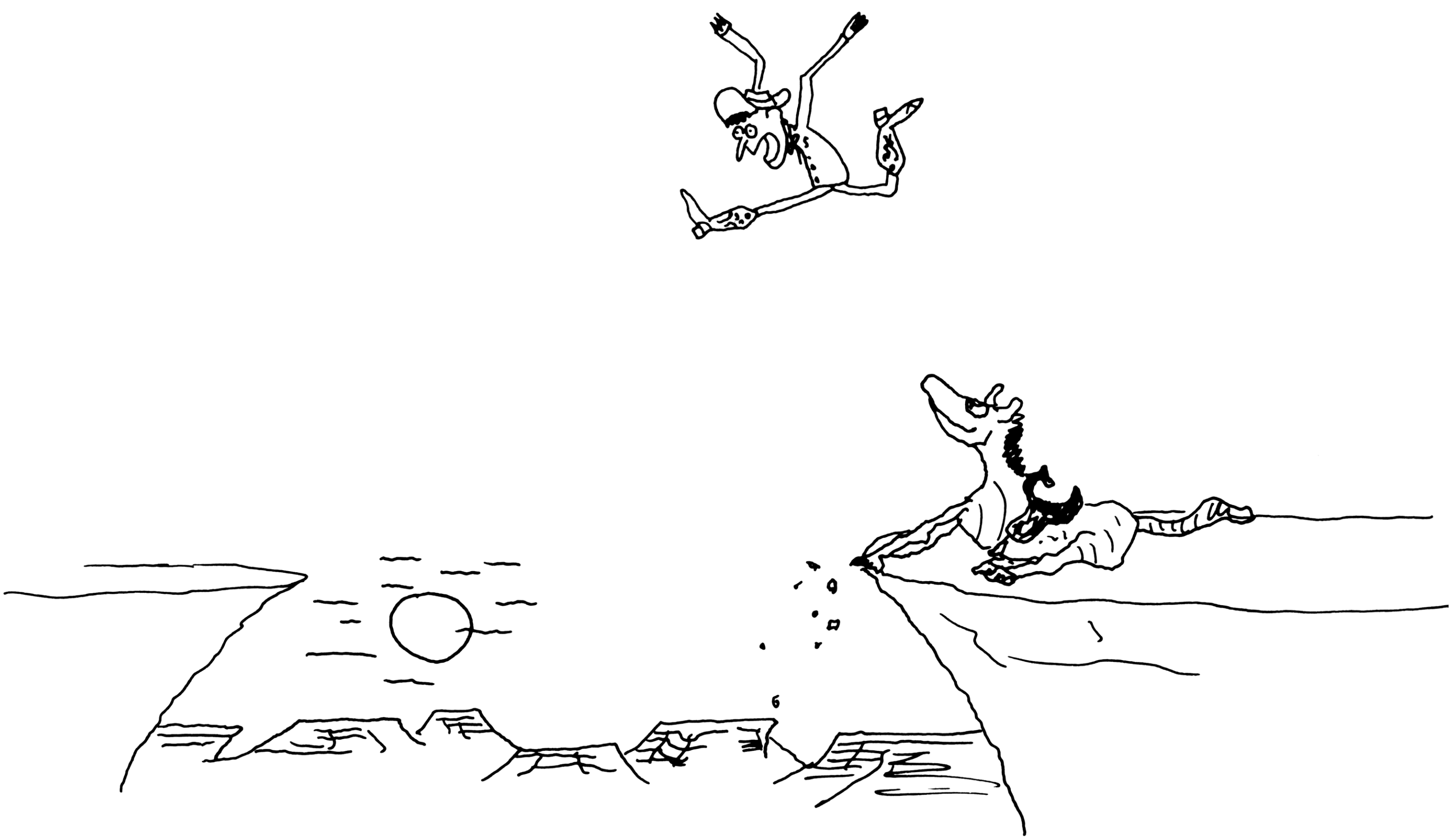
NEW is equal to 42.0000000000. You just stored it there and you want to calculate the new %CH. Press [%CH] . The HP-18C knows you want to calculate. Why does it know this? (See page 52 if you aren't sure.) After it finishes calculating, the registers look like this:

%CH	23.53
NEW	42.00
OLD	34.00

Are you getting the hang of it?

Exercise:	The next week, the price of bananas drops 11.9%. What is the new price?
Solution:	11.9 [+/–] [%CH] [RCL] [NEW] [STO] [OLD] [NEW] (Answer: NEW = 37.00)

Remember, you can solve for any variable in an equation. The calculator rearranges equations to solve for any variable. If it can't find a solution, it will tell you, but that's a rare case as long as your formulas are fairly simple.



Exercise: As a shoe store owner, you typically like to mark your shoes up to about 145% above your cost. This allows you to make a healthy margin if, by chance, someone buys shoes from you at the full price, plus it allows you to drastically cut your prices when you put your shoes on sale (a psychological advantage) and still come out ahead. If a pair of shoes costs you $26.50, what is the regular price at which you sell it?

Solution: [EXIT] [MU%C] 26.50 [COST] 145 [M%C] [PRICE] (Answer: 64.93)

If it's clear to you what's going on here, and you want to skip a heroic and swashbuckling explanation of MU%C, then go to the next page.

Explanation: This is a "mark-up as a percent of cost" problem, so you need to go back to the BUS menu and choose the MU%C formula. You do this by exiting from the %CHG formula (press [EXIT]) then press the [MU%C] key. The display will then look like this:

COST PRICE M%C

From here, you know the COST and what percent you want to mark it up (M%C), so key them in and solve for PRICE.

The answer is 64.93, but as a shoe store owner, you would round this up to $64.99. It only makes sense.

Exercise:	Two months later it's time to put that $64.99 pair of shoes on sale. You are going to reduce the price 30%. What is the sale price?
Solution:	[EXIT] [MU%P] 30 [M%P] 64.99 [PRICE] [COST] (Answer: 45.49)

Explanation: In this solution, it's better to think of the variable name M%P as Margin as a percent of price. The PRICE is the original price, COST is the sale price.

NAMING VARIABLES

Another formula that you could have used to calculate the regular price of your shoes is %CHG. Using that formula, you would store 26.50 as OLD, 145.00 as %CH, and calculate NEW. This is because, mathematically speaking, the equation for %CHG and for MU%C are the same. The only things different about the two equations are the variable names. The variable COST is the same as OLD; M%C is the same as as %CH; and PRICE is the same as NEW. The math is the same for both equations, but it's easier to work markup problems using the variable names COST, PRICE, and M%C, right?

$$100 \times (1 \div \text{OLD}) \times (\text{NEW} - \text{OLD}) = \%\text{CH}$$

$$100 \times (1 \div \text{COST}) \times (\text{PRICE} - \text{COST}) = \text{M}\%\text{C}$$

The reason that HP went to the trouble of programming in the same equation twice — using two sets of variable names — is either one of the following:

1. They knew that understandable variable names make equation solving much easier.

2. They made a mistake.

Since, as a general rule, HP doesn't make very many mistakes, you can assume that reason #1 was their motivation. So take heed! In keying in your own formulas using [SOLVE] , be sure that the variable names you use are somewhat understandable.

Now try this quiz, which uses some of the different built-in equations. As you can see, the solutions are quite simple, once you recognize what kind of problem you're looking at — and therefore which equation to use in solving it:

QUIZ

1. QUESTION: 29 is what percent of 41?
2. The number 43 is 65.15 percent of what number?
3. Exactly how many days are there from April 3, 1987, to June 7, 1989?
4. What date is 280 days after April 3, 1987?

SOLUTIONS

1. [ ] [MAIN] [BUS] [%TOTAL] 41 [TOTAL] 29 [PART] [%T] (Answer: 70.73%)
2. Still at the %TOTL menu press 43 [PART] 65.15 [%T] [TOTAL] (Answer 66.00).
3. [ ] [MAIN] [TIME] [CALC] 4.031987 [DATE1] 6.071989 [DATE2] [DAYS] (Answer: ACTUAL DAYS = 796). This is a built-in formula that's used to calculate dates and days between dates.
4. Press 280 [DAYS] [DATE2] (Answer: 01/08/1988 FRIDAY)

DID YOU KNOW...?

As you'll probably be reciting in your sleep by now, you know that data registers will keep the numbers that are stored in them until YOU change them, right?

Well...ALMOST always (you can't believe everything you read). There are a few instances where certain variable registers will be cleared (i.e. set to zero) automatically:

The variable registers that you use under the BUS menu and TIME menu clear themselves whenever you go back to the MAIN menu. So when you first enter these menus, if you press [RCL] [%CH] for example, it will always be zero.

Also, if you ever change one of the formulas in your personal formula list, all of the registers associated with that formula will be set to zero.

Those are a couple of the instances when registers will automatically clear themselves. These are really just nagging little details that will seldom affect your calculations, but just in case, it's nice to know you don't have to send your calculator in for repair.

Now is a good time to take a break. If you want to, step out and take a walk, stretch your legs and your mind. On your way, think about how the built-in formulas work. (Aren't those percentage formulas handy?)

When you get back, you can choose either to look more at the SOLVE menu or at the FIN menu, which explores the financial calculating capabilities of the HP-18C.

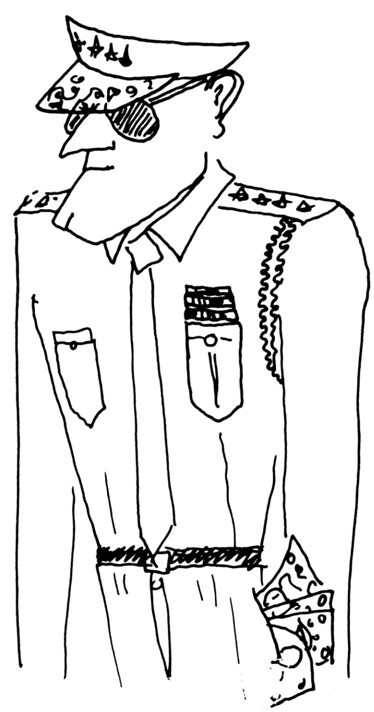
So how do you like your tour guide up to now? Are things making sense and sticking with you? If so, that's good; if not, that's not bad — it just means you need to give it some more time and thought. As you can see, no matter how involved the subject, if you just take things one at a time and at YOUR speed, they all iron themselves out eventually.

Now, are you ready for some more ironing? The remainder of this chapter discusses SOLVE in more detail. You'll see how you can develop your own formulas to solve your daily calculating challenges and how, if you're a student, the HP-18C can help you with some of the tedious details.

Also, you'll see what the HP-18C does when a formula produces more than one possible value for a variable — and how you can help your HP-18C find a solution to such a complicated formula.

If you would rather put off learning more about SOLVE until after you have explored the financial calculating capabilities of your HP-18C, then now is the time to do that procrastinating.

You know all about working with variable registers and preprogrammed (built-in) formulas. Chapter 3 (starting on page 114) covers the built-in formulas under the [FIN] key on the main menu. There, you'll learn about the time value of money, cash-flow analysis, and finance in general. If this is where your interests lie (no pun intended), turn to chapter 3.



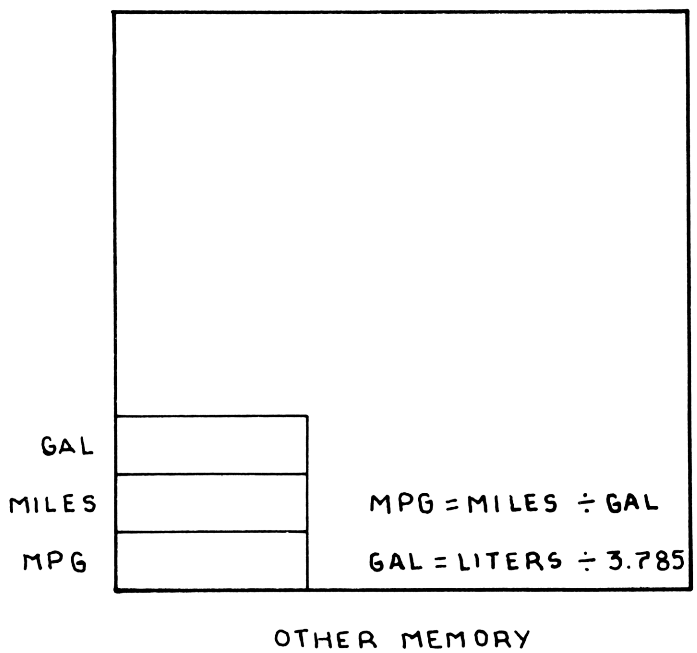
YOUR EQUATION LIST

Remember that formula list that you stored in your calculator back in chapter 1? The two equations that make up this list are:

MPG = MILES ÷ GAL

GAL = LITERS ÷ 3.785

These two equations are stored in the calculator so that "other memory" looks something like this:



Along with the formulas, there are three data registers (MPG, MILE, and GAL) that were created for the mileage calculation back on page 49.

NOTICE that the variable data registers that your formulas use are not created UNTIL you calculate with that formula (by pressing [CALC]) for the first time. But once these variable registers have been created, they stay in the machine until you clear them away. (Remember what a variable register is? To review, look at page 51.)

Exercise: Recall the last numbers that you stored in the registers MPG, MILES, and GAL.

Solution: [ ] [MAIN] [SOLVE] [↑] (move the MPG formula to the calculator line) [CALC] [RCL] [MPG] [RCL] [MILE] [RCL] [GAL] (Answer: MPG = 40.00, MILES = 406.80, GAL = 10.17)

Explanation: The important thing to notice here is that the values for those variables haven't changed since you last left them back on page 55 (or sometime more recent if you've been experimenting with them on your own — which is OK!). Like the numbers in the numbered data registers, the numbers in variable registers are generally stored until you change them or until you change the formula that uses them (with some exceptions, as you read on page 65).

Exercise: You pull into a gas station to fill up your tank. You've gone 374 miles since you last filled up. This time, it takes 47 liters to fill up. How many miles per gallon is your car getting?

Solution: First, move the formula pointer so that the liters conversion formula is on the calculator line. Then: [CALC] 47 [LITER] [GAL] [EXIT] [↑] [CALC] 374 [MILE] [MPG] (Answer: MPG = 30.12)

Is this so simple that it's boring you? If so, try the next section (turn the page). Otherwise, read on.

Explanation: When you press the [EXIT] key, you should see your list of formulas in the display (if you have only our two formulas in your formulas list, you will see the MPG formula on the calculator line).

The exercise asks you to calculate "miles per gallon (MPG)," but it gives you the amount of gas in liters. So the first thing you need to do is to figure out how many GALlons of gas you just purchased. So move the conversion formula onto the calculator line (press [↓]). The calculator line should read GAL = LITERS ÷ 3.785.

Now press [CALC] .

What happens when you press [CALC] for the first use of a particular formula? We haven't done any calculating using this formula yet, so what does the HP-18C do when you press [CALC] ?

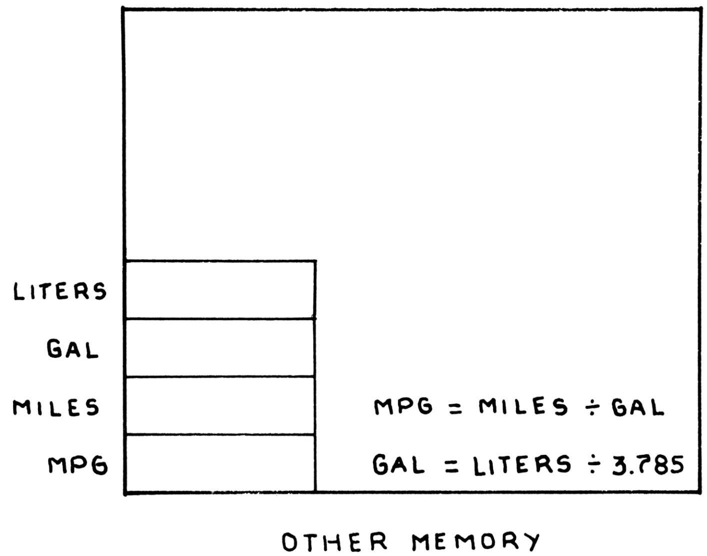
"Mmmm...it creates some variable registers, right?"

Exactly. That is, it creates them IF they haven't already been created. In this case, there are two variable names in the equation: GAL, and LITERS. But a register named GAL has already been created. So the calculator has to create only one register, which it names LITERS.

SHARED VARIABLES

The variable GAL is called a "shared variable." It appears in both of the equations in our formula list WITH EXACTLY THE SAME NAME. When you press [CALC] to use the liters conversion formula, the calculator notices that it has already created a variable data register called GAL, so it DOESN'T create another.

After you press [CALC] , your memory looks like this:



and the menu looks like this:

GAL **LITER**

To start the calculation, you press 47 [LITER] [GAL] . These keystrokes store 47 in register LITERS and calculate GAL using our conversion formula. The HP-18C tells you that 47 liters is the same as 12.42 gallons.

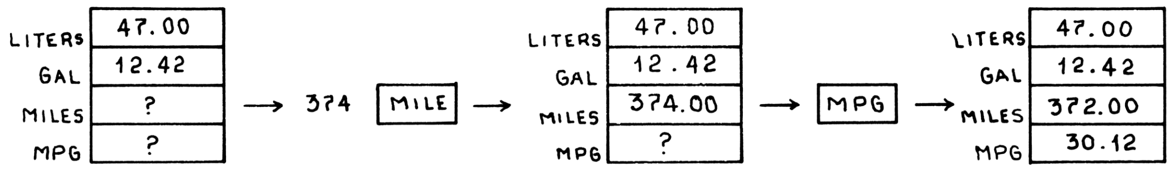
Once you have converted the amount of gas into gallons, you need to use the other formula in our list to calculate your mileage. Press [EXIT] to see your list of formulas, move up to the MPG formula by pressing [↑] , and then press [CALC] . The menu looks like this:

MPG **MILE** **GAL**

Because GAL is a shared variable between these two formulas, the result from your liters conversion (12.42) is ALREADY stored in GAL, right? (But you can press [RCL] [GAL] if you want to make sure.)

So all you need to do is to store the number of miles in MILES and calculate your MPG. Press 374 [MILE] to store the number of miles then press [MPG] . You are getting 30.12 miles per gallon — not bad.

Look at these pictures that show you what you just did:



And that's all there is to shared variables. A shared variable is just a variable data register that is used in more than one formula. Simple.

By now, you're probably getting nauseous from the gasoline fumes, so that's enough of the mileage calculations to last you for a while.

NAMING YOUR FORMULAS

But what if, the next time you pull into a gas station you forget which formula to position on the calculator line to compute mileage? How can you remember what the MPG equation is used for?

Well, it's possible (and advisable) to name that equation. Insert the letters of the name before the equation and separate the name from the equation with a colon (:).

Exercise: Name the MPG formula "MILEAGE" and the liters conversion formula "LTRS*GALS."

Solution: Position the MPG formula to the calculator line and press [EDIT] . Then press [INS] eight times and type MILEAGE: [INPUT] . Next, position the liters conversion formula to the calculator line and press [EDIT] [INS] [INS] [INS] [INS] [INS] [INS] [INS] [INS] [INS] [INS] LTRS [ ] [x] GALS: [INPUT] . These formulas are now named.

Notice that if you press the gold [ ] before the [x] key, you get an asterisk. This is explained in more detail on page 97.

TRANSLATING YOUR DAILY CHALLENGES INTO FORMULAS

If you use any calculator, you use formulas or "equations." For example, everytime you add numbers on your calculator, you are using this equation: A + B = C. "A" is the first number you key in, "B" is the second, and "C" is the number that comes up after you press the [=] key. With the HP-18C, life can be made a lot simpler if you translate the more complicated calculations into equations that you store in the calculator's memory.

Developing the right equations to meet your daily calculating challenges can be a little tricky. It takes a little time and a little thought to develop an equation out of the keystrokes you normally use to resolve some situation. But you only have to do this once. And when you get it all keyed in and you've made sure it's correct, it becomes an impressive timesaver.

Here are some exercises that will help to give you some insight into developing your own equations — to make your "calculating life" easier. Also, these will give you a bit more practice in working with the equation solver and your personal equation list.

Exercise: As a construction contractor in the United States, you are responsible for ordering concrete to lay floors. Develop an equation or two that would help you figure out how many cubic yards of concrete to order for a certain job.

Solution: AREA = FTLEN × FTWIDE

CYDS = (AREA ÷ 9) × (INCH ÷ 36)

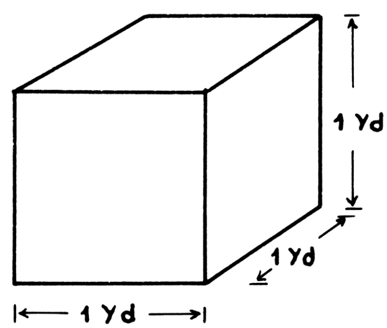
If you came up with a pair of equations similar to these, try the quiz on page 82.

Explanation: We all, at some time in our lives, have to measure areas. In the United States, the common units for measuring short lengths are yards, feet, and inches. (Just for the record, an inch is about this long: ________ ; there are 12 inches in a foot, and three feet in a yard or 36 inches in a yard.)

By multiplying them together, these units of length are used to calculate areas (square feet, square yards, or square inches).

Then, by taking areas and multiplying them by depth, you come up with a measure of volume (cubic inches, cubic feet, or cubic yards).

Now, if you ever buy a large quantity of dirt or sawdust for landscaping, or mixed concrete for laying a patio floor, the typical way to order it in the U.S. is by cubic yards. A cubic yard is equal to a cube with a length, width, and depth of one yard.



So, as a contractor, you have to order concrete by the cubic yard, and you have to order approximately the right amount because it comes in a truck, already mixed and ready to pour.

To get started in developing an equation for any situation, the first step is to visualize yourself going through the calculations for one fairly simple example. Make notes of the PROCESS (the recipe, if you will) involved in getting an answer for that one example. Then use these notes to try and "generalize" the example into an equation that can be used for almost any situation.

But, don't get hung up in these wordy explanations. Concentrate on the steps to take in approaching a problem, and then you'll get to summarize things a bit later.

Now, suppose you're the contractor walking through this hypothetical example of a concrete calculation. Here's what it means to "make notes of the PROCESS or RECIPE involved in getting an answer."

The example: You want to order enough concrete to complete a rectangular floor 25 feet by 30 feet and six inches thick. How many cubic yards of concrete do you have to order?

Well, in order to calculate the volume of concrete you need to order, you just multiply length × width × depth, right?

"Hmmmmm...let's see...that's 25 times 30 times...wait-a-second — I want to calculate cubic yards, but the 25 and 30 are in feet, and then there are inches in there too. What do I do?"

No sweat: You simply need to convert all the measurements into yards by the time you finish your calculation. Or, to put it another way, somewhere along the line, the equations you use have to take into account the fact that, as a contractor, you like to measure areas in square feet and you like to measure the depth of the concrete in inches. After all, it's much easier to say a floor is "six inches deep" than "one-sixth of a yard deep," right? So, take your measurements however you like, and build any necessary conversions right into your equations! Already, you're making some notes:

NOTE 1: Length and width measurements will be in feet. Thickness measurements in inches.

NOTE 2: In order to calculate the area, multiply length by width. Because area is in square feet, divide by 9 (9 square feet in a square yard) to get the area in square yards.

NOTE 3: Multiply the area by the thickness (but first convert the measurement from inches to fraction of a yard by dividing by 36) to get the cubic yards.

So the room in this example is 750 square feet (25×30) or 83.33 square yards. (There are 9 square feet, 3 × 3, in a square yard). To calculate the cubic yards of concrete you need to order, you just multiply 83.33 by $^1/_6$ of a yard. So if you were to do one single equation for this problem, it might look like this:

$$(FTLEN \times FTWIDE \div 9) \times (INCH \div 36) = CYDS$$

The variable names you choose should describe the units of measurement that the calculator is expecting (feet or inches). You chose them like this so that when you get back from your six-week tropical vacation (where you will do very few cubic-yards calculations), you can still remember what the variables in that equation mean.

Out loud, you would probably say this equation as "Feet-in-length times feet-in-width divided by nine, times inches-in-depth divided by thirty-six, equal cubic yards."

Starting to get the idea? Now try this:

Exercise:	Key the above equation into your calculator and calculate the number of cubic yards of concrete to order for a 6 inch floor, 25 feet by 30 feet.
Solution:	[ ] [MAIN] [SOLVE] [(] FTLEN [×] FTWIDE [÷] 9 [)] [×] [(] INCH [÷] 36 [)] [=] CYDS [CALC] 25 [FTLEN] 30 [FTWI] 6 [INCH] [CYDS] (Answer: CYDS = 13.89)

If this was a (tropical) breeze for you, then try the Quiz on Page 82 (before you make your plane reservations).

If you have trouble keying in the equation, you may want to review pages 40 to 43. If you have other questions, keep going here....

Explanation: When you press [SOLVE] and begin keying in this equation, the calculator inserts it into your list right below the equation that was on the calculator line. You don't have to move to the bottom of the list before you start typing.

You can use the two arrow keys [←] and [→] on the alphabet side of the keyboard, along with the [INS] and [DEL] keys to correct any errors. To correct, you can just type right over the error, or you can use DELete to erase the character under the cursor, OR you can use INSert to make room for one character before the cursor.

When you press [CALC], if you get the error "INVALID FORMULA," you may have broken one of the HP-18C's rules for keying in equations. Check to see that you put in all the parentheses, multiply signs, etc. You MUST key in a valid formula (and "valid" is dictated by the calculator). The calculator won't close parentheses for you or correct any other type of error. It simply tries to make sense of what you type. Here are a few rules to keep in mind when you're keying in an equation:

1. Use multiply signs (×) where they are necessary. The calculator will understand the equation AX + B = Y as a variable "AX" plus a variable "B" set equal to a variable "Y." If you want it to take "AX" to mean "A" times "X," you have to key in "A × X."

2. The calculator has an order of preference in which it performs certain operations. It doesn't just work from left to right as it does with arithmetic. In the equation A + B × C = D for example, it will multiply "B" and "C" before it adds in the "A." If you want it to add "A" and "B" first, you need to key in the equation like this: (A + B) × C = D. So unless you usually put things in parentheses, you need to remember these rules:

   In a formula, exponentiations (^, and SQRT) take precedence over multiplication and division (× and ÷), which, in turn, come before addition and subtraction (+ and −).

NOTICE that pressing [CALC] right after you finish keying in an equation is the same thing as pressing [INPUT] [CALC]. The calculator will check to see if the equation is O.K. before it stores it in your list.

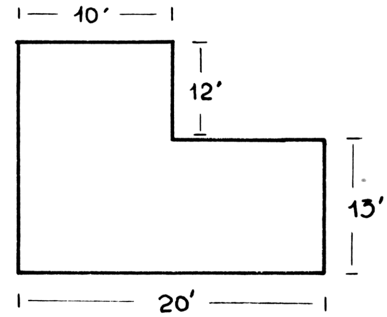
SUMMARY

In developing this equation you did the following:

1. You identified the problem you wanted to solve using the [SOLVE] menu on your HP-18C.
2. You worked through a simple example, making notes along the way about which things were multiplied together, which were added together, etc.
3. You chose understandable variable names for each of the values. You paid attention to the units of measurement and how you converted from one set of units to another.
4. You wrote down an equation that would work for this simple example, and then you tried it out.

Hopefully, by using this method to develop a formula, you've come up with a good way to figure out answers not only for this one simple example, but for many different situations. Let's see....

Exercise: You have to order concrete for a 5 inch concrete slab that looks like this:



How many cubic yards of concrete do you need to order?

Solution: 20 [FTLEN] 13 [FTWI] 5 [INCH] [CYDS] [STO] 0
12 [FTWI] 10 [FTLEN] [CYDS] [STO] [+] 0 [RCL] 0
(Answer: 5.86. Of course you'd probably order six cubic yards to be sure you had enough.) See how to use register 0 as a temporary holding tank?

Exercise: Once you (the contractor) have this equation in your list, you find that you're frequently quoting the square footage of the concrete slabs. Can you modify this equation (or add an equation) so that you can quickly calculate both the area and the cubic yards?

Solution: [EXIT] AREA = FTLEN × FTWIDE [INPUT]

Add this equation to your personal equation list. After you have keyed in this equation, your list should look something like this:

MILEAGE:MPG = MILES ÷ GAL

LTRS&GALS:GAL = LITERS ÷ 3.785

(FTLEN × FTWIDE ÷ 9) × (INCH ÷ 36) = CYDS

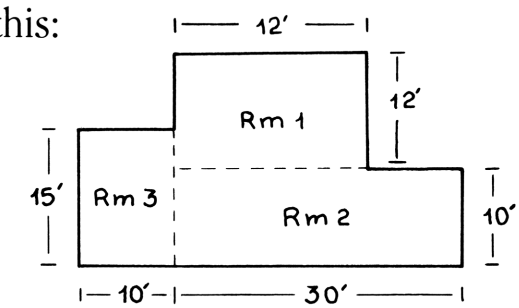
AREA = FTLEN × FTWIDE

Exercise: Make AREA the shared variable in your two concrete equations.

Solution: Position the CYDS equation to the calculator line and press [EDIT] [→] AREA [DEL] [DEL] [DEL] [DEL] [DEL] [DEL] [DEL] [DEL] [INPUT]

Notice that when you have made the above change to the CYDS formula, if you press [CALC] [RCL] [INCH] or [RCL] [CYDS], the numbers that were in those registers before you changed the formula have been destroyed. This is one of the few instances (described on page 65) when the numbers in data registers are automatically cleared.

Exercise: You are contracting an eight-inch slab that looks like this:



What is the area of each room, the total area of the slab, and the cubic-yards of concrete needed to complete the slab?

Solution: Rm 1 area = 144 square feet

Rm 2 area = 300 square feet

Rm 3 area = 150 square feet

Total area = 594 square feet

Cubic Yards = 14.67 (order 15 to be certain)

See if you can figure out the keystrokes to this, following the example on the top of page 78. Are you getting the hang of it?

The chances of you being a contractor in real life are, needless to say, quite slim. But what are the situations that you come across in your work or studies where you can take advantage of these features? This whole concrete exercise was designed to let you see how easy it is to resolve your day to day calculations into timesaving formulas that you can store in your calculator. Once they're stored, you can use them forever!

NOTES

Here are a few more exercises as a quiz, so you can get some more practice in developing equations.

QUIZ

1. Add an equation to your (the concrete contractor) personal list that will allow for circular slabs.

2. As an employee of the state, you are reimbursed if you use your car for work related travel. You get 21 cents a mile and you pay for gas. Key in two equations to simplify your monthly mileage calculations. One equation aids you in accumulating your mileage trip after trip and the other calculates the amount due to you at the end of a month's worth of driving.

3. Your company does direct mail advertising that brings back mail order sales. Your response on mailings varies from 1% to 4% depending on the list you rent and the season. If you take into account everything but the cost of the mailing, the average profit per response is $24.45. The mailing cost varies from 24 cents to 30 cents a flyer depending on how many you mail and, again, on the address list that you mail from. Develop an equation to help you calculate the total earnings from a mailing.

   If you mail out 145,000 flyers, the cost per flyer is 24 cents (including development, printing, postage, and everything). What response do you need to break even? What are your earnings if you have a 4.26% response?

SOLUTIONS

(from here to page 88)

1. The equation you need is:

$$AREA = (PI \times DIAM\hat{}2) \div 4$$

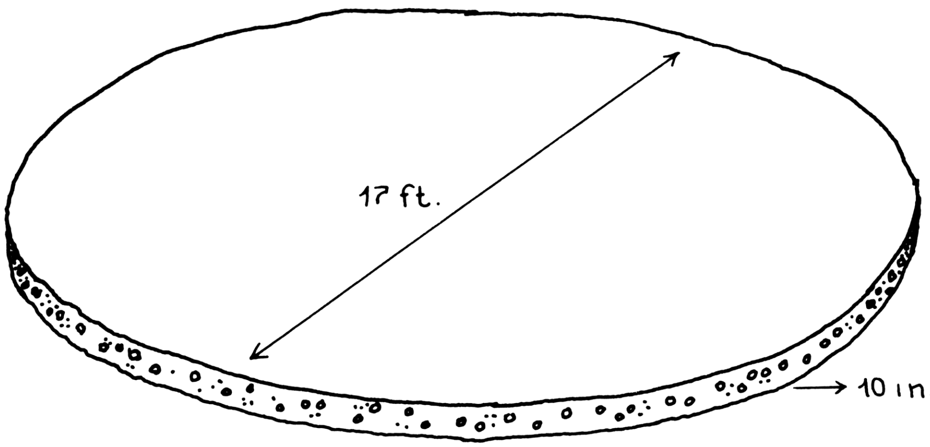
If you understand this, try problem 2. Otherwise, read on:

This formula for the area of a circle is something that you can look up in most algebra books or you can ask your little sister, the math wizard. In fact, when you're first setting up your HP-18C to handle your calculations, many times you may need to turn to a book or some other friend for help in getting the equation right. Don't hesitate! After all, that's what friends are for — and besides, it will only be once for each problem; after the formula is stored in your calculator, you'll never need to bother anyone for it again — and then you can be the one to help someone else (or return the favor to your friend).

Notice in this equation that PI is not a variable name. Rather, it's the name of a number that has an infinite number of digits, starting with 3.14159265359. But it's a handy number to have when you're working with circles, and so HP gave you a name to call it by; you don't have to type out all those digits!

Notice also that you need to use the "^" symbol when you want to raise a number to a power. This exponentiation function is just one of a big set of math functions available for you to use in your equations. All of these functions are listed in your owners manual.

With the “area in a circle” equation stored in your calculator, you (the concrete contractor) can figure out the area of a circular slab of concrete just by measuring the distance across the circle through the center (the DIAMeter).



You would then move to the CYDS equation and calculate the cubic yards required (knowing the thickness).

For example, to calculate the cubic yards required for a 10-inch slab of concrete, 17 feet in diameter, you would do the following:

A. Position the circular AREA formula to the calculator line and press [CALC] 17 [DIAM] [AREA] [EXIT]

B. Position the CYDS formula to the calculator line and press [CALC] 10 [INCH] [CYDS] . (Answer: CYDS = 7.01)

Notice that with this equation keyed in (if you have followed every exercise up until now) AREA is a variable shared between three equations, right?

2. The two equations should look something like this:

$$MCUR = MPST + (MEND - MBEG)$$

$$REIMB = MPST \times 0.21$$

Again, if these are similar to the ones that you developed, move on to problem number 3.

Talk yourself through a problem. Formulas like these can come to you easily if you take a little time, sit down with a pencil and paper, and talk yourself through them. After all, to tell the calculator how to do it, you have to know how YOU would do it, right?

"Let's see...one month, say I take three trips that I should be reimbursed for...the first trip is 250 miles....Um...and I know that because I use the odometer on the car to measure the length of the trip. Yes, of course. I write down the odometer reading when I leave and when I return, then I take the difference...!"

$$MEND - MBEG$$

"That's the mileage of the first trip. Hmmmm, so I remember that number somehow, call it, say, MPST (for Miles PaST), and then on the next trip I take, I calculate that number of miles the same way...and add them to the first trip's miles..."

$$MPST + MEND - MBEG$$

"So for each trip I take, if MPST holds the past mileage I've accumulated so far that month, I can calculate the current total mileage by using this equation:"

$$MCUR = MPST + MEND - MBEG$$

"And every time I do the calculation for another trip, since I want MPST to hold all the past accumulated mileage (including this most recent trip), I'll have to copy the number in MCUR into MPST. That won't be too bad."

"Then at the end of the month, all I have to do is multiply MPST by 0.21 to figure out how much I need to be reimbursed! Voilá:"

$$\text{REIMB} = \text{MPST} \times 0.21$$

Is your reasoning sound? Well, give it a try: You took three working trips during last month. The odometer readings were:

start of first trip: 27,794

end of first trip: 27,846

start of second trip: 27,955

end of second trip: 28,013

start of third trip: 28,206

end of third trip: 28, 477

With the MCUR equation positioned to the calculator line, press [CALC] 0 [MPST] 27,794 [MBEG] 27,846 [MEND] [MCUR] [STO] [MPST] to complete the first trip. You could EXIT at this point (and you normally would if you were accumulating mileage from trip to trip), and MPST would store your mileage until you needed to accumulate more.

For the second trip, press 27,955 [MBEG] 28,013 [MEND] [MCUR] [STO] [MPST] ; for the third trip press 28,206 [MBEG] 28,477 [MEND] [MCUR] [STO] [MPST] [EXIT] .

Finally, position the REIMB equation to the calculator line and press [CALC] [REIM] . (Answer: REIMB = 80.01)

3. $\text{EARNINGS} = \%\text{RESPONSE} \div 100 \times \text{TOTAL} \times 24.45 - \text{COSTPER} \times \text{TOTAL}$

is a formula that will work.

Generally, when you're trying to develop a formula like this for your own use, you've worked it out enough times by hand so that you can just about write the formula down from memory. But with an exercise like this, you may or may not have the background that makes it that easy or obvious. So take a little stroll through the explanation:

Look at the description of the situation and pick out the things that vary. The percentage response varies, and so does the cost of each mailer, the total number mailed out, and the earnings. Then pick some names for these things that vary (variables): TOTAL, %RESPONSE, EARNINGS, and COSTPER are good ones.

Once you've chosen the names, notice that you have a percent in there. You don't want to have to key in any percentage as a fraction (1% = .01), so you make a note that you have to divide %RESPONSE by 100 to get the actual number to work with mathematically:

$$\text{“Responding fraction of TOTAL”} = \%\text{RESPONSE} \div 100$$

Now, to figure out the actual number of mailers that will come back, you have to multiply the fractional response by the amount you sent out, right?

$$\text{“Responses”} = (\%\text{RESPONSE} \div 100) \times \text{TOTAL}$$

And, if you multiply this number of responses by the net profit per sale and then subtract the cost of producing and sending out the mailing, you will have your total earnings.

EARNINGS = ((%RESPONSE ÷ 100) × TOTAL)
× 24.45 − (COSTPER × TOTAL)

Actually, because of the way the calculator evaluates equations, you don't even need to have any parentheses in this particular formula. After all, multiply and divide come before minus, right? But it does help to write it this way to review for yourself just what the proper order of calculations is.

So key in this equation and then solve the second part of the exercise:

If you mail out 145,000 mailers, the break-even point is the %RESPONSE that makes EARNINGS = 0, right?

Press: [CALC] 145000 [TOTAL] .24 [COSTP] 0 [EARNI] [%RESP] (%RESPONSE = 0.98%). If your %RESPONSE is 4.26%, you can calculate your earnings by pressing 4.26 [%RESP] [EARNI]

(Answer: EARNINGS = 116,227.65).

Pretty slick, eh? And notice that if you know a little algebra, you could rearrange the formula to be:

EARNINGS = (%RESPONSE ÷ 100 × 24.45 − COSTPER) × TOTAL

CLEARING EQUATIONS

(A.K.A. NOT ENOUGH MEMORY)

If you have stored every equation that we've told you to up to now, you will soon be running out of memory (your calculator will politely inform you when you do). To clear equations and variable registers, from the MAIN menu, press [SOLVE] then use the [↑] and [↓] keys to go to the equation you want to delete and press [DELETE] [BOTH]. You can clear all equations by pressing [ ] [CLEAR ALL] [BOTH]. You don't really need to keep any of our equations, unless you want to.

SPECIFICALLY THE STUDENT

If you are a college student who has to take math or science classes, by now you're probably realizing that the engineers at Hewlett-Packard have done a lot of your work for you. This HP-18C, with its ability to rearrange equations, has the potential to take care of some of the tedious calculations that you will encounter in your homework and your tests.

You will find that the HP-18C is very useful for verifying your answers on tests and homework and, occasionally, it will take all the work out of a problem. But keep it in the proper perspective. Though a calculator will never be a substitute for understanding, often it can end the tedium of repetitive calculations that frequently blocks understanding. As an owner of the HP-18C, you still need to concentrate on developing a global understanding of mathematics and science, but you can save yourself from a lot of careless errors by making good use of this very accurate calculator.

Look at a few examples of how the HP-18C can be used by you, the student.

Example: "A boat travels up stream 40 miles in the same time it takes to travel downstream 65 miles. The speed of the stream is 5 miles per hour. What's the speed of the boat in still water?"

Solution: See below

Explanation: This particular problem requires you to use the equation RATE × TIME = DISTANCE. The TIME is the same for both upstream and downstream travel, so the equation you would use is:

$$\frac{\text{RATE UPSTREAM}}{\text{DISTANCE UPSTREAM}} = \frac{\text{RATE DOWNSTREAM}}{\text{DISTANCE DOWNSTREAM}}$$

But RATE UPSTREAM is just the speed of the boat minus the speed of the current (and plus the speed of the current for RATE DOWNSTREAM), so the equation could look something like this if you key it into your calculator:

EQLTIME: (S−SCUR) × DWITH = (S+SCUR) × DOPP

Call the equation EQLTIME to describe the fact that the time for the trip upstream is equal to the time for the trip downstream. S is the variable name for the boat speed, SCUR represents the speed of the current, DWITH the distance the boat travels with the current and DOPP the distance the boat travels against the current.

NOTICE: Whenever possible, rearrange your equation to avoid division. Your calculations will be faster if you're not dividing by the variables you're solving for.

For example, this equation (above) is arranged so that there's no division. It's usually easy to do this.

Now key this equation in and try a couple of these algebra examples:

1. A boat travels upstream 40 miles in the same time it takes to travel downstream 65 miles. The speed of the stream is 5 miles per hour. What's the speed of the boat in still water? (Answer: S = 21.00 mph)
2. A boat travels in still water at a speed of 17 kilometers per hour. On a river the boat can travel 26 km upstream in the same time it can travel 36 km downstream. What is the speed of the river current? (Answer: 2.74 kph)

Once you've keyed in the equation and pressed [CALC] the calculator should show you this menu:

S | SCUR | DWIT | DOPP

Then the keystrokes to solve the first problem would be 40 [DOPP] 65 [DWITH] 5 [SCUR] [S]. The second problem is just as easy!

A student could develop three or four different equations to handle the majority of the popular variations of this type of problem. This is just one simple example of the timesaving potential of your calculator.

Another typical equation that comes to mind is for students of chemistry — the ideal gas equation PV = nRT. Before you're through with your chemistry courses, you will probably have to solve a dozen or so problems that use this equation.

You can key in this equation as it is (keying in the constant value of R) or you can rearrange it for the case where the characteristics of an ideal gas change without the mass of the gas changing. For this case, you would key in something like: $P1 \times V1 \times T2 = P2 \times V2 \times T1$, right?

The possiblities are virtually endless; we're just throwing out a few suggestions here.

Another common equation that you will encounter in your algebra class is the quadratic equation. It looks like this:

$$AX^2 + BX + C = 0$$

There are two solutions to this equation, which makes it an interesting equation for the HP-18C to try and solve as is. But in order for the calculator to find both solutions, you need to know how to help it in its search. Helping your calculator find a solution is covered in the following section.

But the two solutions to the quadratic equation are two separate equations in themselves. The two solutions are (in a form you can key into your equation list):

$$2 \times X_1 \times A = -B + SQRT\,(B^2 - 4 \times A \times C)$$

and

$$2 \times X_2 \times A = -B - SQRT\,(B^2 - 4 \times A \times C)$$

After you key these in, try them out on the following quadratics. Notice how easy it is to go from finding X_1 to finding X_2. You don't have to key A, B, and C in twice because they are shared variables (page 69).

1. $X^2 - 11X + 18 = 0$ (A=1, B=−11, C=18; Answer: $X_1 = 9.00$, $X_2 = 2.00$)
2. $5.33X^2 - 8.23X - 3.24 = 0$ (Answer: $X_1 = 1.87$, $X_2 = -0.33$)

If the result between the parentheses of the SQRT function comes out negative, then the roots are complex (they involve the square root of -1) and the calculator will tell you "SOLUTION NOT FOUND." If you want the calculator to solve these cases where the square root is negative, you can key in two equations to calculate the Real and Imaginary parts of the two roots:

$$\text{REAL} = -\text{B} \div (2 \times \text{A})$$

$$\text{IMAG} = \text{SQRT}(\text{ABS}(\text{B}^2 - 4 \times \text{A} \times \text{C})) \div (2 \times \text{A})$$

And the two complex answers, you would write down as:

REAL + i(IMAG) and REAL − i(IMAG),

where "i" is the square root of -1.

We realize we're assuming that you know what's going on here. If you don't want to understand this stuff or it just brings back bad memories, skip it (go to page 94). The reason we're bringing this up is in the hopes that this information will turn on a lightbulb in your mind. These are common calculations in school and you may find our suggestions helpful.

ADVANCED USE OF SOLVE

All of the equations that you've developed up to now use fairly simple operations. The most complicated things you've used are the SQRT and ^ operations. But the HP-18C has a big list of functions that you can use to make your equations simpler and more useful.

The majority of the functions in the HP-18C's repertoire use "arguments" (numbers) inside parentheses. The SQRT function is one example. If you were to use SQRT(A+B) in an equation, the calculator understands this to mean "take the square root of A+B." The number A+B is the argument of the SQRT function. Simple, right?

But there are other functions that have several parts required in their arguments. If you look in your manual under the section titled "SOLVE Functions," you will find a table of all the available functions on the HP-18C. One of these functions is listed as DDAYS (d1:d2:c). This function finds the number of days between two dates, according to one of the three calendars (the actual calendar, the 365-day calendar that ignores leap years, or the 360-day calendar).

If you wanted to find the actual number of days, for example, between April 4, 1988 and June 17, 2001, the argument you would supply for DDAYS would be (4.041988 : 6.172001 : 1).*

The first two numbers tell it which dates to use, and the third tells it which calendar to use. Each part of the argument is separated by a colon (:).

*If your calculator is set to display dates in European notation (see page 13) you would use the argument (4.041988 : 17.062001 : 1). The calculator expects all dates to be consistent with the display format you have set. Since we're writing this in Oregon, all the dates we use from here on will be assumed U.S. notation.

Exercise: You are borrowing $45,775.00 on June 14, 1989 but the first payment is not until the end of the following month. The interest between June 14 and July 1 accrues on a straight line basis at 0.032% of the initial balance per day. How much interest accrues by July 1? Write this as an equation with the loan balance, the dates, and the daily interest rate as variables.

Solution: The equation you would use here would look something like:

IACCUM = I%DY ÷ 100 × BAL × DDAYS
(DTCLOSE:DTFIRST:1)

Then use the keystrokes:

[CALC] .032 [I%DY] 45775 [BAL] 6.141986
[DTCLO] 7.011986 [DTFIR] [IACCU]
(Answer: IACCUM = 249.02)

Notice that the third part of the argument is just a 1. This tells the calculator to calculate the number of days between dates based on the actual calendar.

In this formula, the DDAYS part just figures out how many days there are between the date the loan closes (the money leaves the bank) and the first of the following month. The rest of the formula just figures out how much interest to accumulate each day and multiplies that by the number of days.

MAKING DECISIONS IN A FORMULA

That DDAYS function is one whose argument has multiple parts. Another such function that may be of interest to you is the IF function (it's covered under "Conditional Expressions" in the manual):

Exercise:	Change the two equations for calculating mileage and converting liters to gallons (page 67) into one equation that gives you MPG whether you input liters or gallons. Assume that the maximum capacity of your gas tank is 10.5 gallons and that you only stop to fill it when it's nearly empty.
Solution:	MILEAGE: MPG = MILES ÷ IF (GAS > 10.5 : GAS ÷ 3.785 : GAS)

Explanation: Knowing the capacity of your tank and your habit of filling it only when it's nearly empty allows you to write a formula that makes a decision. The decision is this: If you input a number for GAS that is over 10.5, the HP-18C assumes that you're giving it liters, so it divides GAS by 3.785 to convert to gallons before using it in the equation. If GAS is less than or equal to 10.5, it assumes you're giving it gallons and no conversion is necessary.

Do you see how the notation of the IF argument (the part in parentheses) works? The FIRST portion is the TEST. If the answer to that test is "YES," then the number that will actually be used in the equation is the SECOND portion; if the answer to the test is "NO," then the THIRD portion will be used. After you get used to reading it this way, it's pretty straightforward isn't it?

By the way, you may be wondering where the ">" character is on the keyboard.

You key this character in by pressing [ ] [Z]. When you press the gold [ ] key, you temporarily change the meanings of many of the alphabetical keys — just as the shift key changes the meanings of a typewriter's keyboard. Your manual contains the entire list of these characters. And you can also step through each alphabetical key, preceding it by pressing the gold key, to see what comes up in the display.

GUESSING GAMES

What if you key in an equation that has more than one solution? For example, what if you keyed in the equation: $5.33X^2 - 8.23X - 3.24 = 0$ that has two solutions: $X_1 = 1.87$, $X_2 = -0.33$? What does the calculator do?

Exercise:	Ask your HP-18C to solve the equation: $5.33 \times X^2 - 8.23 \times X - 3.24 = 0$. Key it in as written to the formula solver. What answer does it give for X?
Solution:	−0.33 (Key in the equation; then press [CALC] [X] .)

How do you get the other answer? Well, you have to supply the calculator with a "range" to start searching for an answer. In this case, you know the answer is positive*, so ask the calculator to search between, say, zero and 100. Press 0 [X] 100 [X] [X] . The calculator displays the current values it's using for X as it converges to an answer. The answer it finds is 1.87.

This is the process that you use whenever you want to supply the calculator with a guess or a range in which you want it to search. You key in a guess, press the variable that you are guessing, key in another guess, and then press the variable TWICE more. The calculator will search in the range between your guesses.

*(Do you remember how to tell if the two roots (solutions) of a quadratic equation are positive or negative or mixed? Well, it's clear you've been losing a lot of sleep over this lately, so: "If the sign (+ or −) of the last term (the one with no X's multiplied with it) is −, then the roots are mixed — one is a + and the other is a −. If the sign of the last term is + and the middle term is −, then both roots are −; but if the last term is + AND the middle term is too, then both roots are +."

There, now...don't you feel better?)

DISCRETE ("WEIRD") FUNCTIONS

One caution in using functions with arguments. Many of these functions make the formula less "flexible" as to which variable you can solve for, because they do other things besides calculate with the real numbers that we all know and love so dearly.

For example, look at calendar functions. In the IACCUM formula on page 95, the chances are slim that the formula solver will be able to find an answer for DTCLOSE, because that number represents a date. You can solve for either IACCUM, BAL, or I%DY, given all the other variables. But you can't solve for either of the dates because they are part of the argument of a "weird" function. And watch what happens as the formula solver tries to home in on the answer for DTCLOSE, using its trial and error process:

As you know, the solver would pick a guess for the closing date, DTCLOSE and see how close this guess came to making the formula true. Then it would use the results of this trial to make a better, more educated guess the next time. Well, the problem is, it uses real numbers for guesses, and it thinks that a small change in its guess should produce a small change in the result. So as far as it's concerned, 6.171006 is very close to 6.172006, and it might try to make this little change, thinking it was very close to "homing in" on the right answer. But those two numbers represent dates that are a thousand years apart! So the machine could sit there forever, trying to figure out why one little tweak of the thousandths digit makes this look like a loan written either for President Reagan's SDI program or the baby shower of William the Conqueror.

But don't lose any sleep over this. If you forget, then once in a while you might see some very disconcerting results being flashed up on the display. It can even be funny to watch: Just as it thinks it is "getting warmer," it adjusts its guess just slightly to try to hit it exactly...and the result is totally out of the ballpark again. After awhile, the calculator just gives up and sends out for pizza.

But usually, as in the IACCUM formula, the variable that you are most interested in does not fall within one of the arguments of these weird functions, anyway. Just remember that there are times when a variable in an equation cannot be solved for by the formula solver; it always has to be a "known." OK?

Now, here are some problems on which you can practice your "SOLVEing" skills. To write these formulas, you'll need to use functions out of the section in your users manual titled "SOLVE Functions," so keep your manual open to those pages to see a full list of all your function "ammunition."

Some of these problems may seem very involved, but when you boil everything down to the actual equations, they're actually not that tough. In any case, the solutions follow.

QUIZ

1. Your friend, who is an obstetrician, has just bought an HP-18C. This friend has come to you for help in writing several formulas to help with the day to day calculations in obstetrics. Having owned your HP-18C for some time, you help your friend develop two equations. One takes the starting date for a pregnancy and calculates a woman's due date (280 days later). The other takes today's date and a woman's due date and calculates how many weeks she is into her pregnancy.

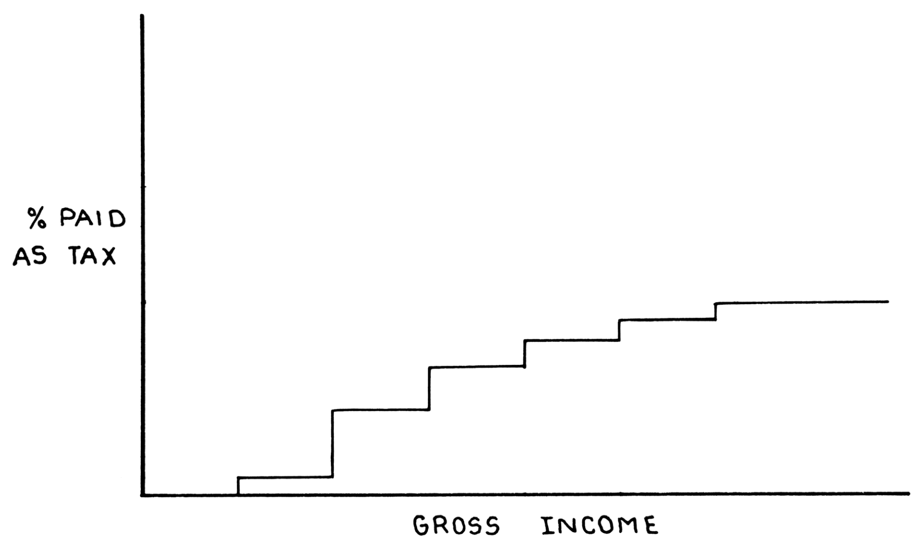
   The woman's due date is a shared variable between the two formulas and the formula that calculates the weeks into pregnancy returns the answer in W.D format where W is the number of whole weeks and D is the number of days in the additional partial week (0 to 6). What are these two formulas?

2. On your job, you travel regularly in America, France, and several countries in West Africa. Because of this, you are regularly changing money back and forth between some type of Franc (French or African) and the U.S. dollar. The exchange rate between the francs is fixed: 1 French = 50 African, but the exchange rate between francs and U.S. dollars varies daily. Write just one equation that will help you in these exchanges.

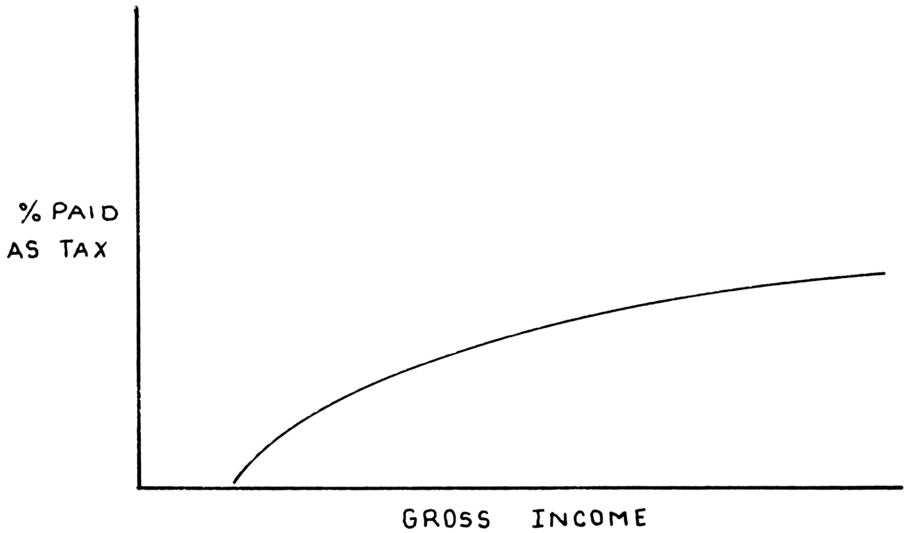
3. The U.S. Federal income tax system is a complicated set of laws, many of which are contradictory, out of date, or lop-sided in their impact on different taxpayers. One of the suggestions to drastically simplify the system has been the elimination of all deductions; that is, a tax on gross income instead of net income. This would also eliminate most kinds of cheating and reduce tax returns to single pages for most people.

Yet, it has also been argued that the progressive nature of the tax brackets — as they now exist — should be kept, so that larger income-earners pay larger percentages of their incomes than do smaller earners.

Well, what if you combined these two ideas? You would have a tax on gross (rather than net) income , but with an increasing (progressive) set of percentage brackets — higher for higher earners:



One problem with this is that if you want to make the brackets truly progressive (easier on the poor, but collecting more from those who have more), you have to have a large number of brackets to cover a range of incomes from $0 to $20 billion or so. So why not take this idea to its logical conclusion and smooth out the bracketing into one continuous curve? It would look like this:



This kind of curve is a called a logarithmic curve, one which is continuously climbing but is also levelling off into a slower and slower "climb." Get the picture?

So suppose this kind of tax system is in place. This means that the tax PERCENTAGE you pay is proportional to the logarithm (LOG) of your gross income. That is,

$$\text{TAX\%} = \text{A} \times \text{LOG (GROSS)}$$

where A is a multiplying factor (the "proportionality constant" — the only number that would need to be changed to produce a tax increase or decrease).

In reality this number, A, would probably be somewhere around 0.5. Thus, a $30,000/year earner would pay a tax percentage of

$$.5 \times \text{LOG(30,000) which is 2.24\%}$$

So his/her tax would be 2.24% of $30,000, or $671.57. Simple, right?

Well, yes it is, but consider the wage earner who brings home a weekly or monthly paycheck. How does his/her employer know how much tax to withhold for that pay period? Every week the employee's yearly total has been rising — and therefore his/her tax percentage rises, too. Write a set of equations to help the employer's payroll clerk do this in a snap on an HP-18C.

4. Another nagging U.S. tax problem has been the Social Security System, which originated in the Depression years to give many poor and/or aging citizens a decent and dignified living. The idea was to take a certain percentage of a current wage-earner's pay (and an equal amount from the employer) and use it as a kind of minimum pension for retired workers who would otherwise have had little or no income. Then, when the current wage-earner retired, he/she could look forward to such benefits taken from the wages of the next generation, etc.

   The problem is, living costs have risen, as has the ratio of retired persons to working persons, so that the system has been forced to raise the contribution percentages to a point where the benefits accruing to a retiree no longer reflect the true value of the money he/she has steadily paid into the system. That is, there is only a slight correspondence between what you pay as a wage earner and what you'll receive upon retirement — and it is paltry in comparison to what you would have if instead you were to invest that same steady amount in some retirement account of your own choosing.

   Prove this. Write an equation that computes the value of an account built up over your working years. For the sake of this example, assume that your wages or salary have just exactly kept pace with inflation, and that you've been investing, say, 5% of your earnings not in the Social Security System but in a retirement plan that has been paying, say, 6% above the inflation rate. (As you know, this would be the same as working for the same annual wages or salary all your life — but with no inflation — investing in an account that pays 6% per year.)

   How much money is in this account by the time you retire? If this was paid back to you in even annual installments over 20 years after your retirement, what would your annual pension be (can you write an equation for this, too)? How does this compare with what you know about typical Social Security benefits?

SOLUTIONS

1. Here's one set of equations that would work:

   DUE = DATE(START : 280)

   W.D = IDIV((280 − DDAYS(TODAY : DUE : 1)) : 7) + MOD((280 − DDAYS(TODAY : DUE : 1)) : 7) ÷ 10

Do you see how the first one works? The DATE function is one which calculates a date that is a certain number of days before or after another date. This function looks at the first portion of its argument (here it's the START date), adds the number of days that appear as the second part of the argument, and figures out what the resulting date is — and that date is what you call the DUE date.

Now, the other calculation looks absolutely horrendous, but before you reach for the red phone, think about this:

If you have a given number of days, say, 25, what do you do to convert that to a number of weeks? You divide it by seven, right? But that will give you a number like 3.571428... — a whole number of weeks and then a fraction of a week. But you want to determine the number of days in that fractional portion of a week, also. Remember how to do that? You take the fractional portion and multiply it by seven again: .571428... × 7 = 4.

So 25 days is 3 weeks and 4 days. If you want to represent this as one number, W.D, it would be 3.4. And what's the process to take the numbers 3 and 4 and convert them into a single number 3.4? You divide the number of days by 10 and add this to the number of weeks, right?

So review what you've decided: You take the number of days that the pregnancy has progressed so far, divide this by 7, keep the whole part of the result, take the fractional part of the result, multiply it by 7, divide this by 10 and add it to the whole part. This finally gives you the W.D number you want.

Fine. But did you know that HP built into the HP-18C two functions that perform all the dividing and recovering the remainder and all that? The functions are IDIV and MOD. Read their descriptions in the manual now, and then return here.

See how much easier that makes this? You take the number of days of pregnancy, use IDIV to get the whole number of weeks that is; then again, take the number of days of pregnancy and use MOD to get the number of extra days beyond that whole number of weeks. Divide this last number by 10 and add to the result of your IDIV.

This certainly explains why the final formula looks like this:

$$\text{W.D} = \text{IDIV(something : 7)} + \text{MOD(something : 7)} \div 10$$

And that "something" is, of course, the number of days the pregnancy has progressed so far. But remember, you only know today's date and the DUE date. You have to work backwards to figure out the date of conception. And what's the formula for that? Well, DDAYS(TODAY:DUE:1) gives the number of days between TODAY and the DUE date, based on the actual calendar, right? That's the number of days REMAINING in the pregnancy. So the number of days already past is simply 280 – REMAINING, i.e.:

$$280 - \text{DDAYS(TODAY:DUE:1)}$$

So this is the "something," the number of days of pregnancy so far, that you put into the final W.D formula. Voilá!

2. Here's a workable formula:

$$FRANC = US \times EXCH \times IF(COUNTRY = 1 : 1 : 50)$$

Hmmmm...not a trivial matter, is it? It doesn't look that way, but as usual, the only sticky part is the reasoning that went into this, not the actual typing of the formula.

First of all, think about how you want to use this: No matter where you are, you want to know how to change dollars for francs, French or African. Doesn't this sound like a set of 2 separate equations to you? Something like this:

$$US \times EXCH = FRENCH$$

$$US \times EXCH \times 50 = AFRICAN$$

You COULD do it this way — have a separate equation for each of the possible exchanges, couldn't you? Ah, but that's not what the question asked, was it? No cheating allowed....

What else can you do? Most importantly, you can realize that there IS no one single formula that will give you either of the above 2 answers anytime you want. (Say what?)

Think about it: The way the solver works, you have to give it values for all but ONE of the variables in any equation, and then it uses those values to solve for the one you don't know. Now, what would happen if you had one magical equation involving all of the above variables? You can actually find one by adding together the two equations of the above set:

$$US \times EXCH \times 51 = FRENCH + AFRICAN$$

But look what happens when you try to use this. Say you want to convert US dollars to AFRICAN Francs. So AFRICAN is your unknown variable — the one you want to solve for. According to the rules of the solver, you would have to know and key in the other values: EXCH and FRENCH.

The EXCH number is no problem; you need to be told this by the bank, anyway. But what use is the formula to calculate an exchange from US to AFRICAN if you have to know ALREADY the exchange for FRENCH? If you know the FRENCH, you just multiply by 50 for AFRICAN. You can do that in your head or on the keyboard of your HP-18C! Why bother with a formula at all?

So there's no one formula that will take care of this little paradox. If you want to know the answer, you practically have to know it already. Well, then, what's this poppycock at the top of the previous page? That sure looks like a single formula — and somebody out there claims it works. What gives?

HP gives...and gives....They've given you a way to cheat — to put more than one formula into one formula, so to speak. Remember the IF statement? You first saw it on page 96.

You use it here to determine whether or not to multiply your number of francs by 50. That is, the formula for exchanging dollars for francs is: FRANCS = US × EXCH. Now, if you're in France (call it COUNTRY #1), that's it — that's your answer. But if you're in west Africa, you need to multiply this by 50 to get African francs (CFA).

So look what that IF statement does: It requires you to have a variable called COUNTRY, a variable whose value will be either 1 for France or 2 for Africa — and you'll key this in as one of your "knowns" when you're using your formula. So when the solver needs to decide whether to multiply by 1 or 50, it uses an IF statement, basing its decision on the value of the variable called COUNTRY.

3. TAX = .005 × ($PREV + $CURRENT) × LOG($PREV + $CURRENT) − .005 × $PREV × LOG($PREV)

Do you see how this works? The formula for the tax PERCENTAGE you pay is: TAX% = .5 × LOG(GROSS)

You already knew that. But you have to realize that a percentage is just a fraction — the ratio of the tax you pay to your income as a whole: TAX% = 100 × (TAX ÷ GROSS INCOME).

So, knowing this, you can substitute one expression for the other, and say that

100 × TAX ÷ GROSS = .5 × LOG(GROSS)

Or, put it a better way:

TAX = GROSS × .005 × LOG(GROSS)

That's the year-to-date tax you owe at any given time. Then the tax you owe now is just the total tax you owe for the year, minus the total tax you owed after the previous paycheck. So if you call all your previous gross income for this year $PREV, and you call your current paycheck $CURRENT, then the total tax you now owe for the year is

.005 × ($PREV + $CURRENT) × LOG($PREV + $CURRENT)

And the tax you owed after the previous paycheck is

.005 × ($PREV) × LOG($PREV)

The difference between the two is what you owe on this current paycheck — what the payroll clerk has to deduct. And notice that after using this handy formula in an HP-18C, the clerk then has to update the value stored in the $PREV register; he/she has to add to it your $CURRENT — to get a new $PREV for next time.

4. Here's one way to compute the future value of all your contributions:

$$VALUE = .05 \times EARNINGS \times USFV(6:YEARS)$$

Now, what's going on here? The EARNINGS variable represents your steady annual income. So this means that .05 × EARNINGS represents your steady annual contribution to this retirement account. But what's this USFV stuff?

Notice in your manual in that table of functions you can use to build equations. This USFV stands for a function that gives you the Future Value of a Uniform Series of $1.00 payments, assuming these payments are periodic and that they are also earning interest at a periodic rate.

Well, here is a situation just made for that kind of function. You're salting away money at 6% for a number of years that you can call YEARS (for some strange reason). The only problem is, you're not just putting away $1.00 per year. You're putting away .05 × EARNINGS dollars per year. No problem, really: The value you'd have at the end is just that many times bigger than if you had been saving only a dollar. That is, instead of this:

$$VALUE = USFV(6:YEARS)$$

You would have this:

$$VALUE = .05 \times EARNINGS \times USFV(6:YEARS)$$

So much for adding machines!

Now, how about the other question: Assuming this is the value in your retirement account when you retire, what kind of steady annual "annuity" income could you draw from it for 20 years?

This is a good formula for that (especially because it shares the VALUE variable, so you don't have to copy it from your previous calculation):

$$\text{ANNUITY} = \text{VALUE} \div \text{USPV}(6{:}20)$$

See what's happening here? Looking again at your function table, you can see that USPV is the Present Value of a Uniform Series of $1 payments made periodically, with a periodic interest rate acting on them meanwhile.

Well, your total value that you have at the present (on the day you retire) is VALUE. And if $1 annual draws for the next 20 years (at 6% per year) represent a certain small Present Value right now, then $2 draws would represent twice that much right now; and $3 draws would come to 3 times, etc. This means that steady draws of "ANNUITY" dollars, would result in "ANNUITY" times as big a present value as $1 draws, right? But that present value also has to be equal to your retirement account VALUE for everything to work out just right.

So ANNUITY × USPV(6:20) must be exactly equal to VALUE, and then you just rearrange this slightly to get the final form, above!

Incidentally, you'll be happy to know that you really don't have to use this kind of reasoning very often on such problems, because HP built so many useful financial calculations into the Business Consultant. So actually, the very easiest thing to do here is to use the TVM menu HP has given you. All this is a real snap — if you just know how to use those built-in formulas.

What's that? You say you're not sure about how to use the TVM menu or the CFLO menu...or most of those money calculations?

Well now...any guesses as to the topic of the next (and last) chapter?....

That's right — it's all about money and how to calculate with it. After all, this is the Business Consultant calculator. And to put it bluntly, if a businessperson doesn't get an understanding of the stuff in Chapter 3 here, he/she could well end up with a thorough understanding of Chapter 11 somewhere else....

But this chapter you've just finished has been a pretty good once-over for the SOLVE part of the HP-18C, don't you think? So take a brain-break, and go ice-skate, or hula dance, or play speed chess...whatever. Have a tall, cold something-or-other, and let the following realities wash over you:

You now know how to use the SOLVE routine quite well. ("How... well...do you know it?") You know it SO WELL that you even know:

- How to use most of the formulas HP already built into your HP-18C;
- That the machine will create "variable registers" for each of the variables in any formula you key in yourself;
- That you can name each of these variables and when you use the formula, these names will appear on the menu keys;
- That you can share these variables among more than one equation;
- That you can even name your formulas and store them in your own personal formula list, using them, editing or deleting them whenever you want;

- That to create a formula of your own, you should reason it out as if you had to do it, making notes of the process you go through, and then it's very nearly like that when you tell the calculator what to do — and it will do it over and over...at a blinding speed;
- That you can even help the calculator find an answer within a given range of numbers, by giving it a couple of starting "guesses."
- That some kinds of variables can't be solved for because they are mixed up with "weird" functions.
- That there's only the one more chapter to this book, and if you take that break now and come back all fresh and relaxed, it'll be a piece of cake.

Chapter 3.

EASY MONEY

You'll notice that the first key in the main menu is the [FIN] key. When you press that key, you're asking the calculator to offer you its FINancial calculating features. It's time now to take a good long look at the financial calculating power that lies beneath this [FIN] key.

Believe it or not, you already know everything you need to know to use and enjoy your HP-18C for many different things. But to use its financial calculation powers, you also have to know a bit about finance.

This doesn't mean you have to be a whiz with numbers. That's why you have a calculator: Because the equations are already built into the machine, it can grind out answers much faster than you can. But you still have to ask the right questions of your calculator, and to do that, you have to know the meanings of each of the variables AND the concepts that went into developing those formulas, right?

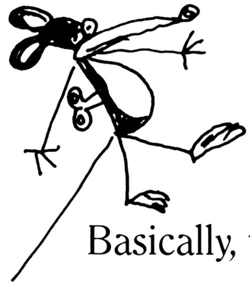
A PEEK AT YOUR INTERESTS

The whole world of finance is based upon one simple fact:

Borrowed money earns interest over time.

So it's best to begin all this financial problem-solving with a quick reminder on how interest accrues.

(Don't skip over any of this just because it seems tedious. Even if you're a financial wizard, you may find some subtleties here that you've not really contemplated before, so relax and enjoy the familiar scenery.)



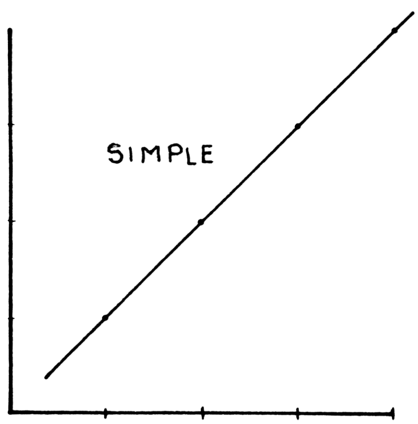
SIMPLE OR COMPOUND?

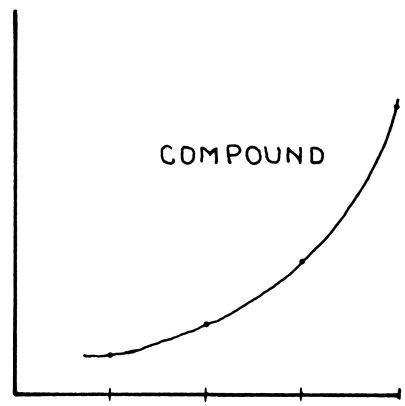
Basically, there are two forms of interest:

A. Simple interest

B. Compound interest

Take a look:





A. Simple Interest is the less common method nowadays. For simple interest, the amount of money charged per period — as interest — is defined as a set percentage of the AMOUNT ORIGINALLY LOANED.

So, if $100.00 is loaned for 6 months at 1% per month simple interest, then the amount owed for interest will be exactly $6.00. For each month of the loan, the borrower must pay 1% of the original $100.00; that's $1.00 per month, for 6 months.

B. Compound interest is the much more widely used method. With compound interest, the amount of money charged per period — as interest — is defined as a set percentage of the amount owed AT THE BEGINNING OF THAT PERIOD.

Notice how compound interest differs from simple interest: Simple interest is a percentage of the amount originally loaned (originally owed), but compound interest is a percentage of the amount owed at some other point in time — and this point changes.

So, in the SIMPLE interest case, the borrower saw the $100.00 amount change to $101.00 after 1 month, 102.00 after 2 months, etc.

If, on the other hand, that $100.00 loan were 1% per month COMPOUND interest, the amount owed after 1 month would still be $101.00, but after 2 months, it would be $102.01; after 3 months, it would be 103.03; etc. The second month's interest is computed as 1% of the amount owed at the beginning of the SECOND month — that is, 1% of $101.00, NOT 1% of $100.00.

Thus, interest is earned on interest earned previously, and thus the name — COMPOUND interest.

Since compound interest is the method of concern in most financial problems, it will be the main focus in this course. The financial equations that are in your HP-18C are based on compound interest.

FROM NOW ON, WHENEVER YOU SEE THE WORD "INTEREST" IN THIS BOOK, YOU CAN ASSUME THAT IT'S COMPOUND INTEREST.

Now, all this may seem pretty obvious. But here are those subtleties that are too often overlooked:

SUBTLETY #1: In either form of interest, there is exactly one time period which is the Defined Interest Period (D.I.P.), and exactly one Defined Interest Rate (D.I.R.) for that period.

The example with the $100.00 specifically states that interest accrues "at 1% per month." So the D.I.P. is 1 month, and the D.I.R. is 1% (one percent).

However, it's conventional to quote interest rates on an annual basis. A bank would take that 1%, multiply it by 12 (months in a year), and say "12% Annual Percentage Rate (A.P.R.)."

THE BANK WOULD NEVER USE THE A.P.R. NUMBER ITSELF DIRECTLY IN CALCULATIONS. IT WOULD ALWAYS DIVIDE IT BY 12 FIRST AND THEN USE THIS D.I.R.

THE A.P.R. IS A CONVENIENT APPROXIMATION.

Always make sure you know the D.I.R. and D.I.P. before you start a financial calculation!

SUBTLETY #2: In that $100.00 example, no mention was made of the amount owed after 2.5 months, or 3.75 months or 4.19 months, etc.

Strictly speaking, the D.I.R. and D.I.P. define only what the loan balance will be at one point in each period. There must be other definitions to determine how that balance changes BETWEEN those points.

With these subtleties in mind, you can now proceed in solving financial problems with your Business Consultant....

The problem-solving method goes like this:

1. Define the problem! Understand clearly what's known and what's unknown.

2. Present the right question to your calculator — in terms it can understand — so that it can find that unknown for you.

Look at these two steps in detail....

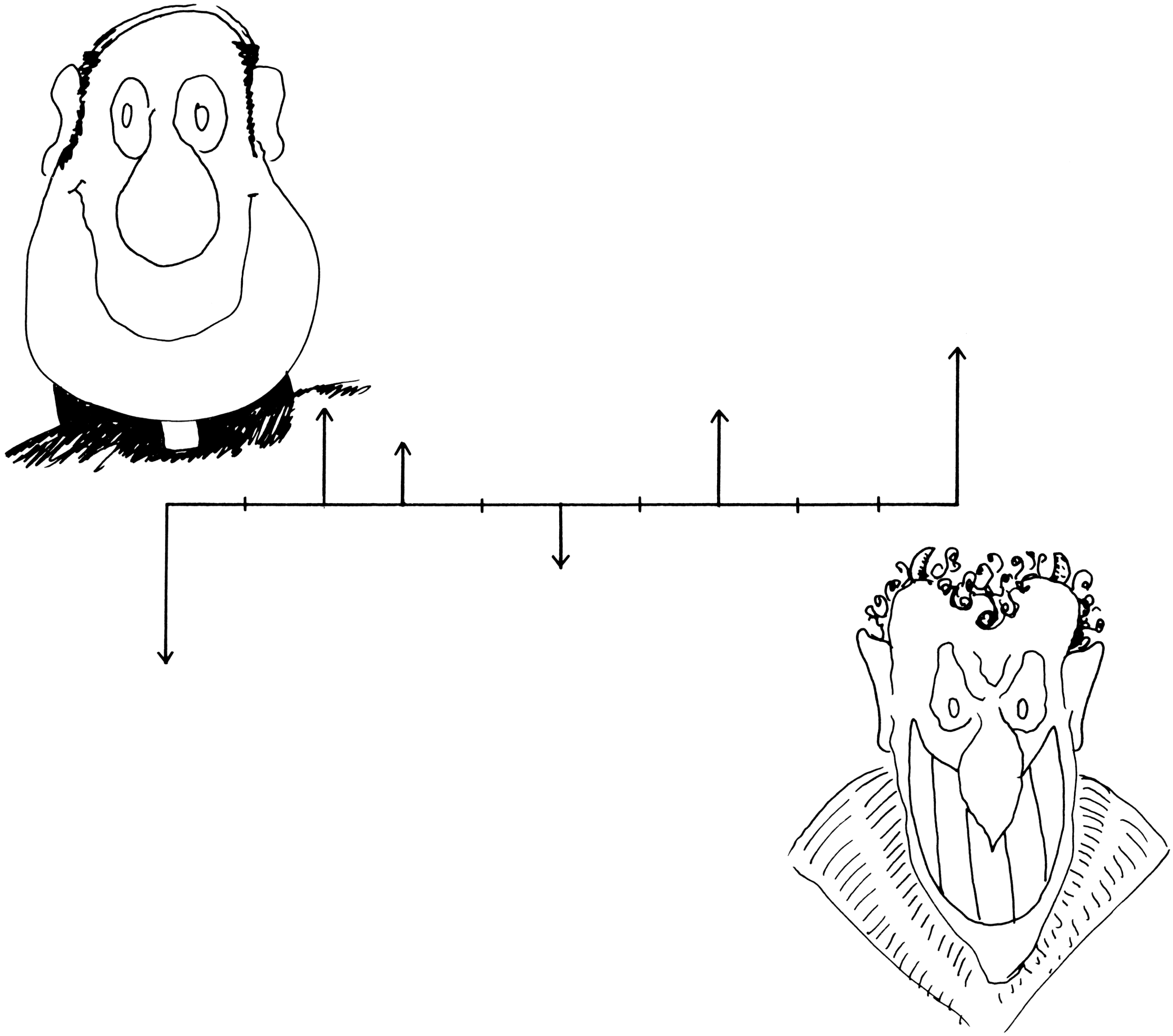
1. Define the problem! You may not believe this, but this is the most important and most difficult part of all. Too many financial mistakes have been made because people have not clearly described the question — to themselves! They get too impatient to start punching buttons.

A calculator minimizes the amount of paper you have to use. BUT, it is not a substitute for paper! You should always have a pencil and paper on hand whenever you are approaching a complicated financial problem.

Why? Well, as you know, a picture is worth at least a thousand words, especially when you're trying to reduce a financial contract or proposal to its bare essentials. And with the scratch paper you can draw a cash-flow diagram. This picture will tell you at a glance what the facts are — without all the jargon and confusion of a verbal description.

CASH-FLOW DIAGRAMS

OK...but what exactly IS a cash-flow diagram?



Here is a cash-flow diagram. You'll see a lot of these from now on, because they make it easy to define and understand any financial problem. So the first thing to do in any financial calculation is to draw a cash-flow diagram! This should become a reflex.

Of course, you don't have to be an artist to draw them. The diagrams are merely rough pictures to help you visualize the problem. But to make them really useful you should know the "rules."

There are five rules for drawing a cash-flow diagram:

1. Always pick the perspective of either a borrower or a lender on one cash-flow diagram. In other words, either a borrower or a lender be (heh, heh).

If you're buying money market shares, or putting money in a savings account, you should consider yourself a lender. If you're taking out a loan to buy a house, then you're a borrower, of course.

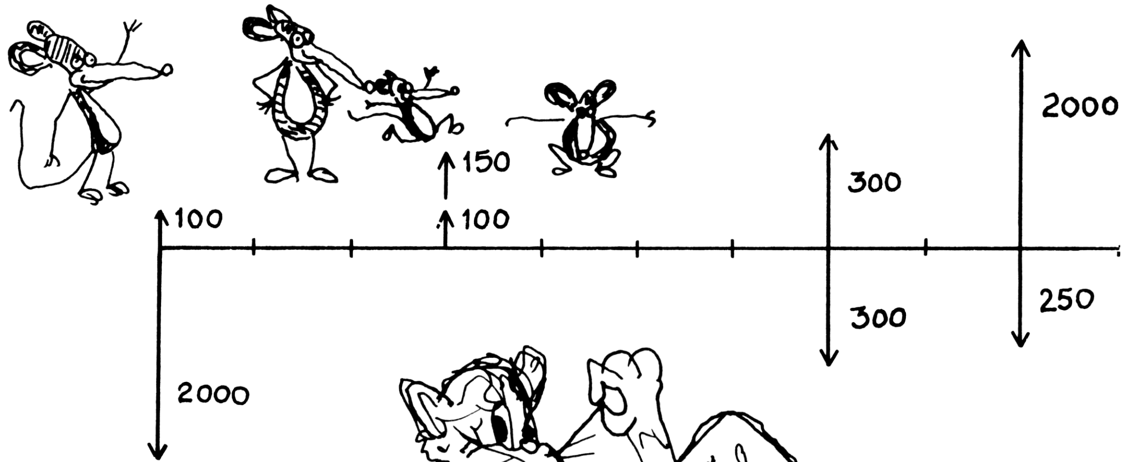
But remember: How any investment or loan will look on a cash-flow diagram will depend upon whether you're the lender or the borrower. So in drawing the picture, pick one perspective and keep it — and for money's sake, don't change your mind halfway through!

2. Once you've picked your perspective, the directions of the vertical arrows then denote the directions of the transactions. An upward arrow means that you receive money (a positive cash- flow); a downward arrow means that you pay money (a negative cash-flow).

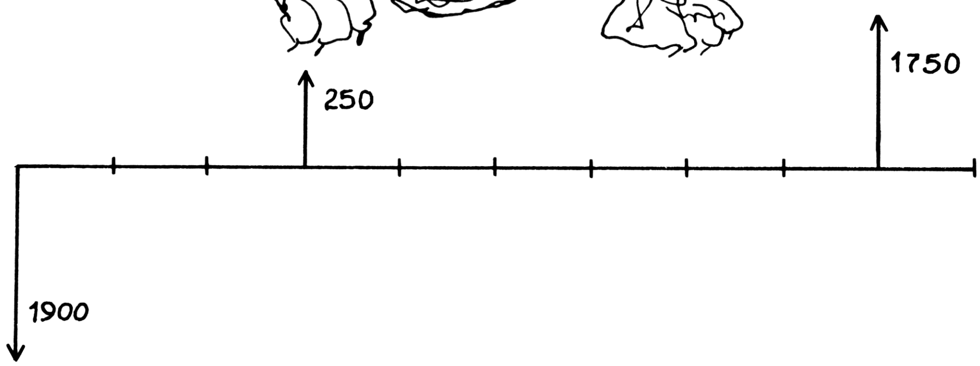
3. The lengths of these vertical arrows should reflect the amounts of the transactions. A longer arrow means more money — but don't quibble over millimeters if the general idea is clear.

4. The horizontal direction represents time (flowing from left to right). Usually, this line is marked at regular intervals to denote the D.I.P.'s (defined interest periods). This makes sense because the HP-18C is equipped to handle only regularly occurring (i.e. periodic) cash-flows, as you'll soon see.

5. Whenever you have multiple transactions that occur simultaneously, you can add them all together to obtain one net transaction. Thus:



is the same as:



Those are the "rules" for drawing cash-flow diagrams. You'll get plenty of practice drawing these diagrams in the upcoming examples, so don't worry about being able to recite these rules on cue.

Now that you know the five rules for DRAWING cash-flow diagrams, here's the real beauty of the cash-flow diagram: You can ADJUST it to make it simpler and to get a clearer picture of the advantages or disadvantages of a financial scenario.

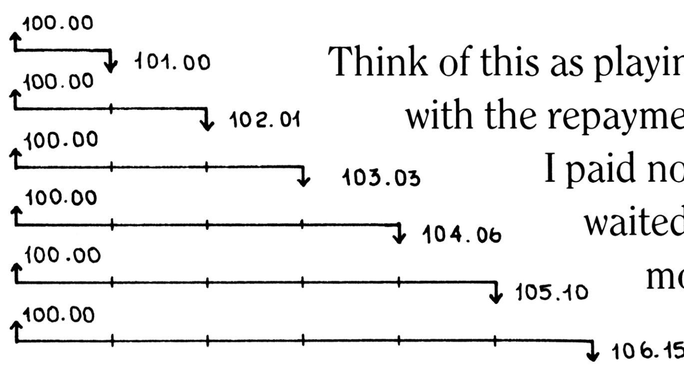
How does this work?

Well, remember that $100.00 loan for 6 months? The D.I.P. is 1 month and the D.I.R. is 1% for this problem (12% APR).

After each month, the balance owed is slightly more:

AFTER	BALANCE IS
month 1	$101.00
month 2	$102.01
month 3	$103.03
month 4	$104.06
month 5	$105.10
month 6	$106.15

Now, suppose you could decide to repay the loan at any given month. You could draw six different versions of the loan:



Think of this as playing "what-if?" with the repayment. "What if I paid now? What if I waited three more months?", etc.

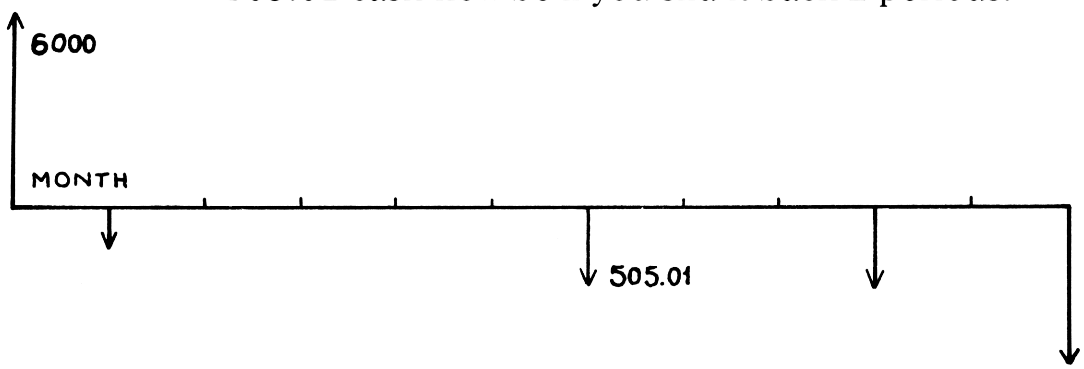
As you ponder, you're sliding that repayment up and down the time line. And wherever you put it, the picture is accurate, as long as you adjust the amount to account for the interest accrued.

The only thing that determines how that transaction shrinks or grows (as you slide it around) is the prevailing interest rate.

It's easy to see how this "sliding" affects this simple case. But it works just the same for each individual cash-flow in any, more complicated situation. THAT'S where it's really handy:

On any cash-flow diagram you can move any transaction forward or backward in time and maintain COMPLETE accuracy — provided that you let that transaction grow or shrink according to the prevailing interest rate.

Try this: The interest rate prevailing over the following cash-flow diagram is 6% A.P.R., with monthly compounding periods. How much would that \$505.01 cash-flow be if you slid it back 2 periods?



Solution: \$500.00 (because 505.01 ÷ 1.005 ÷ 1.005 = 500.00)

That's about all there is to know about cash-flow diagrams. Always draw a diagram before keying a problem into your calculator, because that diagram is the first step to translating your problem to the calculator's "language."

After a while, of course, for the simpler problems, you may draw this picture just in your mind, not with pencil and paper. But for the more complicated situations, it's best to take some time to put the picture on paper. In the long run, it will save you time AND help you to avoid costly errors.

So now you're halfway there:

1. You know how to define a problem clearly.

2. Now you need to be able to present the right question to your calculator — in terms it will understand.

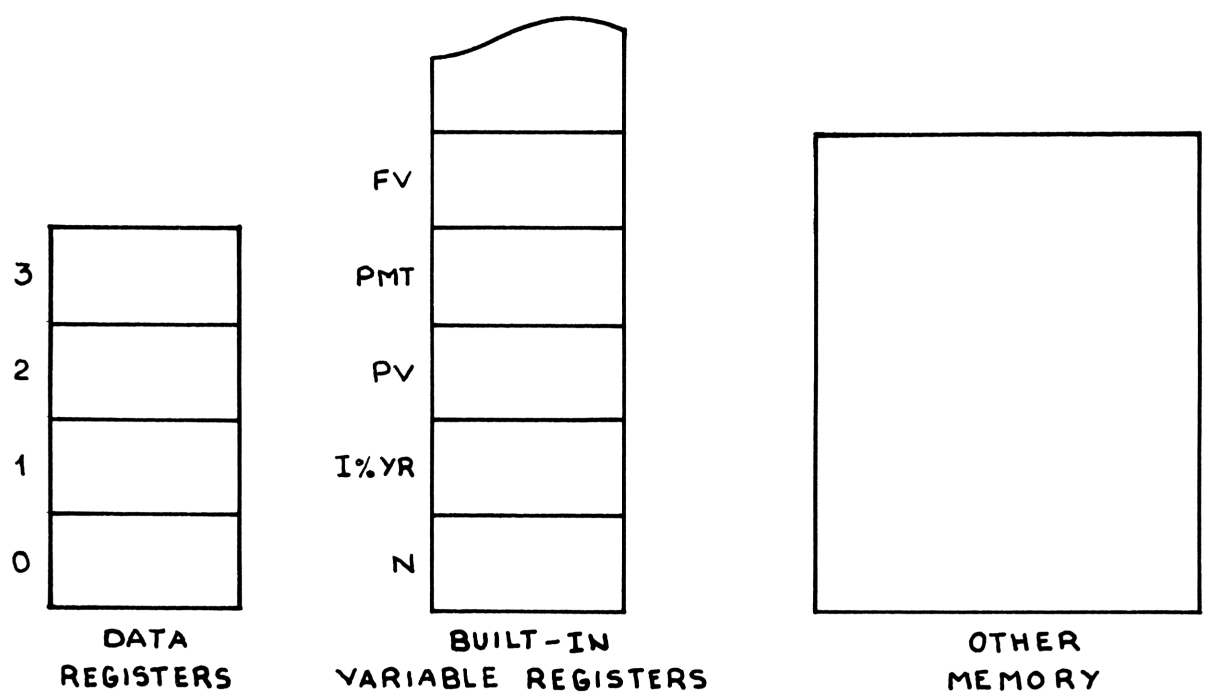
Your HP-18C can't "see" that nice cash-flow diagram you draw for yourself. You have to draw the picture in terms it understands.

DRAWING THE PICTURE FOR YOUR CALCULATOR

There are two ways to describe cash-flow diagrams to your HP-18C. One method uses five variable registers to hold your knowns and unknowns. The other method uses a number list (remember number lists?) like the ones you keyed in back on page 33.

Look at the five-register method first: These five variable registers — named N, I%YR, PV, PMT, and FV — are available to you when you press [FIN] from the main menu and then choose the [TVM] (Time Value of Money) formula. And because each of these variables has its own key on the menu, you might call this method the "5-key" method.

Though this "picture-drawing method" is the less flexible of the two, it's VERY useful when you're describing loans, leases, mortgages, annuities, or any cash-flow diagram that has one long series of EVEN (identical) cash-flows.



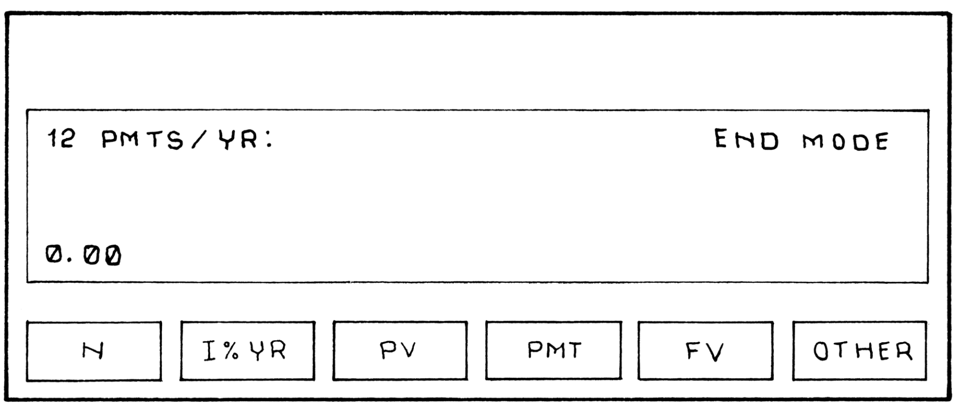
Try this: Move to the [TVM] menu and clear every register under that menu.

Solution: [FIN] [TVM] [ ] [CLEAR ALL]

No problem, right? This was just to get you familiar with the TVM menu, so don't get the idea that you will have to be clearing all these registers all the time. Remember how registers work? If you don't like what numbers are stored there, you can overwrite them with new numbers when you're ready to, but meanwhile leave the other numbers there. After all, when you clear a register, you are simply storing a new number there, anyway — namely, the number 0.

So of the many different ways to clear things from your calculator, CLEAR ALL should be the one you use LEAST FREQUENTLY. If you get in the habit of using CLEAR ALL, one of these days you'll wipe out some information that you don't want to lose.

Now your display should look like this:



[N] : total Number of payments

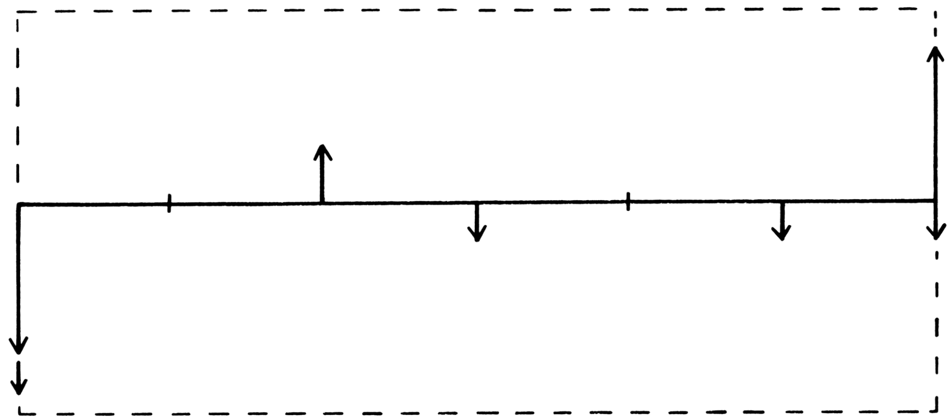
[I%YR] : Interest rate per YeaR

[PV] : Present Value

[PMT] : PayMenT

[FV] : Future Value

The best way to think about these 5 values is that they form a picture frame that you can set over a cash-flow diagram:



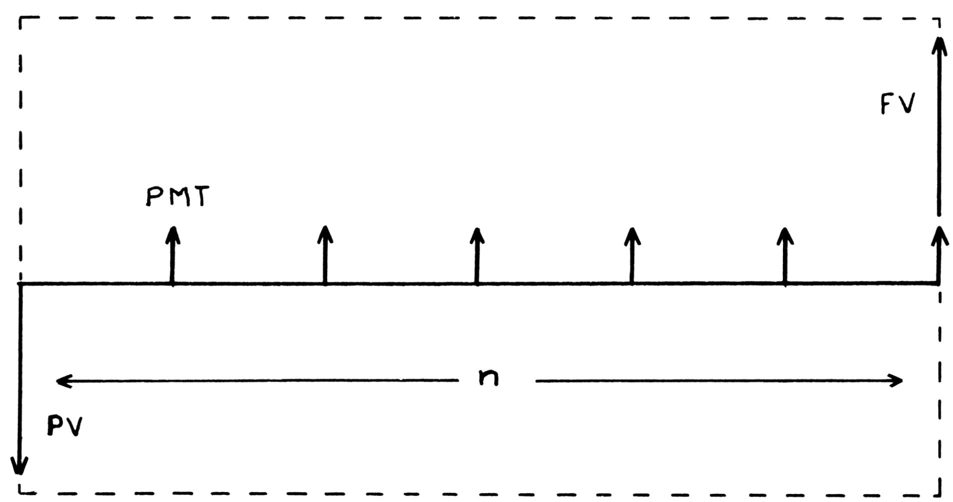
[PV], [FV], [N], and [PMT]

The Present Value (PV) is the net cash-flow that occurs at the LEFT side of the picture frame.

The Future Value (FV) is the net cash-flow that occurs at the RIGHT side of the picture frame.

The Number of periods (N) is just that — it's the number of D.I.P.'s occurring between the PV and the FV.

The payment (PMT) is a convenience item, really, for cases where the picture is like this:



The payment amount (PMT) is the amount of EACH of a level series of cash-flows — occurring exactly once every D.I.P. Of course, that means there are "N" PMT's. On the previous diagram, N = 6, so there are six payments, corresponding to the six periods.

And remember! The only cash-flow diagrams that you can describe to your calculator using this five-variable method are the diagrams that have a level series of payments (PMT's).

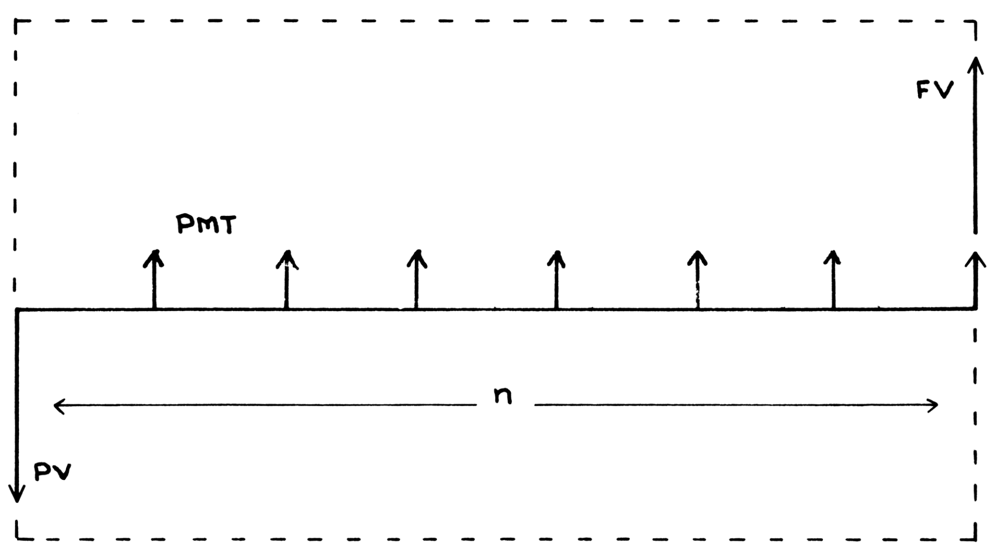
Now, when you store numbers in the PV, PMT, and FV registers, you're telling the calculator the amounts of these cash-flows AND their directions (up or down). You indicate direction by adjusting the sign (positive or negative) of these numbers.

Use positive numbers for the upward cash-flows (when you receive money), and use negative numbers for the downward cash-flows (when you pay money). Remember how to use the [+/−] key? See page 30.

Another thing: The HP-18C demands that PV and FV be of opposite sign. If PV is negative, then FV must be positive, and vice versa. This is consistent with the idea of investment and return (or borrowing and repayment), right?

(Right)

Now, here's another look at that loan picture you just saw:



Wondering why there are two arrows at the right-hand end? After all, you could "net" them into one transaction, couldn't you?

The reason is this:

FV is the cash-flow that occurs at the right end of the picture OVER AND ABOVE the PMT that may occur there (even if the two occur simultaneously).

And PV is the left-side cash-flow OVER and ABOVE any PMT that may occur there.

That's what the calculator means by PV and FV.

[I%YR]

You've probably noticed that nothing's been said about the [I%YR] variable yet. It's really very simple:

The number in the I%YR register represents the Defined Interest Rate (D.I.R. in percentage form) MULTIPLIED by the number of periods (D.I.P.'s) in a year. (D.I.R. and D.I.P. are discussed back on page 117. If you've forgotten what they mean, better take a moment to review them now.)

Be sure to remember that the calculator does this multiplying — this "annualizing" — for you. You may form the (good) habit of thinking purely in terms of Defined Interest Rate rather than an annualized rate; but when you use the 5-key method, the calculator will always produce the answer for interest IN ANNUALIZED FORM. And it will always interpret any given ("known") I%YR that way, too.

"So how does interest fit into the picture frame idea?"

The interest is the "glue" that holds that frame together. In effect, it determines how big FV must be to compensate for PV and for "N" periods of equal PMT's. OK?

Now you're all set:

A. You know how to picture the memory of your calculator, how to use it to do arithmetic, and how to use the keyboard.

B. You know that you need to use cash-flow diagrams to define a problem AND that it's "legal" to move cash-flows around on that time line (as long as you adjust them to the prevailing interest rate).

NOTES

QUICK REVIEW

From the main menu, press [FIN] [TVM] . Now, what effects will the following keystrokes have? Don't worry about the numerical answers. Just ask yourself: When will a number be stored, and when will one be calculated, recalled, etc.?

1. 100 [PV]

   [+/−] [FV]

   1 [N]

   [×] 12 [I%YR]

   [PMT]

2. [RCL] [FV]

   [STO] [PV]

   [FV]

(See the next pages for the answers.)

QUICK ANSWERS

Here are the results of those keystrokes. These are important to understand completely.

1.

KEYSTROKES	EFFECT
100 [PV]	Keys in 100 to the calculator line, then copies it into the PV register.
[+/−] [FV]	Changes the 100 on the calculator line to −100, then copies that into the FV register.
1 [N]	1 goes on the calculator line and is copied to the N register.
[×] 12 [I%YR]	Multiplies the 1 on the calculator line by 12 and stores the result in the I%YR register.
[PMT]	Calculates the correct number for PMT, based upon the other 4 variables (N, I%YR, PV, and FV). This is a calculation instead of a storage, since you just stored into a variable register (I%YR).

2. [RCL] [FV] Recalls to the calculator line a copy of the number contained in the FV register.

[STO] [PV] Stores (copies) that number from the calculator line into the PV register.

[FV] Calculates the correct FV based upon the current values of N, I%YR, PV, and PMT. Again, this is a calculation because a value was just stored in a variable register.

You'll notice that a copy of the result of every financial calculation will end up on the calculator line as well as in the correct financial register. For example, when you press [FV] the second time in the above example, the answer ends up both in the FV register and on the calculator line.

So, how does all this sit with you? You're probably thinking that this background information and keystroke practice is all well and good, but when will you actually get to apply all these rules and keystroke mechanics?

All these details are probably floating around in a financial fog in your mind....

Yes, fans, that's right — it's the moment we've all been waiting for....

FINANCIAL CALCULATIONS

Here's a good first example. You're going to imagine yourself a farmer purchasing a tractor. But keep in mind that it's not what you're buying that matters. Whether you're in farming, real estate, leasing, banking, or any other kind of trouble, interest works the same way. The challenge is to wade through the terminology to get to the bare essentials. Now all this fog will start making some sense.

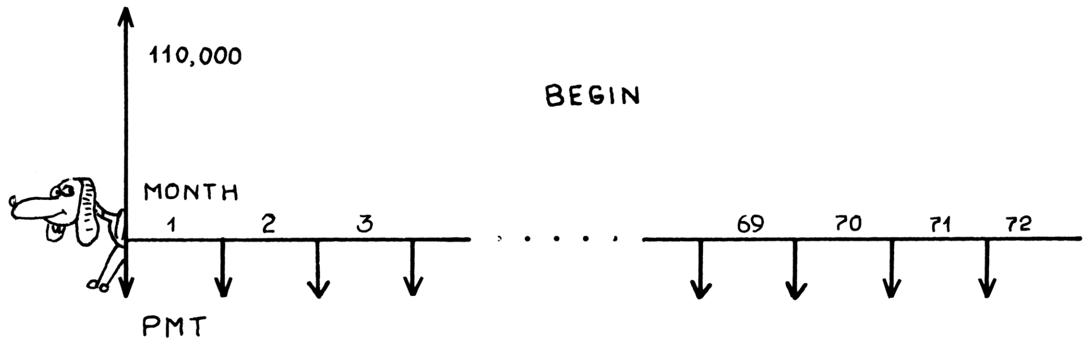
Here goes: As a young farmer, you've decided it's time to improve your equipment. You want to borrow $110,000.00 to buy a new 4-wheel-drive tractor. You want a six-year loan with regular monthly payments that completely pay off the loan in those 72 installments.

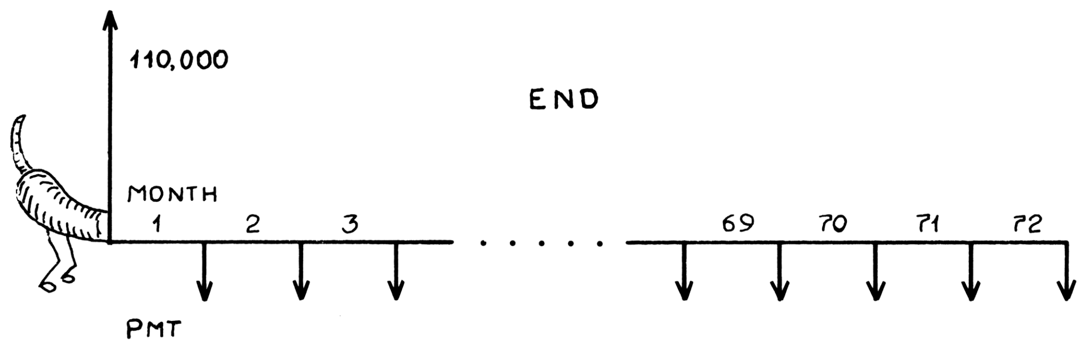
The major tractor dealers are boasting 7.75% A.P.R. financing. What does that mean your monthly payment would be?

(If you know how to solve this, try page 142. But if you're in the slightest doubt, read on...)

This IS a fairly complete description of a typical loan problem, but one detail is missing: Will the monthly payments be made at the beginning or at the end of each month? Do you even care?

Well, compare the two pictures:





BEGIN OR END?

As you can see, in the first case, a payment is due at the beginning of the loan. As soon as you get the money, you turn around and make the first payment. This reduces the balance sooner, so there is less interest paid on the borrowed money.

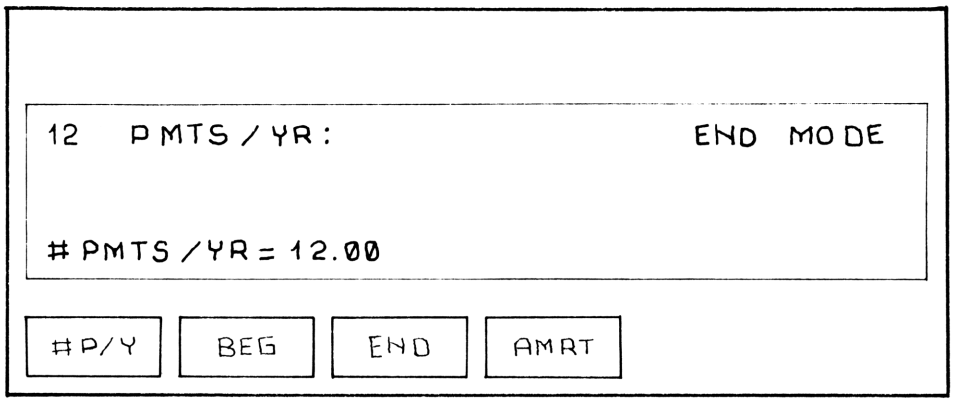
With less interest to be paid, the PMT amount (which covers both interest and principal) will be less. SO it DOES matter whether the payment is at the BEGinning or the END of the period.

So what about your tractor loan? Which is it going to be?

Well, in a real contract, it would have to be stated, but for this problem, just assume the more common case — the payment occurs at the END of each month.

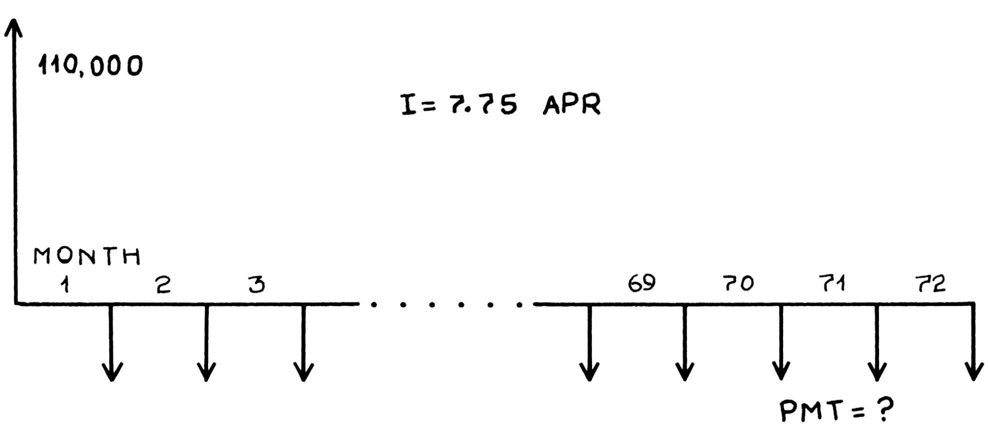
Press the [OTHER] key (the last blank key). This takes you to a menu that tells the calculator certain key details about a TVM financial calculation. Here you can change the number of payments per year (and thus change the D.I.P.) using [#P/Y], AND you can tell the calculator whether the payments are at the BEGinning or the END of the payment period.

Press 12 [#P/Y], and then press [END]. This sets the number of payments per year to 12 (monthly D.I.P.'s) and sets the calculator to END MODE (payments occur at the END of the month). The display will now reflect this information:



NOW DRAW THE COMPLETE PICTURE

(This isn't too hard — you've already seen it.) You're the borrower, so you receive the loan and pay the installments; when you key in your PV, it will be positive, and the PMT amount you calculate should come out negative:



The unknown on this diagram is the PMT; that's what you want to find — what your payments will be.

But what about FV? What is it?

In this case, there is no FV; that is, FV = 0. The description of the loan said it would be entirely paid off (amortized) by those 72 level payments. And remember what FV represents? It's the amount of the remaining transaction AFTER the 72nd month and AFTER the 72nd payment. If there's nothing left, then FV must be zero.

But you still need to tell that to the calculator! DON'T just assume that the FV register contains a zero.

Remember! The HP-18C has Continuous Memory. If there's some non-zero number in any register, it will stay there for months — until you change it. It's like a budget deficit — it won't just melt into zero because you ignore it.

FOR EVERY CALCULATION YOU PERFORM WITH REGISTERS N, I%YR, PV, PMT, AND FV, YOU SHOULD USE FOUR NUMBERS TO SOLVE FOR THE FIFTH. NEVER IGNORE ONE!

So...you've pretty well defined this tractor loan problem:

END mode

PV = 110,000

FV = 0

N = 72

PMT is the unknown you're after.

Wait a minute...what's I%YR?

The interest rate was quoted as 7.75% A.P.R., but it doesn't say how often compounding occurs.

The fact is, there are many times when the only clue you have is the payment period. If the payment period is monthly, then unless it's stated otherwise, the interest will compound monthly.

All you have to do is key in that 7.75% A.P.R. (Annual Percentage Rate). The calculator will automatically divide it by 12 (the number of payments in a year), to come up with the D.I.R. REMEMBER, it's this D.I.R. that is actually used to do the calculation itself. As things get more complicated, you MUST keep that in mind.

In fact, the only reason the calculator knows how to properly divide I%YR, is because YOU told it (using [#P/Y]) how many payments are in a year. Remember: the A.P.R is only a convenient approximation of reality; the number 7.75% is arrived at merely by multiplying the actual monthly D.I.R. by 12.

With that in mind, try this:

Store the A.P.R. (7.75) in the I%YR register.

Solution: [EXIT] (if you're still in the OTHER menu) 7.75 [I%YR]

NOW you can draw the COMPLETE picture for your HP-18C:

110,000 [PV]
0 [FV]
72 [N]

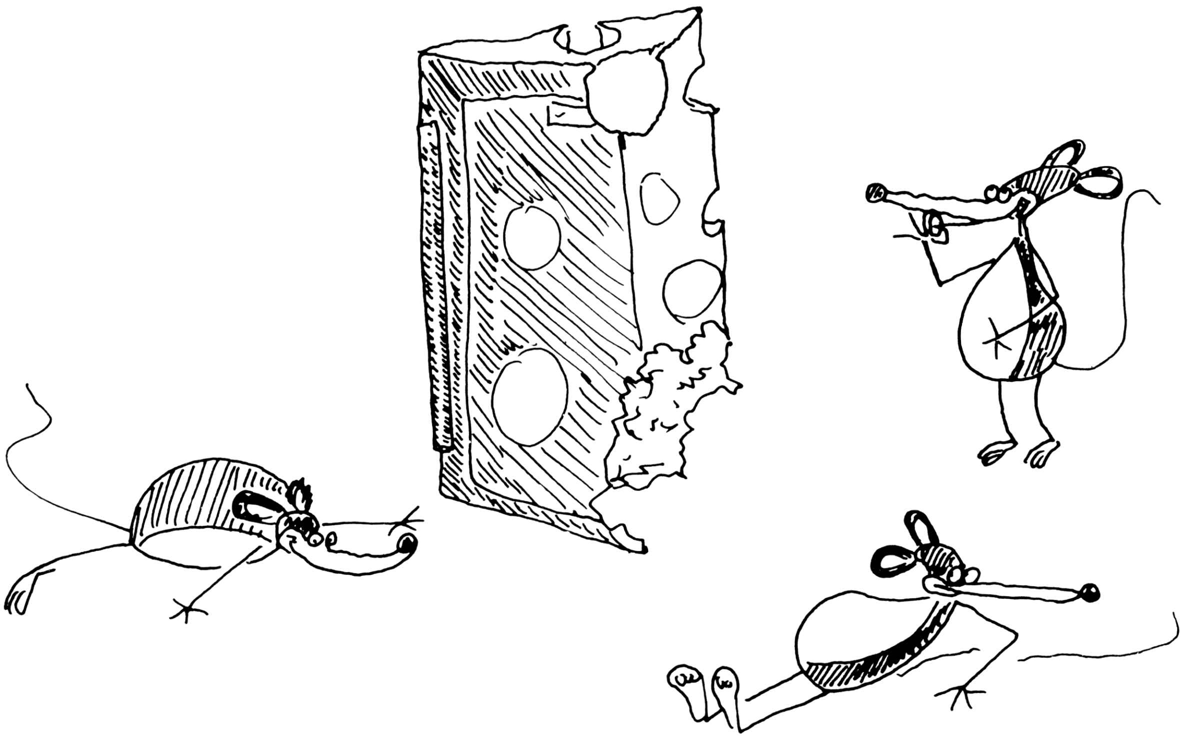
(If you think about what's happening in the financial registers, you'll realize that the order in which you key in these values doesn't matter.)

Now solve for the payment by pressing [PMT]. The answer is PMT = −1915.26. It's negative because you're paying it, not receiving it.

TO REVIEW

1. You got a verbal description of the loan.
2. You debated on BEG vs. END mode: END mode (also called "annuity in arrears").
3. You drew the correct picture of the situation on a cash-flow diagram, establishing your perspective as a borrower and therefore the signs (+ or −) of PV, PMT, and FV.
4. You observed that since the 72 payments "completely amortized" the loan, FV must be zero.
5. You stored the quoted A.P.R. in [I%YR], knowing that you had set the correct number of payments per year and that the payment period and the compounding period were the same.
6. You "plugged in" all the other information: PV = 110,000.00, N = 72, FV = 0 — and solved for PMT.

7. You were thoroughly impressed with the speed and power of this calculator, and you thought this first problem was a piece of cheese.



But keep in mind that you're learning more than just this example. Retain the concepts — don't just concentrate on a given set of keystrokes!

After all, the keystroke procedure itself IS pretty trivial, no? The difficult part is deciding what to put into the calculator so that it will grind out the correct answer — every time.

$1,915.26

There's your payment on that 4-wheel drive tractor, OK?....No...? ...You can't afford that much every month?

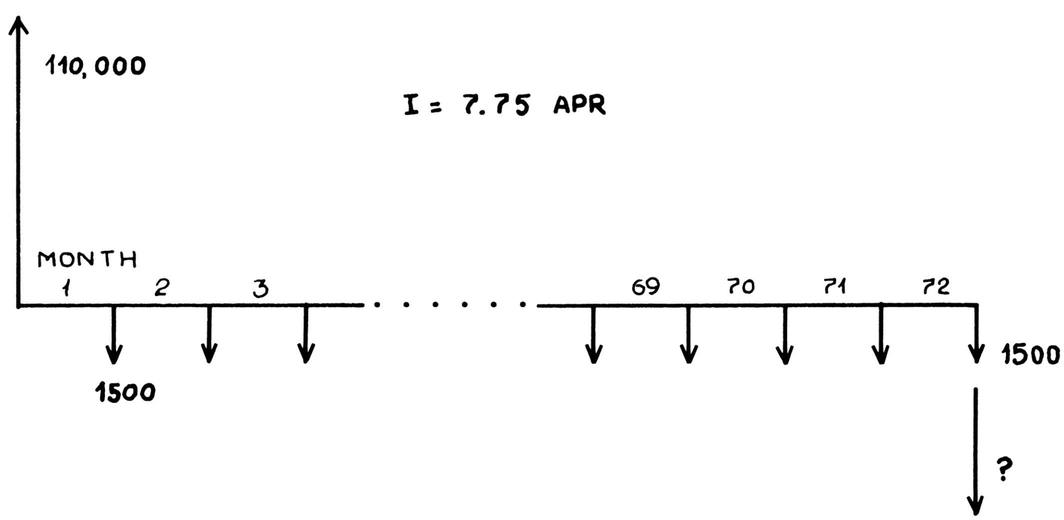
Well, how much would you be comfortable paying? Say...$1500.00?

OK, but that means there will be a lump-sum remaining balance to pay off at the end of 72 months. At this interest rate, $1500 per month simply won't "completely amortize" $110,000 in 72 payments (because it takes $1915.26 per month to do that, as you just proved).

Are you willing to pay that "balloon payment," as it's called? Before you commit yourself, you'd better figure out how much it is. (If you already know how to do this, then do it and skip ahead to page 144.)

The first step, as always, is to see what the situation looks like on a cash-flow diagram. This time, you know the payment amount. It's $1500.00, and from your perspective, this steady PMT is a downward arrow, right? But you don't know FV. That's the balloon amount — the balance remaining AFTER the 72nd PMT and AFTER the 72nd D.I.P. (Remember this definition? It's on page 129.)

So here's what the picture would look like for this case:



This is a good example where none of the five financial numbers is zero, and where you can (and should) reuse most of the values currently sitting in those five registers:

PV = 110,000 — same as before (don't touch it)

N = 72 — same as before (don't touch it)

I%YR = 7.75 — same as before (don't touch it)

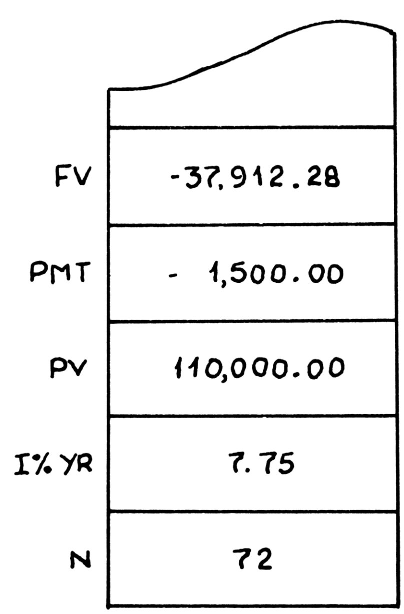
PMT = −1500 — a new value (touch it)

The only thing you're changing is PMT. FV will be calculated from the above information, so don't waste your time keying everything in again. Just change the one number, PMT, and then recalculate FV to get the balloon amount:

1500 [+/−] [PMT] [FV] (−37,912.28)

You'll have to pay $37,912.28 at the end of 72 months — in addition to your 72nd regular PMT.

Starting to get a feel for playing "What-If?" with these five keys? Here's how the variable registers look at this point:



Uh-oh!...that balloon amount is a bit too steep, isn't it? (Yep.)

OK...try to find a happy medium — a low enough PMT without such a huge ballon at the end.

So what's the greatest balloon amount you'd tolerate? $28,000.00? Fine. Now check to see what PMT amount that implies. Change only what you have to (FV), and then find the corresponding PMT:

28,000 [+/−] [FV] [PMT] (−1608.57)

Even if that payment amount isn't too comfortable, is it at least feasible?...It is? Good! Your "what-iffing" has paid off!

This is the whole story of working variations on 5-key problems: you vary one parameter, leave 3 others intact, and solve for the fifth.

Need some more practice? Sure you do — and it's your lucky day, because now that you've decided what loan you can afford, it's time to go shopping for that money.

There are several brands of 4-wheel drive tractors that you are considering, and the financing is a big factor in your final choice.

The first tractor dealer is anxious to do business. He agrees to the six-year loan and the balloon payment at 7.75 A.P.R., but there is one other detail: The interest is a nominal 7.75% A.P.R. all right, but it's compounded DAILY. This can't possibly make much difference in your payment or your effective rate, can it?

Whoa! The D.I.P. (Defined Interest Period) doesn't match the payment period. As you know, the payment period and the compounding period must ALWAYS match if you want to get the right answer with your HP-18C. So how do you even COMPUTE a monthly payment with daily compounding interest? (If you already know how, turn to page 149.)

INTEREST CONVERSIONS

It boils down to this: You need to CONVERT a daily compounding rate to its equivalent monthly compounding rate. But how?

This is really no problem at all on the HP-18C. In fact, the calculator already has such an equation built into it! Press [EXIT] to step back one menu (to the FIN menu). You'll see that one of your choices here is [ICONV] (Interest CONVersions). Press this key.

Now you're offered the menu: [EFFCT] [CONT]. From this menu, you will usually choose the [EFFCT] (EFFeCTive rate) key unless you are dealing with continuous compounding (which is rare).

Press [EFFCT]. The calculator then offers you this menu:

NOM% EFF% P

The question you want to answer using these variable registers is: "What NOMinal rate compounded monthly gives the same EFFective rate as 7.75% compounded daily?"

Exercise:	What nominal rate compounded monthly gives the same effective rate as 7.75% compounded daily?
Solution:	7.77425201684%

Did you get this answer? Do you understand why every decimal place is important in the answer? (If so, you may move ahead to page 149.)

Explanation: When you enter this EFFCT menu, the display shows you a description of the equation that it uses to calculate the variables NOM%, EFF%, and P. It's saying to you:

"EFF% = NOM% compounded P times a year."

That means that P is the number of compounding periods in a year, so before you compute the effective rate for daily compounding you have to decide how many days are in a year. Some banks base their calculations on a 360-day year; some use 365 days year. (Your tractor dealer forgot to tell you until you asked him, but he uses a 365-day year.)

So to figure out the effective rate of 7.75% compounded daily, simply press:

7.75 [NOM%] 365 [P] [EFF%] .

The effective rate, with daily compounding, turns out to be 8.06%.

Now, to calculate the nominal rate that would give that same effective rate if it were compounded monthly, just press

12 [P] [NOM%]

It's that simple! The answer is 7.77425201684 (press [DISP] [ALL] to verify this). The reason for all those extra digits is to emphasize the fact that if you jot down this answer on a napkin — to save it for future calculations — you'd better write down every digit or you'll get incorrect subsequent answers upon reusing that number.

The calculator always uses 12 digit numbers. The ONLY answer you should write down with 2 decimal places is your final answer. Don't round things off mid-way through — the calculator doesn't!

So, other than writing it on a napkin, how else do you move this newly-calculated percentage rate from this menu to the TVM menu — for use in your tractor loan problem?

Well, there are two ways: You know that the numbered registers are always available to store values, so right now, you could press [STO] 1 or [STO] 2 (etc.), to save this number until you need it.

OR you could take advantage of the fact that the value on the calculator line is preserved as you move from menu to menu. That means that you could go ahead and move to the TVM menu first, and then store this value directly into the I%YR register as soon as you get there. (After all, that's where you're going to need it for your tractor calculation, right?) Try this second way. Press:

[EXIT] [EXIT] [TVM] [STO] [I%YR] [DISP] [FIX] 2 [INPUT] .

Question:	Why press [STO] [I%YR] ? Why not simply [I%YR] ?
Answer:	Since the last thing you did (changing the menus doesn't count) was to calculate a variable, you MUST use the [STO] key. Otherwise, the HP-18C will recalculate [I%YR] based on the other four values (7.75%) and you'll have to go back and convert the interest rate again (not too handy).

Now (finally) you're ready to check what this daily compounding business would do to your tractor payment. You've stored the converted interest rate — the monthly rate that is EQUIVALENT to 7.75% compounded daily. And everything else is the same as it was before; the numbers in the financial registers are as follows:

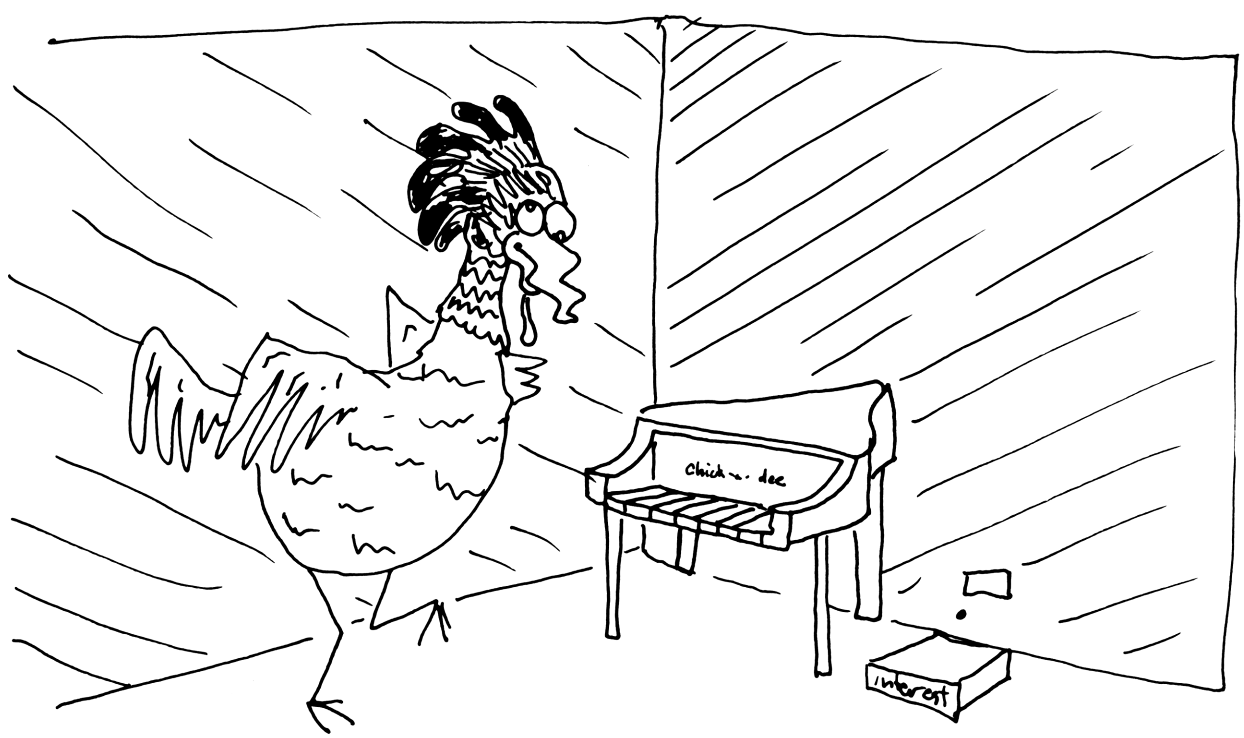
N = 72 I%YR = 7.77

PV = 110,000.00 FV = −28,000.00

PMT = ? (you want to calculate this)

Use the [RCL] key to recall these values if want to check them. Then calculate your payment: [PMT] (Answer: –1610.10).

Well, that doesn't change it much — less than a $2 increase (over the original payment amount you figured, $1608.57). But now that you've had a taste of "wheeling and dealing," you decide to shop around for a better deal on your new four-wheel. So, you fold up your HP-18C and head to the next farm implement dealer.

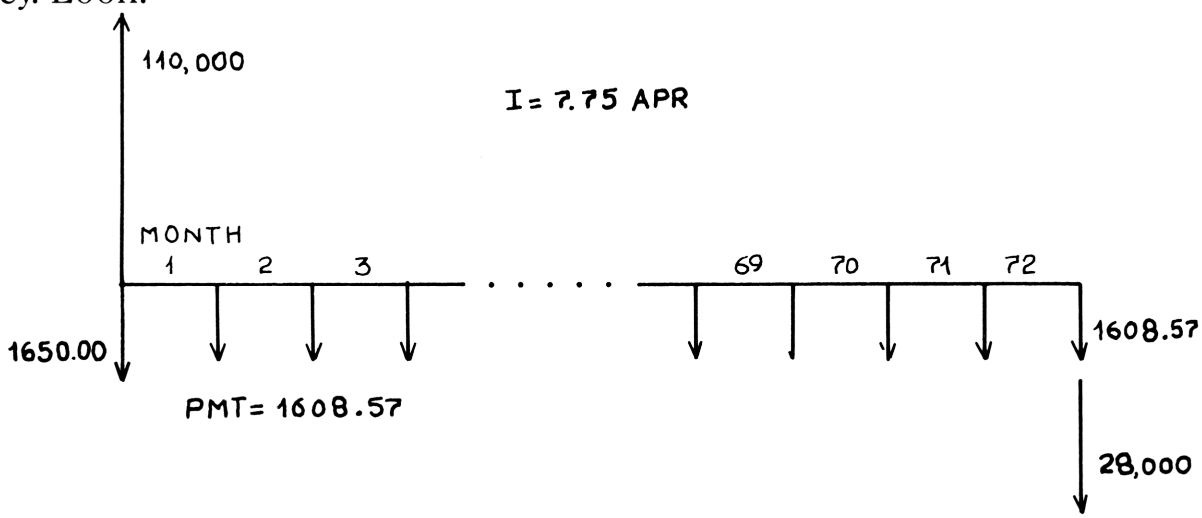


On the way, of course, you're thinking about how that daily compounding can jack up the effective rate. By compounding more often, small amounts of interest are added on earlier, so that each small amount is there to collect interest sooner. It boggles the mind, but it works, and now that you've thought it all through once, you're better prepared for the next session of tire-kicking....

The next dealer you visit agrees to most of your terms, including monthly compounding (7.75%), but with this added stipulation:

A finance charge equal to 1.5% of the loan must be paid at the time the loan is signed ("points up front"). This charge does NOT reduce the repayment amount; it's a separate financing fee altogether.

How does this look from your point of view? Obviously, it's not as good a deal as the straightforward loan you want, nor even as good as the previous dealer with the daily compounding. With the finance charge, you're simply paying more money. Look:



Remember the rule? When two or more cash-flows occur simultaneously, you can add them together to get one net cash-flow.

So you're receiving a $110,000 loan, but at the same time paying a $1,650 finance charge. Clearly, you're really getting only a $108,350 loan. BUT, you're still making payments on the full $110,000. That finance charge is NOT applied toward the balance!

What does this do to the interest rate you're being charged (as if you couldn't guess)? Is the nominal rate still 7.75%?

(If you know how to solve this, try page 151.)

Of course, your payment and balloon will be just what you prescribed (recompute it here for practice):

72 [N]

110,000 [PV]

7.75 [I%YR]

28,000 [+/–] [FV]

[PMT] Answer: –1608.57

Look familiar? That's what you'll pay every month. In fact, the whole loan situation looks precisely like what you first decided you could afford, EXCEPT that the loan amount you'll receive is only $108,350. (Thus, to buy the $110,000.00 tractor, you'll need to come up with the $1650.00 somewhere else.)

So what's the true A.P.R. you would be paying here? What interest rate is the "glue" holding this picture together? Well, since all other variables stay the same as before, don't touch them. All you need to do is plug in the true Present Value:

[RCL] [PV] [–] 1.5 [%] [PV] (see how that [%] key works?)

Now solve for I%YR. Press: [I%YR] Answer: I%YR = 8.21

"I'll be danged." That's NOT the 7.75% you were looking for, is it?.

See how "points up front" — those prepaid finance charges — can change the true interest on a loan? Suddenly, you decide you don't like the paint job on this model anyway....

The next shop down the road is more helpful. Their lender will finance the tractor as you have prescribed (7.75 compounded monthly, 6 years, $28,000 balloon), except they would like each payment at the beginning of the month, rather than at the end ("annuity in advance," instead of "annuity in arrears"). How does this change things?

Well, you've already seen the two pictures compared (look back at page 136).

If you agree to this loan, you'll owe a payment immediately upon signing. Now, this starts to sound like a finance charge, but it's not. In this case, the initial payment DOES apply toward repaying the loan. And this DOES change the PMT amount:

[OTHER] [BEG] [EXIT] (changes from END mode to BEG mode)

110,000 [PV]

72 [N]

7.75 [I%YR]

28,000 [+/−] [FV]

[PMT] Answer: PMT = −1598.25 (remember why it's negative?)

That's LOWER than your prescribed "tolerable" PMT (and it's the tractor you like the most)!

You'll take it? Great. But hold on a minute — there seems to be a little hocus-pocus going on here: YOU will save money each month, compared to what you thought was a 7.75% A.P.R. — compounded monthly — and yet the lender will indeed earn a true-blue (-green?) 7.75% A.P.R.! Voodoo economics?

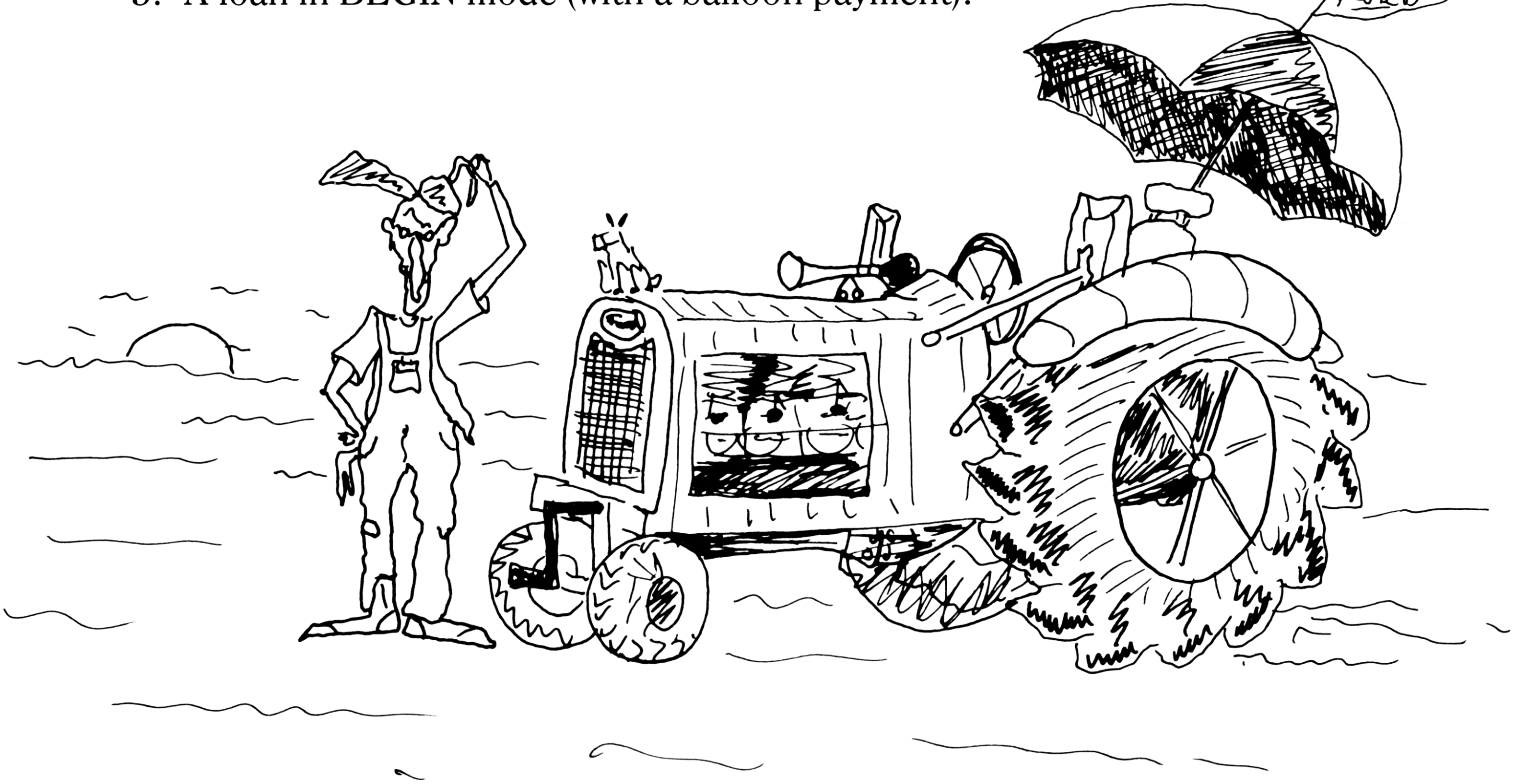
No, there's no contradiction here. You'll save money, not by paying a lower interest rate, but by borrowing for a SHORTER TIME (i.e. because of BEGin mode, you're paying back the money sooner). The SAME rate will, of course, earn DIFFERENT dollar amounts over DIFFERENT lengths of time.

Well now:

- The lender is happy with the earnings.
- The tractor dealer is happy with the sale.
- You're happy with the tractor and satisfied with the loan.

But are you satisfied with your understanding of these 5 financial keys on your HP-18C? That is, can you now solve these problems?

1. A fully amortized loan.
2. A loan with a balloon payment.
3. A conversion from a daily compounding rate to the equivalent monthly rate.
4. A loan with prepaid finance charges ("points up front").
5. A loan in BEGIN mode (with a balloon payment).



NOTES

TEST YOURSELF!

Solve these problems. In case you need hints, the solutions begin on the next page. Remember, a cash-flow diagram is a must!

1. A mortgage is written at 15.5% A.P.R. It amortizes totally in 30 years of $400 monthly payments (in arrears). How much was loaned?

2. If the above loan had $350.00 payments (annuity in advance), what would the remaining balance be after the 360th month? After the 120th month?

3. A finance company agrees to loan $100,000.00 at 17% A.P.R., compounded daily (on a 360-day year), in exchange for quarterly payments (in arrears) that will amortize the loan in 15 years. A 2% finance charge is due and payable at the beginning of the loan. (Good grief!)

   a. What is the payment amount?

   b. What is the remaining balance after 10 years?

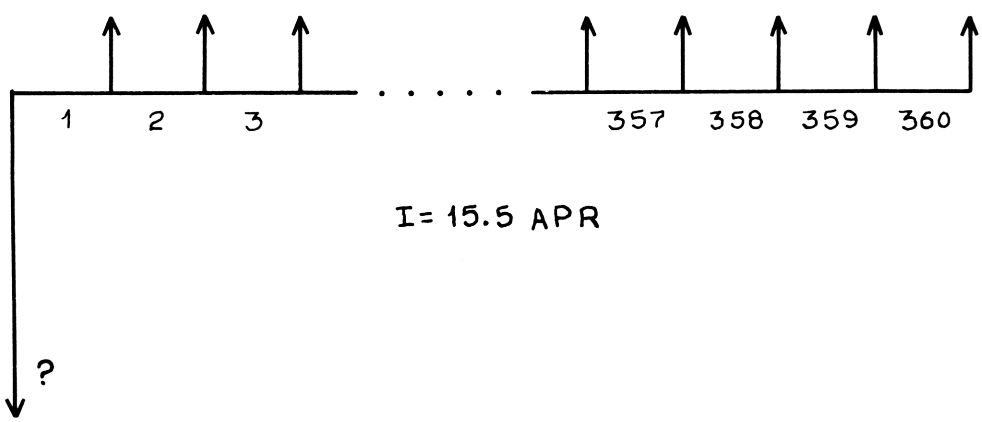
   c. What is the nominal A.P.R. earned for that 10 year situation (taking into account the "points up front")?

   d. What EFFECTIVE annual interest does that nominal A.P.R. represent?

4. Farmers generally prefer to make the payments on their loans coincide with the sales of their crops. Many make annual payments on equipment, seed, and other supplies. But suppose you arranged your tractor loan so that you make one big payment in August (that coincides with your blueberry sales), to make up for January through August; and one smaller payment in December (when you usually sell your wheat), to make up for September through December. How do you figure out what those payments will be, assuming all the terms stay the same (interest rate, compounding period, BEG mode, etc.)? Assume that your loan started on January 1.

TEST SOLUTIONS

1. The situation is this:



And the keystrokes are these:

[OTHER] [END]

12 [#P/Y] (If the display doesn't already say 12 per year)

[EXIT]

360 [N]

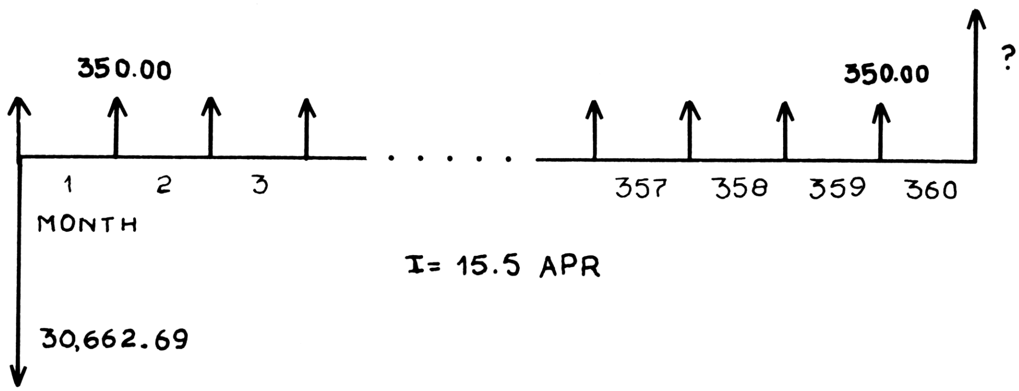
15.5 [I%YR]

400 [PMT] 0 [FV]

Solve for the present value: [PV] Answer: PV = −30,662.69

This was the amount of the mortgage (sort of a weird number for a mortgage, actually). Can you tell that this problem was solved from the perspective of the lender? (See page 121 if you can't.)

2. The situation — a revision of the previous problem — is this:



Don't touch [N] , [PV] , or [I%YR] ; they're all correct from the previous problem. Just press:

[OTHER]	[BEG]	[EXIT]
350	[PMT]	
	[FV]	Answer: FV = 353,916.61

Heavens to Murgetroid! That balloon amount is over 10 times the original amount of the loan! Something must be wrong.

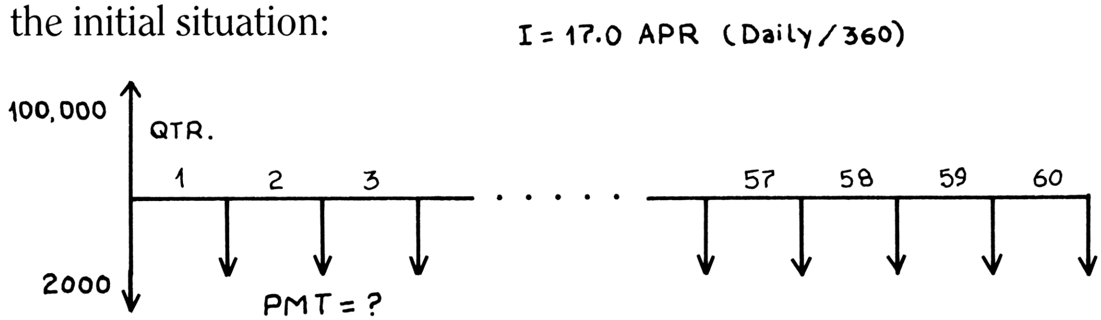
"DO NOT ATTEMPT TO ADJUST YOUR MACHINE." It's behaving as it should — as you would too, if someone gave YOU payments too small even to cover each month's interest. This means that the unpaid interest is constantly being added to the (untouched) principal, producing a balance that is growing rather than shrinking every month. This is called "negative amortization."

And what about a 120-month balloon? As you can see, simply by changing the number in the N register, you can vary the term of the loan, "calling" it due and payable (as a balloon) whenever you want — another experiment, courtesy of the "What-If" method.

Solution: 120 [N] [FV] Answer: FV = 42,448.84

Again, this is more than the original mortgage because each month's payment is less than the interest charged for that month.

3. Here's the initial situation:



First, find I%YR by detouring to the ICONV menu, converting the daily rate to a quarterly rate, and then returning to TVM to store it:

[EXIT]		
[ICONV]	[EFFCT]	
17	[NOM%] 360 [P] [EFF%]	
4	[P] [NOM%]	(Answer: NOM% = 17.36)
[EXIT] [EXIT] [TVM] [STO] [I%YR]		(Returning and storing)

Now find the payment for this loan situation:

100,000	[PV]	
60	[N]	(15 years has 60 quarters)
(Don't touch [I%YR])		
0 [FV]		(Why zero? See page 138)
[OTHER] 4 [#P/Y] [END]		(Set 4 payments per year and END mode)
[EXIT]		(Come back to the TVM menu to calculate)
[PMT]		a. Answer: −4,708.42

Should this value be negative?

Now that you know the actual PMT amount, you can find the remaining balance after 10 years (40 payments):

40 [N] [FV] b. Answer: –62,101.87

Now, considering the "points-up-front" finance charge, the actual nominal A.P.R. is easy to calculate:

98,000 [PV]

(Why is this 2% less? See page 149, if you don't know.)

[I%YR] c. Answer: I%YR = 17.84%

Finally, you're asked to turn this nominal rate into an effective annual rate:

[EXIT] [ICONV] [EFFCT]

[STO] [NOM%] (Why do you have to use the [STO] key?)

4 [P]

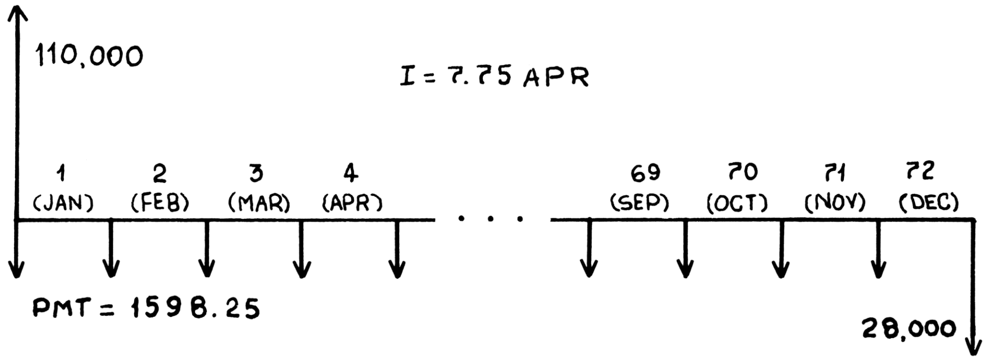
[EFF%] (Answer: EFF% = 19.06%)

So at this interest rate and compounding schedule, $100.00 would turn into $119.06 after one year. Pretty slick, eh?

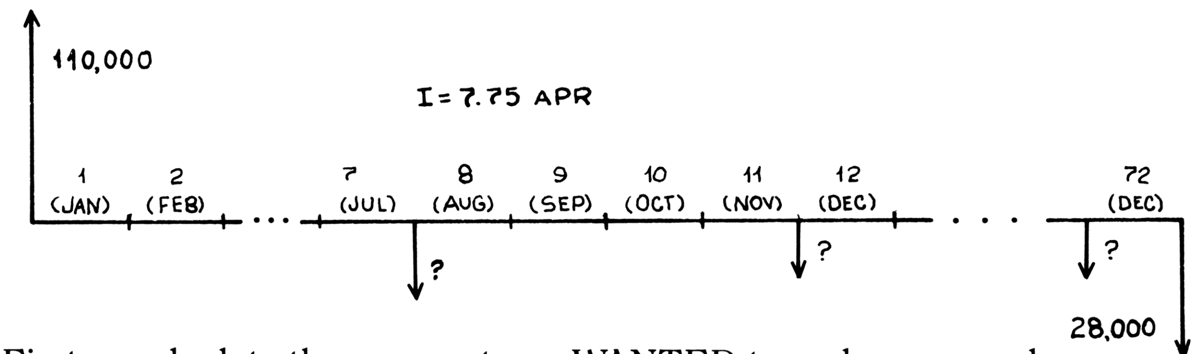
Now get back to the TVM menu: [EXIT] [EXIT] [TVM]

4. This problem is not difficult if you look at the picture and remember that you can slide cash-flows around — as long as you adjust for the interest rate.

You have a loan that looks like this:



And you want to turn it into this:

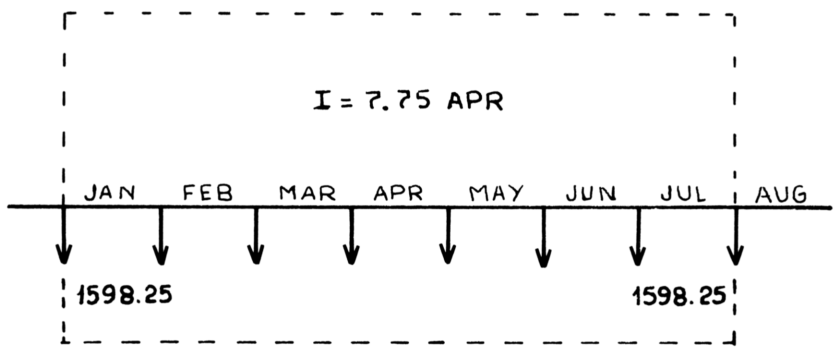


First, recalculate the payment you WANTED to make on your loan:

[OTHER] [BEG] 12 [#P/Y] [EXIT]	(set BEGin mode and 12 pmts/yr)
7.75 [I%YR]	(this was the interest rate)
110,000 [PV]	(this is what we borrowed)
72 [N]	(six years of monthly payments)
28,000 [+/−] [FV]	(28,000 balloon payment)
[PMT] → −1598.25	(look familiar?)

So much for the warm-up. Now how about this big, hairy problem? Usually, the hardest thing about any problem in finance is weeding out the irrelevant verbiage in a contract and getting the problem down to a hard and cold cash-diagram.

In this problem, in order to figure out the payments you'd need to make in August and December — payments that would be equivalent to regular monthly payments for one year — you need only look at the payment stream. For example, to figure your August payment, you just have to find the Future Value of all previous payments that year:



Notice that because the loan is "Annuity in Advance" (BEGin MODE) you need to slide all the payments through July to the first of August, using an FV calculation. Then you add that result to the regular August payment (which also occurs on the first of August). This is your actual August payment. Keystrokes:

0 [PV]	(looking at the payment stream only)
7 [N]	(need to slide these payments to the end of July)
	(don't touch [I%YR] or [PMT])
[FV]	(Answer: FV = 11,480.52)

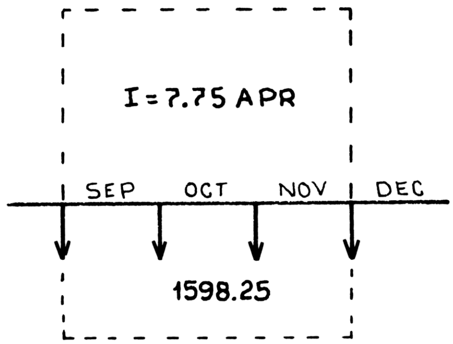
Now, add this to your regular August payment:

[+/−] [+] [RCL] [PMT] [=] (Answer: −13,078.76)

Now press [STO] 1 to store this number (to save it for use in an upcoming example).

So your August payment (due on the first day of August) is $13,078.76. (That's a lot of blueberries...)

Now what about the December payment? Well it's the same process. The picture looks like this:



You need to slide the September, October, and November payments to the end of November and add them to your December payment, which occurs at the first of December, right?

3 [N] [FV]	(The other values are constant; this does the sliding)
[+/−] [+] [RCL]	
[PMT] [=]	(Your new December payment: −$6455.19)
[STO] 2	(Store this for an upcoming example!)

NOTICE that when you use these keys just for sliding cash-flows, once they reach their destination, the calculator flips the result to the other side of the cash-flow line (changes the sign). It does this because it always assumes that you've given it a complete investment picture (i.e. these keys always assume "investment/return, investment/return,...").

In this case, however, you were merely doing a preliminary calculation — not a full investment picture — and you were merely using the math power of the 5-key formula to slide cash-flows up and down the line. You didn't want the net cash-flow to be flipped; you wanted one equivalent larger cash-flow to REPLACE several smaller ones. Thus, you had to do some corrective sign changing (using the [+/−] key) to make up for this. Understand?

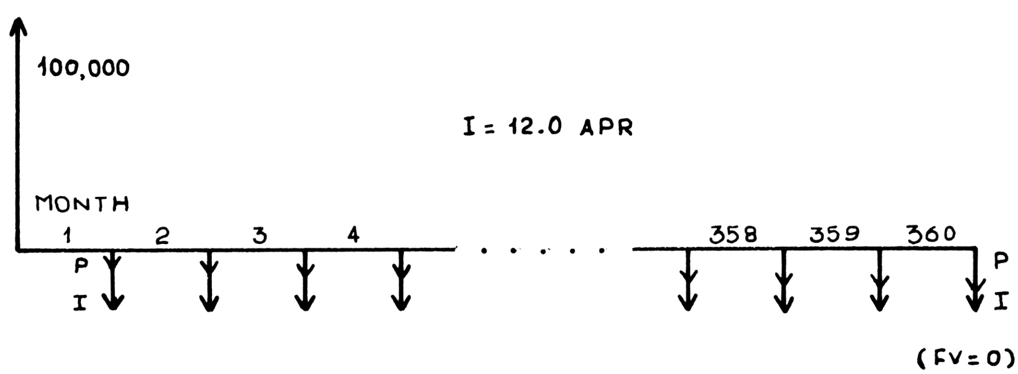
MORE ABOUT THE 5-KEY EQUATION: SOME SPECIAL TOPICS

Congratulations! At this point, you've really covered just about all you need to know about the 5-key equation and how to use it. The next few pages discuss some considerations which aren't exactly crucial, but they will definitely help your understanding at times. If you're so inclined, then, keep on reading here. Otherwise, you're ready to graduate to the next major topic — page 169.

AMRT (Amortization Schedules)

For tax purposes and other reasons, you will often want to see a month-by-month or year-by-year breakdown of the principal and interest payments you make on a mortgage — or any other loan with steady, level payments. This is called an amortization schedule (both the words mortgage and amortization are based on the root "mort," which has to do with death — meaning that these steady loans "kill off" a debt slowly but surely).

Look at this mortgage picture:



Notice that, although the PMT amount remains level, the relative proportions of principal and interest change with each payment. The way the loan works, your monthly payment ALWAYS covers the interest being charged for that month, plus a little bit toward the principal. Thus, at the beginning of a mortgage, almost the entire payment is for interest, with just a few dollars going toward the principal.

As time goes on and the principal has been whittled away, the interest being charged on the remaining principal becomes less and less, allowing even more room for further reductions in the principal. Finally, at the very end of the loan, the PMT consists almost entirely of principal.

Problem: Suppose you want to generate an amortization table for the first 12 payments and payments 49-60 of that mortgage on the previous page. How do you do it?

Solution: First, you enter the normal set of 5-key parameters in the TVM menu, and solve for PMT (END mode, with 12 PMT's/year):

100,000 [PV] 360 [N] 12 [I%YR] 0 [FV] [PMT] (–1028.61)

Next, you enter the AMRT menu (through the OTHER selection on the TVM menu):

[OTHER] [AMRT]

Then you specify what chunk of time you'd like to take at once. Choose 12 periods (one year), and off you go:

12 [#P]	PAYMENTS: 1-12
	BALANCE = 99,637.15
	INTEREST = –11,980.47
[PRIN]	PRINCIPAL = –362.85

Now for payments 49-60, skip three years: [NEXT] [NEXT] [NEXT], and then,

[NEXT]	PAYMENTS: 49-60
	BALANCE = 97,663.41
	INTEREST = –11,758.33
[PRIN]	PRINCIPAL = –584.99

(If you are the proud owner of a printer for your HP-18C, this AMRT example makes a good printout, since there's so much information! Use the [TABLE] key on the AMRT menu)

PINCHING PENNIES ('til they split)

After working the AMRT example, it should be fairly clear to you how a loan amortizes. Notice that even in the 5th year of a 30-year mortgage, the borrower has paid off less than 3% of the principal (it's a dog's life)!

But notice something else: If you go back to the TVM menu (do that now: [EXIT] [EXIT]), you'll still have all the original 5 values intact! The AMRT calculations make copies of these values to work with, leaving you the originals.

So recall your original PMT: [RCL] [PMT]

And ask to see all the digits: [DISP] [ALL] (–1,028.61259693)

Of course, nobody writes a check for that amount — only dollars and cents (2 decimal places). But this IS a mathematically correct answer, and this is what the calculator assumes will be paid every month! Well, you know better: everything is rounded to dollars and cents. So what difference does it make — that the calculator assumes these tiny fractions of pennies are being paid, but actually they're rounded off? Test it: Key in 1,028.61 [+/–] [PMT] to give the machine an exact-to-the-penny PMT amount.

Now solve for Future Value: [FV] (FV= –9.0761615)

FV should be exactly zero at the end of the 360 months to properly amortize the loan. This residue is the buildup of the difference — between what the calculator knows is more mathematically correct and what the check amounts were.

And you can tell from the minus sign that the loan has been overPAID by about nine dollars. Thus, to be entirely fair, you might say that the lender should allow the borrower to deduct this overpayment from the final installment.

So remember: You would have to be awfully lucky to arrange a mortgage with numbers such that the payment just happened to work out exactly (mathematically) to the penny. Usually, there will be a partial-cent difference between absolute accuracy and the amount of the installment. This residue builds up over the life of the loan and should be accounted for in the final payment. Sometimes this residue is in the lender's favor; sometimes in the borrower's.

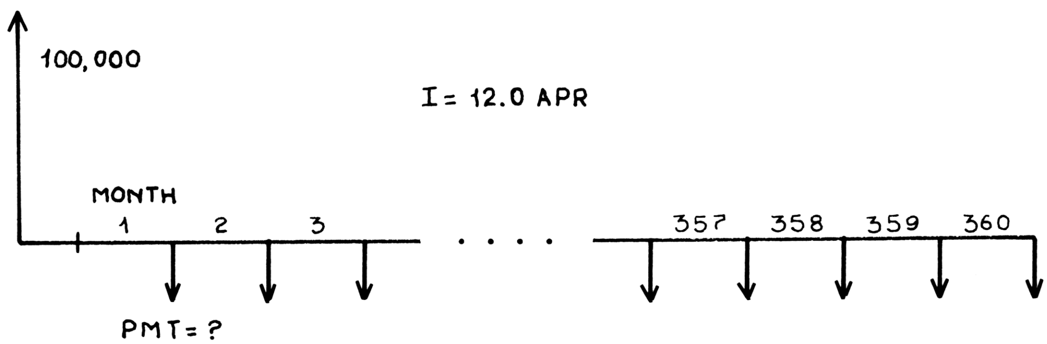
Nobody loses too much sleep over the actual dollar amount, BUT it may help to explain why your calculations differ by tiny bits from written tables or somebody else's machine.

This is just a bit of helpful trivia to reassure you that YOUR calculator is AT LEAST as good as the other guy's (and probably much more faithful and accurate)!…"a message brought to you by…"

Now, press [DISP] [FIX] 2 [INPUT] to go back to a 2-digit display.

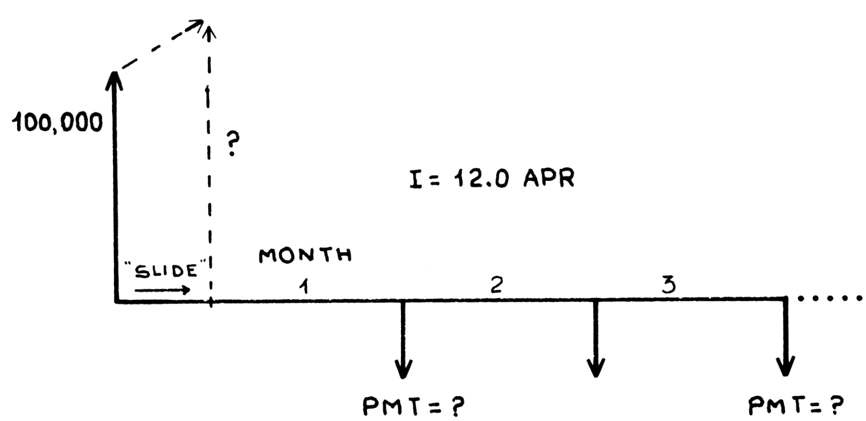
TYING UP LOOSE ENDS

You've probably heard of (or even been involved in) a mortgage or loan which is signed on a certain date, with monthly payments (in arrears — END mode), but with the first such PMT due in, say, 45 days from that date. The diagram looks like this:



Obviously, the loan has about 15 extra days to accrue interest (and that can be substantial, since you have the entire principal accruing it). How do you figure a level payment that takes into account that extra interest?

Simple: Just do a preliminary calculation, moving the whole loan forward a half-period. This amount would then represent a hypothetical loan that began "on time:"



Here are the keystrokes:

100,000 [+] .5 [%] [=] (Answer: 100,500.00)

Since interest accrues at 12% per year, this is the same as 1% per month, or .5% per half-month. So you just add .5% to the original $100,000, and there you have it — the loan is moved forward a half a month.

Now that you have your new hypothetical amount, plug it in as your "real" PV, and grind out the PMT amount:

[STO] [PV] 360 [N] 12 [I%YR] 0 [FV] [PMT] (–1,033.76)

Clever, eh? It's not nearly as easy to do this at the other end of the timeline — when the partial period is at the end of the mortgage — so don't even ask.

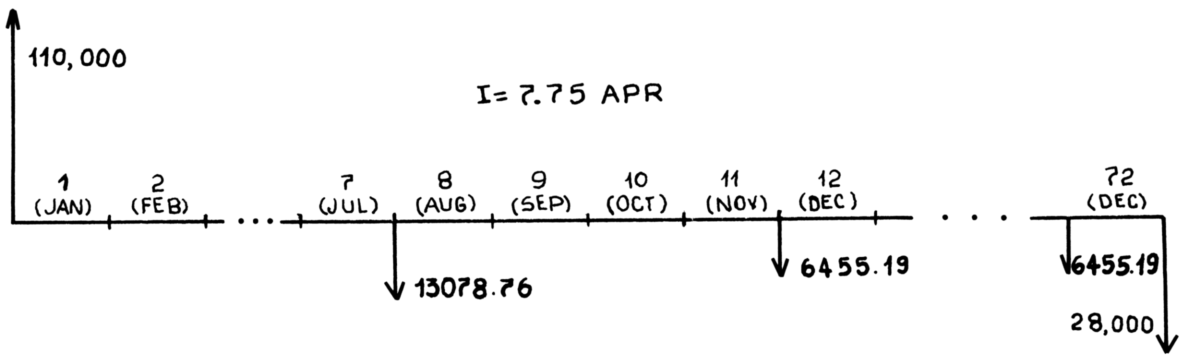
That's it for the 5-key (TVM) equation. Now, take a break and go make yourself a blueberry milkshake (recipe below), or something equally refreshing — you've earned it after all this keystroking. And while you're relaxing, contemplate the financial calculating you've just done. You know:

- How compound interest works;
- How to draw a cash-flow diagram;
- How to "translate" this diagram into a form your HP-18C can "see," (including BEGIN vs. END), using the 5-key TVM equation;
- How to play "What-If?" with the TVM equation;
- How to convert between interest rates that compound at differing intervals, and how to incorporate finance charges and balloon payments into your calculations;
- How to make a world-class blueberry milkshake:

  Put 1 cup (250 ml) frozen blueberries in blender. Add just enough buttermilk to submerge blueberries. Blend until consistency is that of milkshake. Sweeten to taste with sugar or honey. Nectar of the gods.

UNEVEN CASH FLOWS

Remember that test problem (number 4) way back on page 154? It produced a rather interesting cash-flow situation (pun intended):



The payments are no longer level; they are uneven. So, how would you draw this new picture — as is — for your calculator, if, say, you wanted to verify that you did everything right?

Well, what if someone gave you the above picture and asked you to figure out the prevailing interest rate (assuming you didn't already know it was 7.75% A.P.R.). This picture COULD represent a real estate investment, for example, where you are making payments twice a year. How do you evaluate an investment that doesn't have nice, even cash flows?

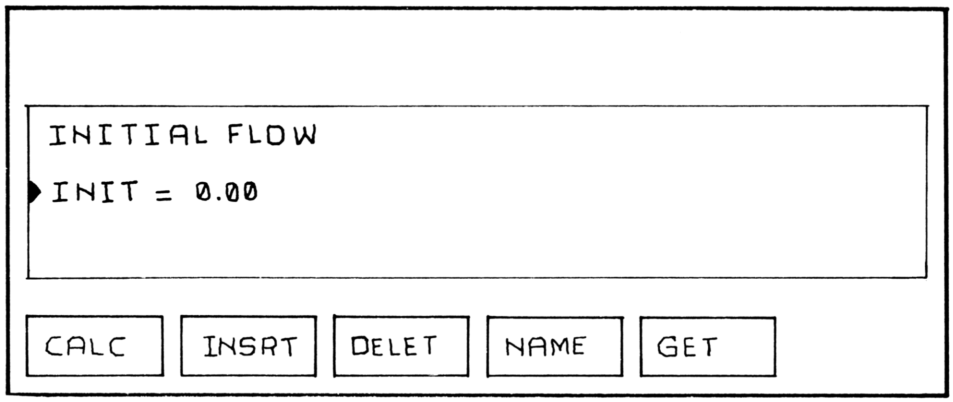
[CFLO]

There's more than one way to skin a cash-flow line.

Way back on page 125, you may recall something to the effect that there are TWO ways to describe cash-flow diagrams to your calculator. The first way is with the 5-key equation, using N, I%YR, PV, PMT, and FV, as you just saw in the previous section.

The second method, which is the next topic, uses number lists, so if you don't remember how lists work, you may want to take a short side-trip now, to review pages 33 to 39.

From the main menu, if you press [FIN] [CFLO], you are shown a number list (actually a cash-flow group list) that looks like this:

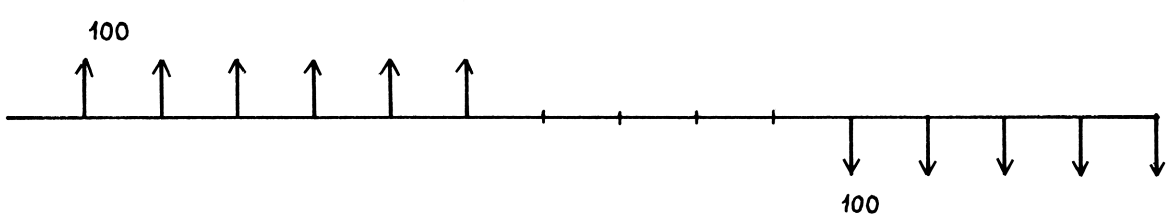


The number lists you worked with back on page 33 were just that: lists of numbers. The calculator would give you a running total of these numbers, and you could do some statistics calculations with them, but still they were just numbers.

But these "cash-flow group" lists are different. The numbers that you put in these lists describe groups of cash-flows on a cash-flow diagram. You can describe ANY cash-flow diagram using this list method! But before you can describe a cash-flow diagram using one of these lists you have to know what a "cash-flow group" is.

"So what's a cash-flow group?"

A cash-flow group is merely a series of CONSECUTIVE regular, even, cash-flows. A group can consist of only one cash-flow, or it can consist of many. Here are several cash-flow groups:



To draw this complete cash-flow diagram, all you have to do is describe these groups, one at a time, from left to right (present to future). The first group (group 1) always begins at the END of the first period. (ANY cash-flow that occurs at the BEGINNING of the first period is called the INITIAL flow and is treated separately.)

To describe group 1, you need only mention these two things:

1. The dollar amount of each cash-flow is $100.00.
2. The number of cash-flows in this group is 6.

Now look at group 2 on that diagram. You would say:

1. The dollar amount of each cash-flow is ZERO.
2. The number of cash-flows in this group is 4.

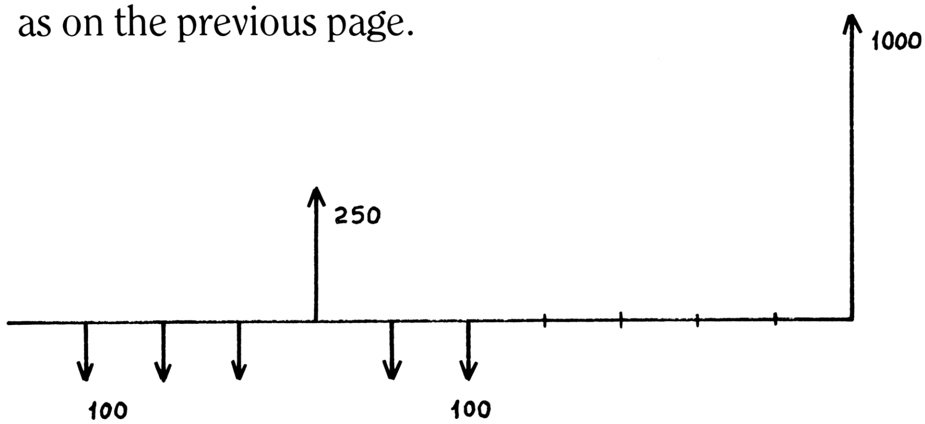
As you can see, when describing an uneven cash-flow situation to the HP-18C, YOU MUST DESCRIBE EVERY PERIOD ON THE CASH-FLOW LINE. Some periods will have positive cash-flows, some will have negative cash-flows, and some will have cash-flows that equal ZERO. And REMEMBER! ZERO is still a number. You need to think of a period having no cash-flow as a period having a cash-flow with a dollar amount of ZERO.

Finally, look at the last group on that diagram:

1. The dollar amount of each cash-flow is −$100.00.
2. The number of cash-flows in this group is 5.

Pretty simple, is it not? Notice how EVERY PERIOD ON THE DIAGRAM IS ACCOUNTED FOR.

Try this: Describe this uneven cash-flow situation in exactly the same fashion as on the previous page.



Solution: There are five cash-flow groups on the above diagram, plus an INITIAL cash-flow:

A. The INITIAL (zeroth) cash-flow at the beginning of the time line:

1. has a dollar amount of $0.

B. The FIRST cash-flow group:

1. has a dollar amount of –$100.
2. consists of 3 cash-flows.

C. The SECOND cash-flow group:

1. has a dollar amount of $250.
2. consists of 1 cash-flow.

D. The THIRD cash-flow group:

1. has a dollar amount of –$100.
2. consists of 2 cash-flows.

E. The FOURTH cash-flow group:

   1. has a dollar amount of $0.

   2. consists of 4 cash-flows.

F. The FIFTH cash-flow group:

   1. has a dollar amount of $1000.

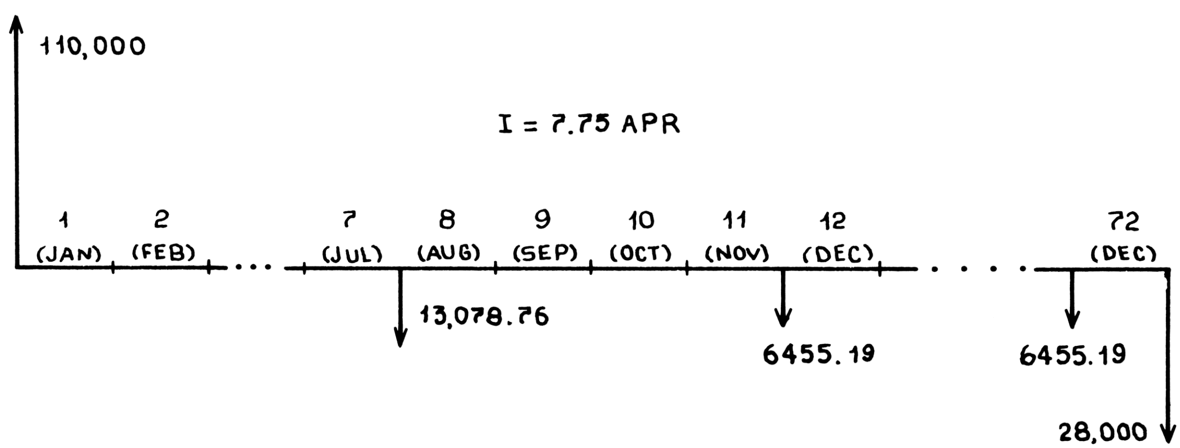
   2. consists of 1 cash-flow.

Do you see what's happening? You can describe any cash-flow GROUP using only these two phrases:

1. The dollar amount of this cash-flow group is $XXX.XX.

2. This cash-flow group consists of X cash-flow(s).

Now it's a simple matter to put this description into your cash-flow list. Here's another picture of that August-and-December payment schedule in problem 4 (page 154):



Your Mission: Describe this picture to your HP-18C.

When you first pressed [CFLO] , the display came up asking you for the initial flow, right? In this case it's 110,000. So key in 110,000 and press [INPUT] .

The list pointer (you remember the list pointer) is now at FLOW (1). The calculator wants to know the dollar amount of the first cash-flow group. This amount is zero, right?

So press: 0 [INPUT] .

Now the list pointer jumps down to #TIMES. This zero cash-flow lasts for six (count 'em: 6) periods.

So press: 6 [INPUT] .

Now the list pointer is at FLOW (2). Cash-flow group 2 consists of 1 cash-flow of −13,078.76, right? And this number is stored in register 1 (with incredible foresight, you stored it there when you were back on page 161).

Now press: [RCL] 1 [INPUT] .

The list pointer jumps to #TIMES. Notice that the calculator puts a 1 both on the calculator line and as the #TIMES. It assumes there is at least 1 cash-flow in this group. That means you can either press: 1 [INPUT] , or [INPUT] , or just [↓] , which essentially says, "Yep, that one's OK, so I'll go on without touching it at all."

Continue this process until you've painted the entire picture for the six years:

WHEN THE LIST POINTER SAYS	YOUR KEYSTROKES ARE
>FLOW(3)=	0 [INPUT]
>#TIMES=1	3 [INPUT]
>FLOW(4)=	[RCL] 2 [INPUT]

WHEN THE LIST POINTER SAYS	YOUR KEYSTROKES ARE
>#TIMES=1	[INPUT]
>FLOW(5)=	0 [INPUT]
>#TIMES=1	7 [INPUT]
>FLOW(6)=	[RCL] 1 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(7)=	0 [INPUT]
>#TIMES=1	3 [INPUT]
>FLOW(8)=	[RCL] 2 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(9)=	0 [INPUT]
>#TIMES=1	7 [INPUT]
>FLOW(10)=	[RCL] 1 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(11)=	0 [INPUT]
>#TIMES=1	3 [INPUT]
>FLOW(12)=	[RCL] 2 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(13)=	0 [INPUT]
>#TIMES=1	7 [INPUT]
>FLOW(14)=	[RCL] 1 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(15)=	0 [INPUT]
>#TIMES=1	3 [INPUT]
>FLOW(16)=	[RCL] 2 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(17)=	0 [INPUT]
>#TIMES=1	7 [INPUT]
>FLOW(18)=	[RCL] 1 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(19)=	0 [INPUT]
>#TIMES=1	3 [INPUT]
>FLOW(20)=	[RCL] 2 [INPUT]
>#TIMES=1	[INPUT]

WHEN THE LIST POINTER SAYS	YOUR KEYSTROKES ARE
>FLOW(21)=	0 [INPUT]
>#TIMES=1	7 [INPUT]
>FLOW(22)=	[RCL] 1 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(23)=	0 [INPUT]
>#TIMES=1	3 [INPUT]
>FLOW(24)=	[RCL] 2 [INPUT]
>#TIMES=1	[INPUT]
>FLOW(25)=	28000 [+/−] [INPUT]

(Whew!) Once you finish the above keystrokes, you have keyed in a cash-flow list that looks like this:

INIT FLOW = 110,000.00

FLOW(1) = 0.00 #TIMES = 6

FLOW(2) = −13,078.76 #TIMES = 1

FLOW(3) = 0.00 #TIMES = 3

FLOW(4) = −6,455.19 #TIMES = 1 . . . (etc. This is just the first year of six....you get the idea.) And remember: If you make a mistake or simply want to check yourself, you can use the [↑] and [↓] keys to move up and down the list, change things that are incorrect — by positioning the list pointer to that entry — key in the correct number, and press [INPUT] .

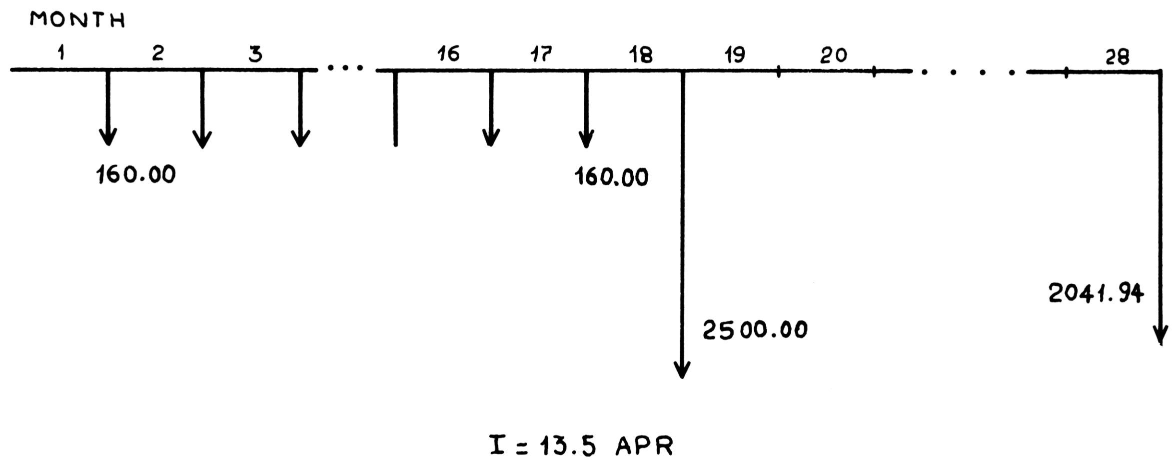
"So now that I have described this cash-flow situation to my calculator, what can I do with it?"

This list is like the number lists you stored before. You can name it (in fact, give it the name P4 right now) and tuck it away in your calculator, only to call it back later for calculations or whatever. The number of lists you can store in the machine is limited only by the size of its memory (and it will tell you when it runs out of memory).

So, what do you want to find out from this particular list? It represents a cash-flow diagram of a tractor loan. You can calculate the interest rate that holds this picture together; this rate is your IRR%. Or, if you already know that rate, you can use it to slide all the cash-flows to the beginning or end of the time line, resulting in either an Net Present Value (NPV) or Net Future Value (NFV).

NET PRESENT VALUE (NPV)

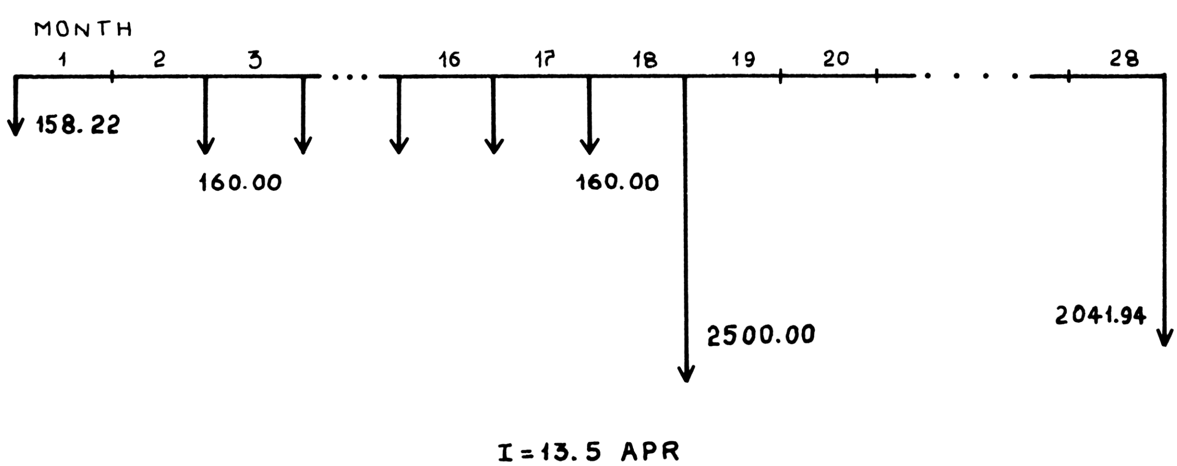
Look at this payment schedule:



We claim that IF the prevailing interest rate is 13.5% A.P.R., this monthly payment schedule has a "value" (up front) of $6000.00. In other words, if you agree to embark upon this schedule of payments to us, we will give you $6000 now, and that $6000 loan will be earning 13.5% A.P.R.

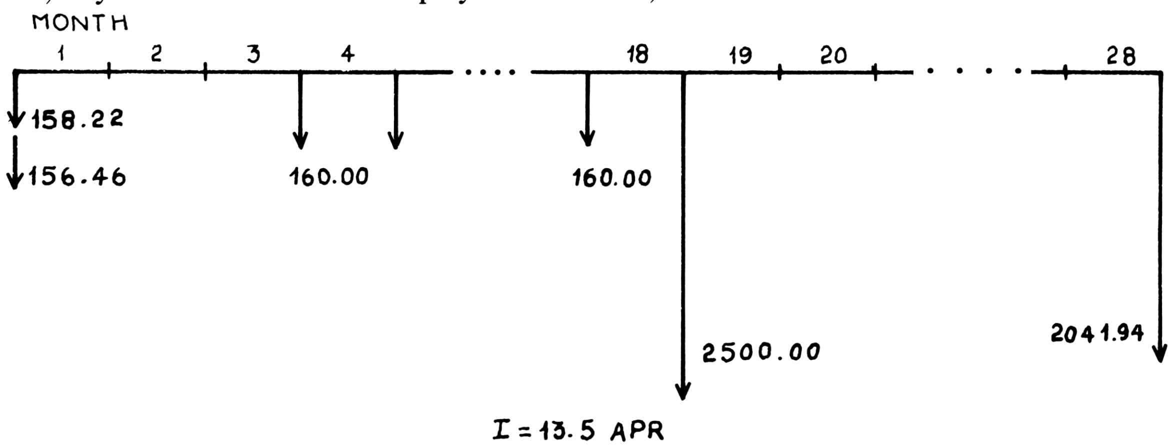
You've already seen cases of sliding cash-flows up and down the time line, but look again — closely — at this process.

In this cash-flow situation, if you were to slide the first $160.00 payment to the beginning of the time line it would look like this:



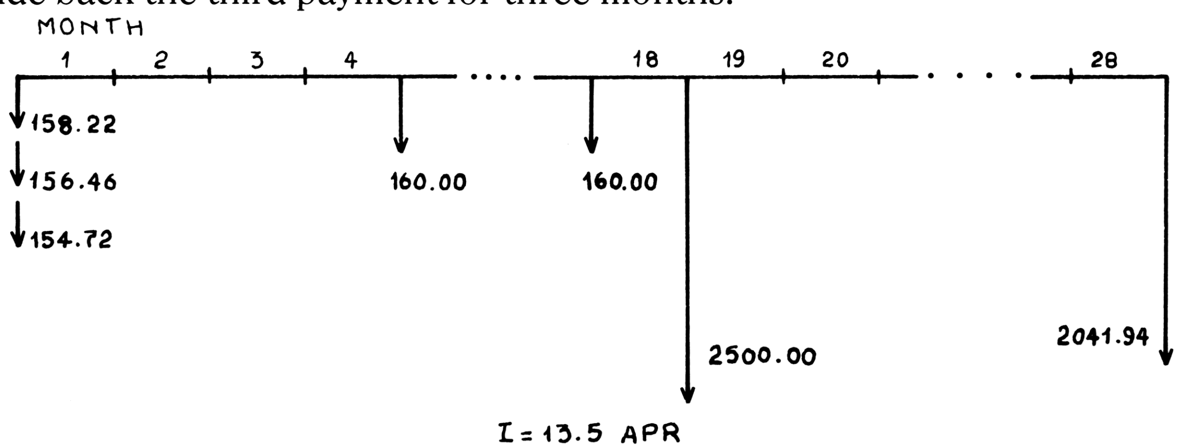
By sliding it back one month, the first $160 payment is reduced (by the 13.5% A.P.R) to $158.22. (Don't worry about confirming this number; just be sure and understand why it is reduced, and look back on page 123 if you need a reminder.)

Next, if you slid the second payment back, it would look like this:

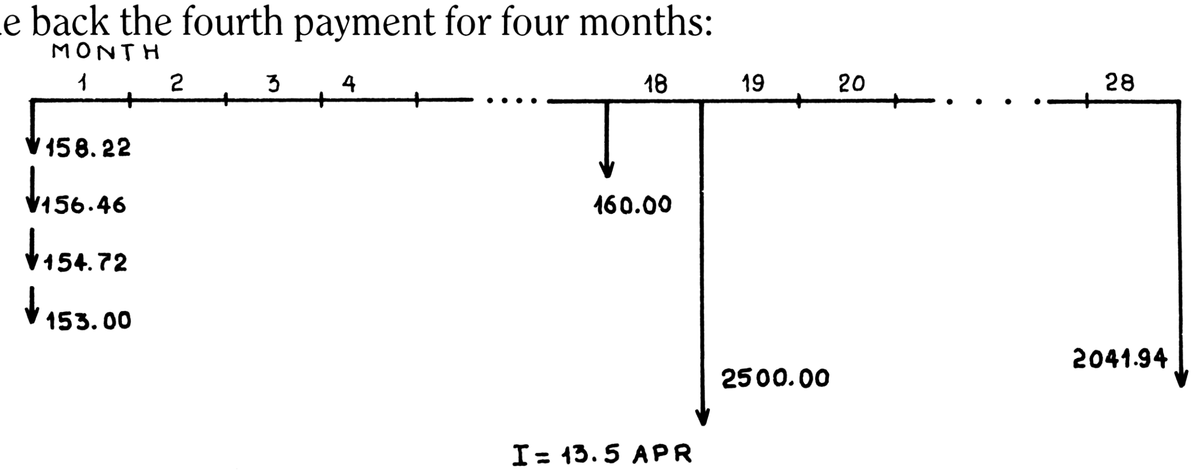


The second $160 payment is reduced to $156.46 by sliding it back for 2 months. If you were to continue in this endeavor...

Slide back the third payment for three months:

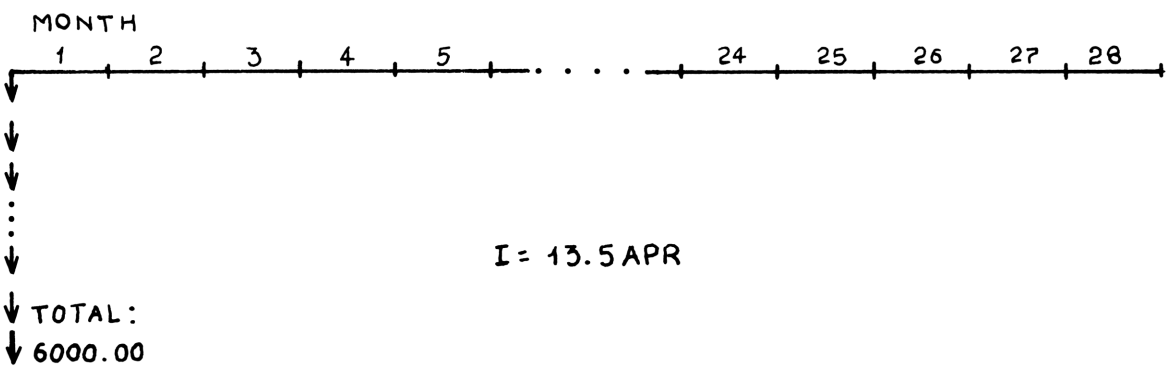


Slide back the fourth payment for four months:



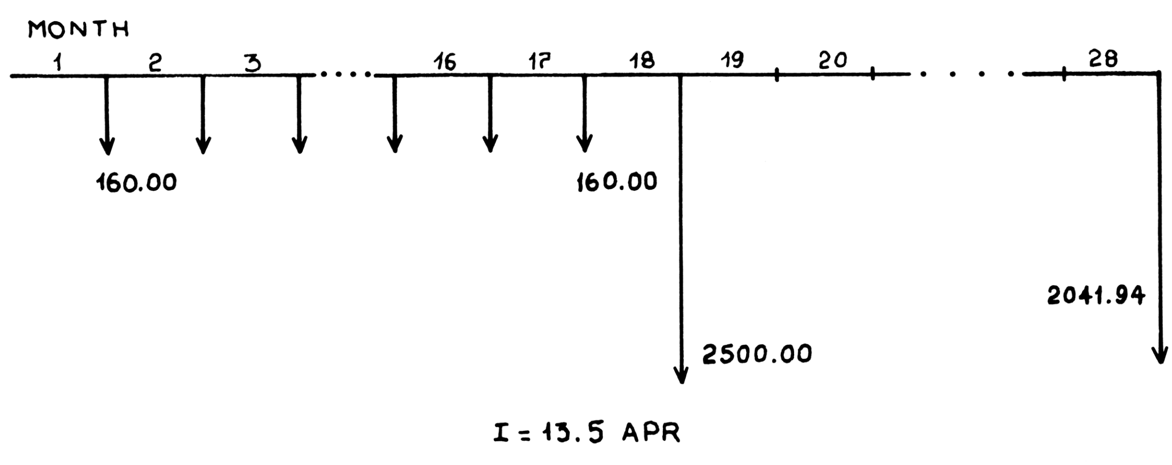
. . .

etc. And if you keep sliding cash-flows back to the beginning of the time line — even the $2500 and $2041.94 cash-flows — and finally net (add up) all those cash-flows at the beginning of the time line, you would end up with this:



This is said to be the NET PRESENT VALUE of that payment schedule. And, because ALL of those cash-flows were negative, the net present value of those cash-flows is also negative (the arrow is pointing down).

So, if our claim is correct, then this cash-flow situation has a Net Present Value of –6000.00:



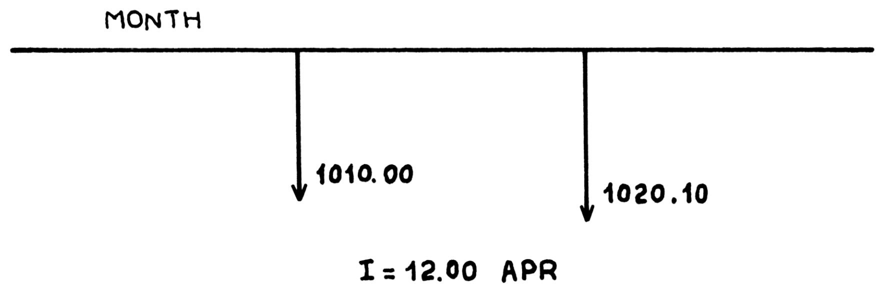
To summarize: The Net Present Value of a cash-flow diagram is the number that results when you SLIDE EACH CASH-FLOW BACK TO THE BEGINNING OF THE TIME LINE (ADJUSTING EACH ACCORDING TO THE PREVAILING INTEREST RATE) AND ADD UP ALL OF THESE REDUCED ("DISCOUNTED") CASH-FLOWS.

NOTES

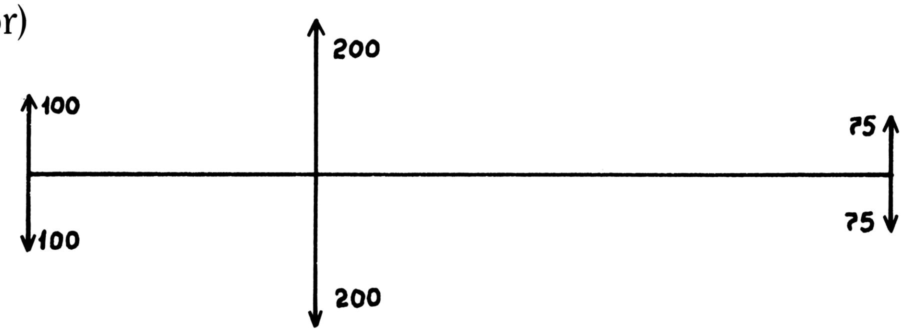
Think you've got the idea? To find out, try these problems (the answers are on the following pages):

TEST

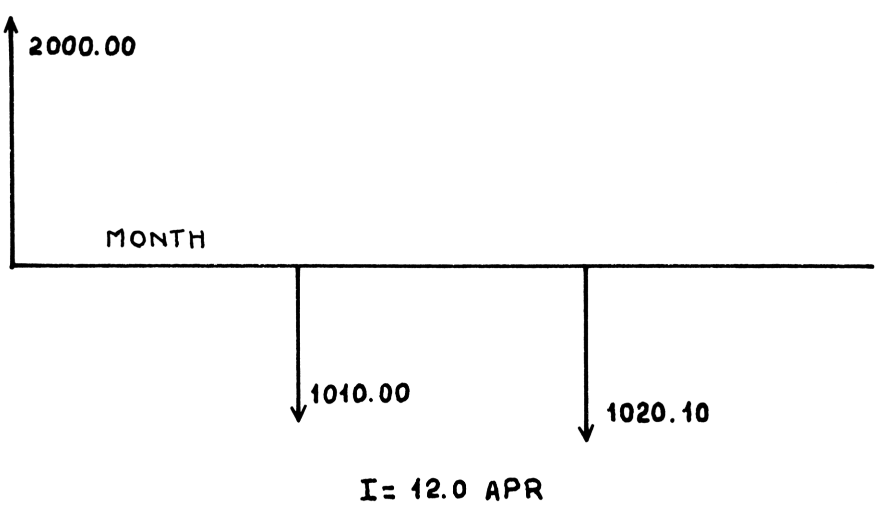
1. Without touching your calculator, what is the Net Present Value of this cash-flow situation? (Hint: 12% is 1% per month; 10 is 1% of 1000; and 10.1 is 1% of 1010.)



2. What is the Net present value of this cash-flow situation? (again, no calculator)



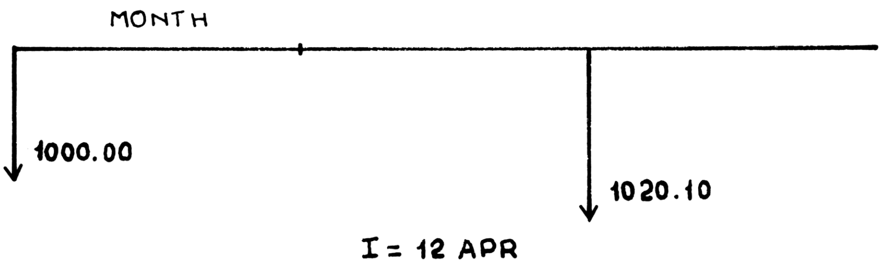
3. What is the Net present value of this cash-flow situation?



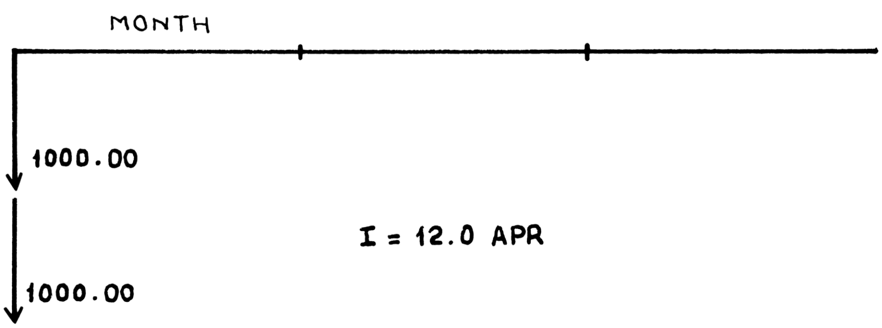
4. Describe the payment schedule on page 180 to your calculator and calculate the NPV of the whole mess, assuming the interest rate is 13.5% APR.

ANSWERS

1. The Net Present Value is –$2000. Slide each cash-flow back to the beginning of the time line. First "slide:"

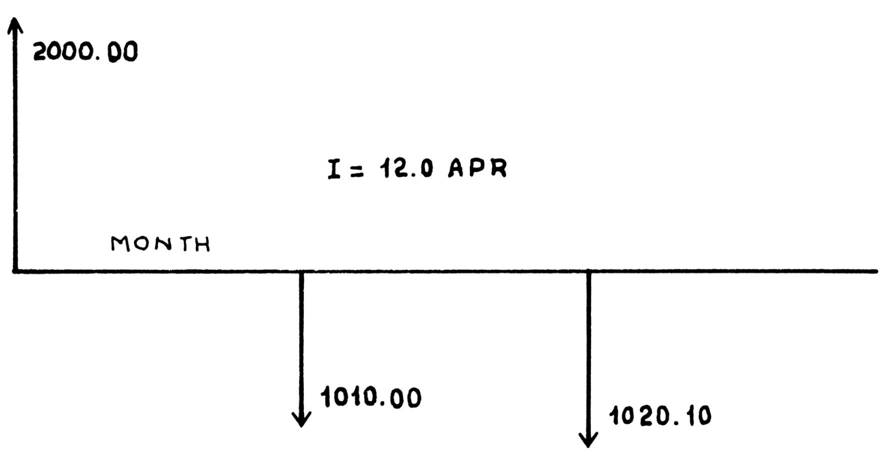


Second "slide:"

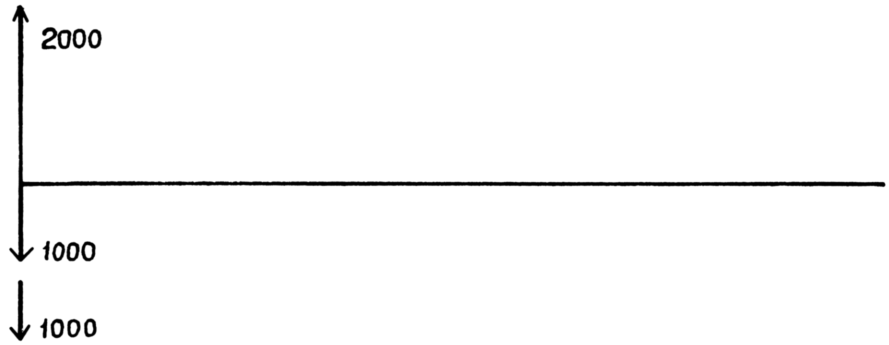


2. Zero. Why? Well, no matter what values these cash-flows take — after being slid back — they will still be equal and opposite and therefore "net" out to be zero, right?

3. Zero. This:

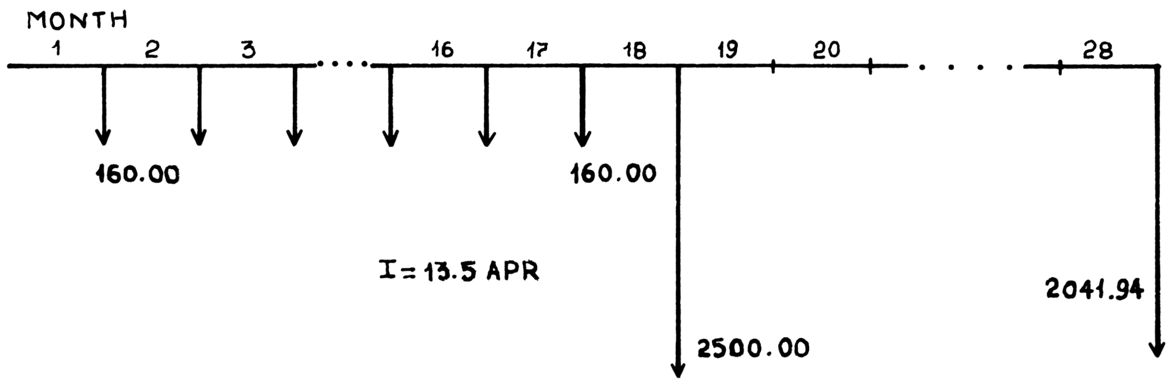


is equivalent to this (just like problem 1):



which is zero (just like problem 2).

4. Here's the picture you're trying to describe:



First, if you haven't already named the list from that tractor loan, do so now (from the CFLO menu, press: [NAME] P4 [INPUT]). Next, to start a new list, press [GET] [*NEW] . Then key in this list:

INIT = 0.00

FLOW(1) = −160.00

#TIMES = 17

FLOW(2) = −2500.00

#TIMES = 1

FLOW(3) = 0

#TIMES = 9

FLOW(4) = −2041.94

#TIMES = 1

Once you have keyed in this list correctly, calculate the Net Present Value by pressing [CALC] . Notice that the first thing the display says when you press [CALC] is this reminder: "I% NEEDED TO CALCULATE NPV, NUS, AND NFV." This makes sense, right? In order to slide cash-flows around, you need to know the prevailing interest rate (see page 123 for a reminder of why this is so).

The diagram says that I = 13.5% A.P.R.. So press: 13.5 [I%] , and calculate NPV (press [NPV]). You should get −6000.00, right?...

WAIT A MINUTE! What's this? The answer is "NPV = −1362.28." Isn't the NPV of this cash-flow situation supposed to be −6000.00?

Yes, it is (something's moldy in Copenhagen). The problem here is that you keyed in an annualized interest rate, 13.5, when you needed to key in 13.5 [÷] 12.

WHENEVER YOU'RE DOING CALCULATIONS ON A CASH-FLOW LIST, THE INTEREST RATES ARE PERIODIC — NOT ANNUALIZED!

REMEMBER THAT!

And yes, you're right: This is inconsistent with the [I%YR] key you used when you had level payments. In that menu, the calculator is expecting an annualized interest rate — and you also have to tell it how many payments are in a year. But here the calculator doesn't know how many periods are in a year — and it doesn't need to know — because you are ALWAYS going to give it the PERIODIC interest rate (the D.I.R.).

So, to verify that the NPV truly IS −$6000.00, press: 13.5 [÷] 12 [I%] [NPV] . The answer is −6000.00.

So, that's what Net Present Value is all about: If you have a set of UNeven cash-flows, and you know the prevailing D.I.R., you can slide all those arrows to the left end of the picture frame and add them together to find a Net Present Value (NPV).

NFV (Net Future Value)

Once you understand NPV, then NFV is a piece of cake. With NFV, instead of sliding values to the beginning of time, you slide them to the end. Again, the calculator will do all the hard arithmetic work, once you have described the cash-flow diagram in a FLOW list.

POP QUIZ

1. Find the Net Future Value of that cash-flow diagram (on page 184), the one that has an NPV of −6000.00.

POP ANSWER

1. Press [NFV] (NFV = −8207.11)

   Now press: [EXIT] [ ] [CLEAR ALL] [YES]

   to clear the current list...

... and proceed to the next exciting episode...

INTERNAL RATE OF RETURN (IRR%)

IRR% is another calculation that you can perform on a cash-flow list (which represents a cash-flow diagram, of course). You can use IRR% to calculate the interest rate that prevails over an investment.

On the NPV and NFV problems, one of the things you already knew was the prevailing interest rate. But it may be that you DON'T know that and instead wish to calculate it. If so, then you should use IRR%. As an example, GET that list called P4 (press: [GET] [P4]).

This list describes the entire picture of the loan that you had on your new 4-wheel drive tractor (remember? pages 169 to 173). You can prove that this picture is correct by calculating the IRR%: It should give you 7.75%, right?

Press: [CALC] [IRR%]

Remember. The calculator is showing you the Defined Interest Rate (D.I.R.). You're earning 0.65% per period, but the calculator doesn't know whether a period is a year, a month, a day, or a second. Only YOU know that it's monthly.

Since there's 12 D.I.P's in a year, press [×] 12 [=] .

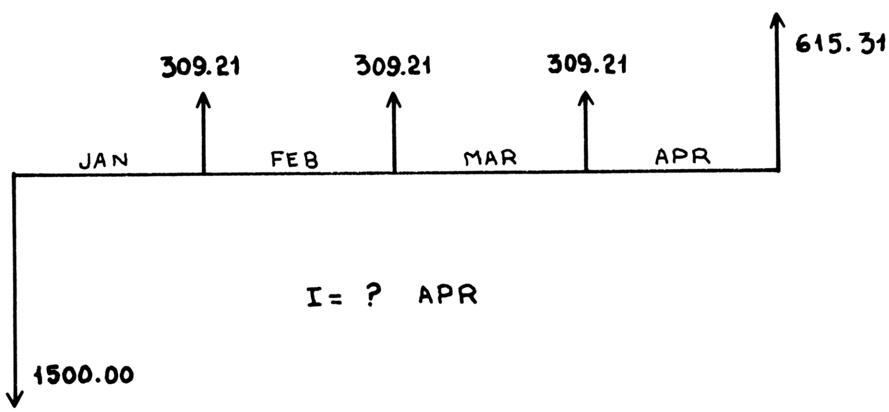
Voila! There's the 7.75%. Calculate IRR% again (press: [IRR%]). Notice that IRR% takes a little time (if you get a "SOLUTION NOT FOUND" message, check your list to make sure it's correct — page 174). This calculation is a trial-and-error solution; the calculator makes "educated" guesses until it finds the right answer.

Another way to think about IRR% is that it is the interest rate that causes the NPV of a cash-flow situation to be zero. For example, take problem 3 on page 183: The NPV of that cash-flow scenario was zero, so the interest rate we were using WAS the IRR%.

Now store this IRR% you've calculated (0.65) in [I%] . If you then calculate NPV (press [NPV]) at this point, you will get a number that's (essentially) zero. You've merely proven what you already knew: the rate holding this picture together is 7.75% A.P.R.

FACT: If you analyze the cash-flow diagram that describes any completely amortized loan (with even OR uneven payments), it will have an NPV of ZERO, and the IRR% is simply the Defined Interest Rate.

Try this: You loan out $1500 so that the cash-flow diagram below completely amortizes the loan in 4 months: What is the prevailing A.P.R. that applies to this situation? In other words, what is its (annualized) IRR%?



Solution: 12.20% A.P.R. Here's what you do:

[EXIT] [GET] [*NEW]

1500 [+/−] [INPUT]

309.21 [INPUT]

3 [INPUT]

615.31 [INPUT]

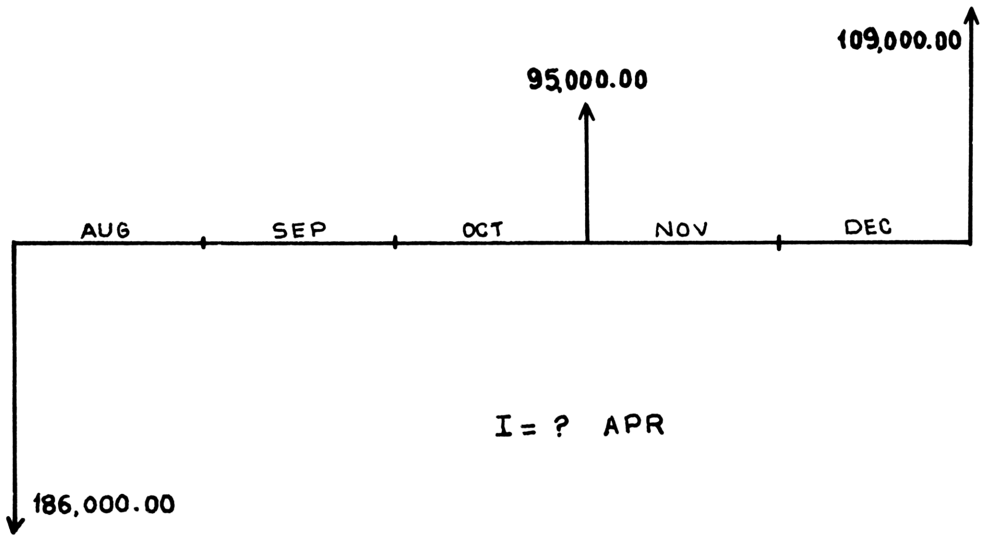
[CALC] [IRR%]

[×] 12 [=]

[EXIT] [ ] [CLEAR ALL] [YES]

Do you understand what you're doing when you press [IRR%] ? You're asking what interest rate will tie the whole picture together. Try another:

Exercise: What's the IRR of this cash-flow situation?



Solution: 27.63% A.P.R. Here are the keystrokes:

186000 [+/−] [INPUT]

0 [INPUT]

2 [INPUT]

95000 [INPUT] [INPUT]

0 [INPUT] [INPUT]

109000 [INPUT]

[CALC] [IRR%]

[×] 12 [=]

[EXIT]

Now continue practicing with this quiz:

QUIZ

(Solutions begin on page 193)

1. A loan is written at 15% A.P.R., with $450 monthly payments, in arrears, for 30 years. What is the loan amount? Find it by using the NPV operation on your calculator. (No cheating with the 5-key equation!). Do the same for annuity in advance.

2. As an investor, you're offered a chance to "buy" a double mortgage from a lender. The first mortgage was written for $90,000 for 30 years, with end-of-the-month payments at 12% A.P.R. After 15 years a second mortgage for $30,000 was added, at 13.0% for 20 years, with monthly payments also in arrears. If you want to obtain a 16% yield (A.P.R.) on the money you invest, what should you pay for the right to "inherit" this contract at the end of the third year of the second mortgage?

   (You have all the knowledge you need to do this one. Take your time and work it through; then look at the solution.)

3. On that double mortgage from the previous problem, suppose that you manage to chew the price down to $75,000. What is your resulting yield?

4. How much money should you deposit in a bank account that pays 8% A.P.R., compounded monthly, so that you can withdraw $10,000 per quarter for 20 years, starting 20 years from now? What about $15,000 withdrawals?

5. You have invested in several mutual funds in the past few years. Their histories look like this:

Fund #	Date	Amount Invested	Value on 12-31-86
1	9-30-82	1,500.00	—
2	3-15-83	500.00	—
3	4- 1-83	500.00	—
2	5-31-83	9,000.00	—
3	9-30-83	20,000.00	—
1	11-30-83	1,500.00	—
3	2- 1-84	500.00	—
1	6- 1-84	500.00	—
2	8-31-84	5,000.00	—
2	10-15-84	2,900.00	—
1	6- 1-85	4,500.00	—
3	7- 1-85	1,000.00	—
1	11-15-85	600.00	—
3	1-15-86	2,600.00	—
2	5- 1-86	50,000.00	—
3	6-15-86	1,500.00	—
2	9-15-86	2,600.00	—
1	11-30-86	2,400.00	—
1	—	—	17,417.92
2	—	—	110,841.31
3	—	—	41,327.98

What is your overall return for this whole time period — for all the money you've invested?

6. You have $20,000 and you're moving to a new town for a 5-year contract job.

   A quick check of that town's housing market shows that you can buy a $95,000 home for the $20,000 down, $400 monthly (interest only) payments in arrears, and about $200 a month in taxes, insurance, and maintenance. And after the 5 years, with the way things are going, you can expect to sell it for $120,000.

   On the other hand, you can rent that same house for $600 per month (paid at the beginning of the month) and just salt away your $20,000 in a money market at 12% A.P.R. (compounded monthly).

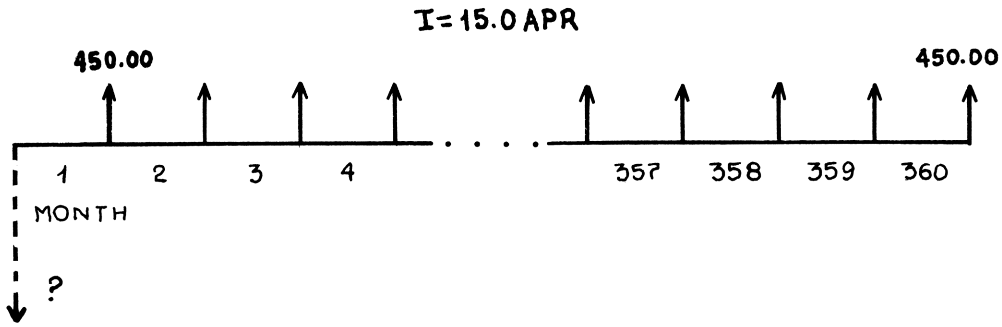
   A. Given these scenarios (and ignoring any tax considerations), should you rent or buy? ("To buy or not to buy — that is the question.")

   B. Of course, it's really fairly stupid to ignore tax considerations, so ask the same question again, but with the following taken into account:

      Say that you are in the 40% tax bracket (your government takes away 40% of your taxable income) and say that if you buy the house, $475.00 per month is deductible from your taxable income because of the interest you are paying on the mortgage. Assuming that these deductions don't decrease your tax bracket, should you rent or buy?

TEST SOLUTIONS

1. Here's the picture you have to draw for your calculator:



You need to use NPV to find that dotted-arrow amount, the "purchase amount" of the loan. Nothing to it:

INIT = 0 FLOW(1) = 450.00 #TIMES = 360

Then press [CALC], store the interest rate (press: 15.5 [÷] 12 [I%]), and press [NPV]. (Answer: NPV = 34,495.53)

That was the loan amount for annuity in arrears. What about for annuity in advance? Can you just switch to BEGIN mode? NO WAY! When you're working with cash-flow lists, BEG and END mode have no relevance. Except for the INITIAL FLOW, which occurs at the beginning of the time line, you describe the cash-flow that occurs at the END of each period on the cash-flow diagram.

But don't start all over! After all, there are only two changes you need to make:

A. The INITIAL FLOW = 450 instead of zero

B. FLOW(1) occurs 359 times, instead of 360.

Understand the reasoning? And by now, you should be able to make these changes in your cash-flow list without much help — go for it.

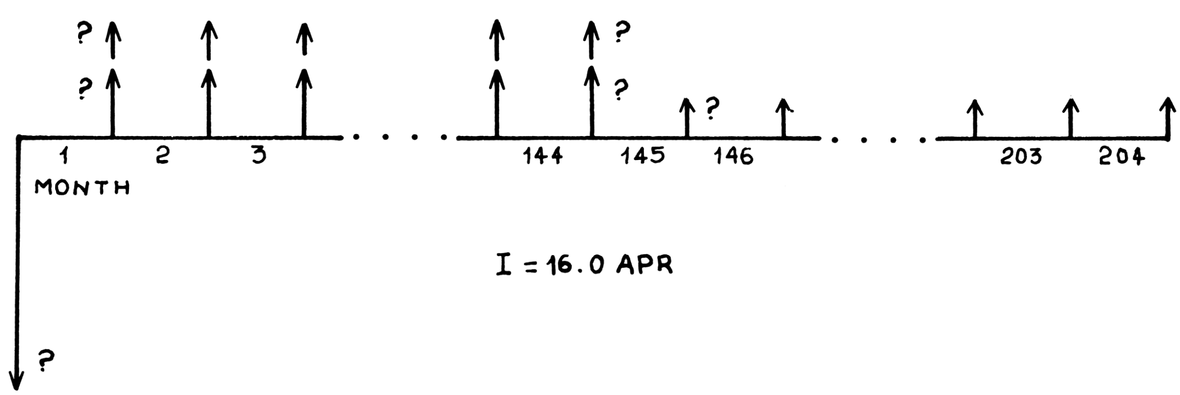
Finally, press [CALC] [NPV]. Answer: NPV = 34,941.10

2. This is really quite a simple problem — when you draw the picture.

As the investor, you take the perspective of the lender. You pay out a certain amount at the beginning of the time line, and in return you will receive payments according to the specified schedule. Of course, you want those payments to amount to an overall yield of 16% A.P.R. on the money you paid out.

You can find the proper amount to pay out by computing the Net Present Value of all those future cash-flows — using your desired yield as the discount rate — the "governing interest rate" for the diagram. This NPV will be positive, meaning that you will be receiving the equivalent of that much money when you "buy" this cash-flow situation now with an equal amount of (negative) cash-flow.

Here's the situation at the time you're offered the deal:



For 12 years you'll receive payments on both the first and second mortgages (144 combined payments). After those 12 years, payments on the first mortgage will stop, but payments on the second mortgage will continue for 5 more years (60 payments). It's all there on the picture.

First, you need to use the TVM solution to find the payment amounts on each mortgage. Thus: [ ] [MAIN] [FIN] [TVM]

A. The payment on the first mortgage: If the display says something besides "12 PMTS/YR: END MODE," then press [OTHER] , and just change the things you need to change.

90,000	[+/−] [PV]	
360	[N]	
12	[I%YR]	(12% compounded monthly)
0	[FV]	(completely amortized)
[PMT]		Answer: 925.75

That was easy! Now store that result somewhere ([STO] 1).

B. The payment on the second mortgage is the same story:

30,000 [+/−] [PV] 240 [N] 13 [I%YR] 0 [FV] [PMT] =351.47

Now store this amount is register 2 ([STO] 2), and then add this payment to the payment in register 1 ([STO] [+] 1).

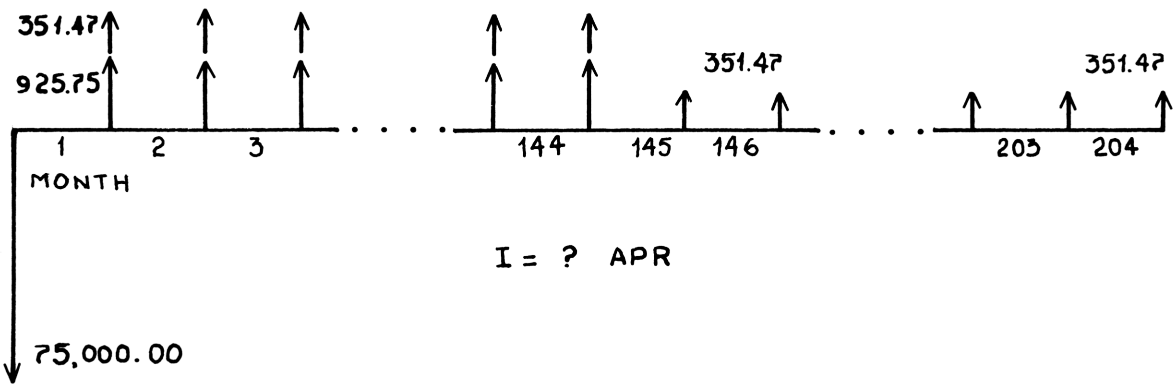
The amount of the first 144 payments (1277.22) is stored in register 1 (recall it if you want to look at it); the last 60 payments will just be the amount of the payment for the second mortgage (stored in register 2).

Now you're ready to draw the picture for the calculator:

[EXIT] [CFLO] ([ ] [CLEAR ALL] [YES]) 0 [INPUT] [RCL] 1 [INPUT] 144 [INPUT] [RCL] 2 [INPUT] 60 [INPUT]

You want to obtain a yield of 16% A.P.R. on your investment. So press: [CALC] 16 [÷] 12 [I%] .

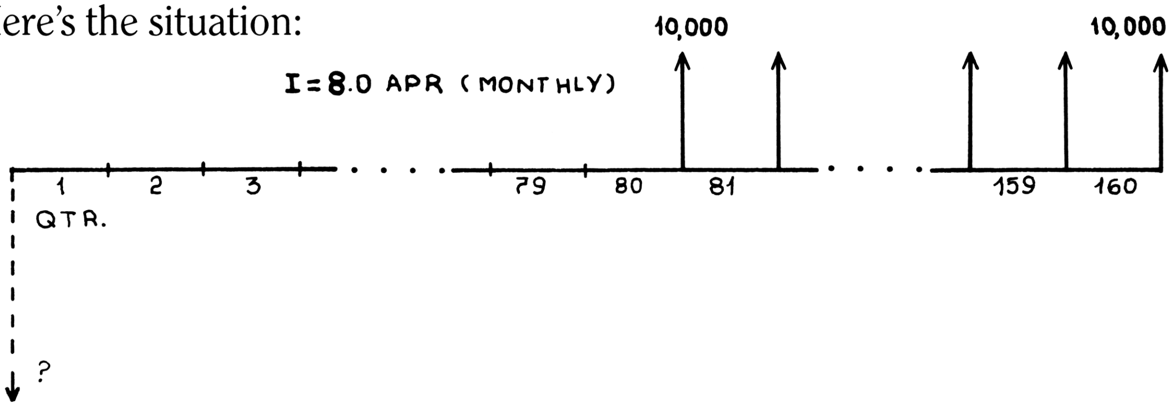
Finally, press [NPV] . Answer: 83,714.73. This is what this scenario is worth to you — if you are to yield 16% A.P.R. and you pay cash now for the right to receive those later flows.



3. Above, you see the situation. Just change the initial flow (on the list from the previous problem) to – 75,000: [EXIT] [ ] [↑] 75,000 [+/–] [INPUT] ...and turn the crank (patiently): [CALC] [IRR%] ...uh, that's a lot smaller than the 16% yield in the original problem. Shouldn't it be bigger? Yes...but this is a monthly IRR. How do you fix it?

   [×] 12 [=]
   Answer: 18.57
   That's better!

4. Here's the situation:



Again, you need to find the dotted arrow (NPV). So first, convert the rate from a monthly D.I.R. to a quarterly D.I.R:

[ ] [MAIN] [FIN] [ICONV] [EFFCT] 8 [NOM%] 12 [P] [EFF%] 4 [P] [NOM%] [÷] 4 [=] (why divide?) [EXIT] [EXIT] [CFLO] [CALC] [STO] [I%]

The rest is easy: [EXIT] [ ] [CLEAR ALL] [YES] 0 [INPUT] 0 [INPUT] 79 [INPUT] 10,000 [INPUT] 80 [INPUT] [CALC] [NPV] Answer: NPV = 81,967.88

For $15,000 withdrawals, just change FLOW(2) to 15,000 and then: NPV = 122,951.83

5. The key to this problem is not to panic. It looks incredibly complicated, but it's not, really.

The first temptation is to try to trace each fund's growth rate independently, and then try to somehow average the results. But simple averaging is almost never the correct way to treat compound growth rates. And anyway, look again at the question: You want to find out what the overall return is — just as if it were all in one bucket. So treat it that way!

Ignore the fund numbers totally. What you have here is a set of negative cash-flows over the course of several years, and you want to balance them against the positive value you would get upon cashing in all three funds on December 31, 1986. It's just a large IRR% problem, with all cash-flows being negative except the last one.

Next problem: Not only are the cash-flows uneven, but they don't even occur in regular intervals. Do you punt? Not altogether, although this IS a little bit more of a problem: Look again at the dates of the cash-flows. See how they are all at the beginning/ending of months OR in the middle of the month? That means you can get quite an accurate approximation of your yield by choosing a half-month to be your standard time period for the cash-flow diagram. (Remember? You can choose any length of time you want — as long as you stay consistent — because the CFLO equation doesn't know anything about how long a period is; it just knows how to increase money once per period.)

This decision solves the problem of those periods when there are no investments at all: those are ZERO cash-flows, and you have to key them in just like any others.

Remember this little trick — it's handy to use: Whenever your cash-flow dates are irregular, you can always define a smaller period and then fill in the resulting gaps with zero cash-flows — just as you did in your August/ December tractor loan.

So in this case, using half-months as compounding periods, your investment history looks like this:

CF Group #	Date	Cash-Flow	# OF TIMES
INIT	9-30-82	–1,500.00	(1)
1	—	0.00	10
2	3-15-83	–500.00	1
3	4- 1-83	–500.00	1
4	—	0.00	3
5	5-31-83	–9,000.00	1
6	—	0.00	7
7	9-30-83	–20,000.00	1
8	—	0.00	3
9	11-30-83	–1,500.00	1
10	—	0.00	3
11	2- 1-84	–500.00	1
12	—	0.00	7
13	6- 1-84	–500.00	1
14	—	0.00	5
15	8-31-84	–5,000.00	1
16	—	0.00	2
17	10-15-84	–2,900.00	1
18	—	0.00	14
19	6- 1-85	–4,500.00	1
20	—	0.00	1
21	7- 1-85	–1,000.00	1
22	—	0.00	8
23	11-15-85	–600.00	1
24	—	0.00	3
25	1-15-86	–2,600,00	1
26	—	0.00	6
27	5- 1-86	–50,000.00	1
28	—	0.00	2
29	6-15-86	–1,500.00	1

CF Group #	Date	Cash-Flow	# OF TIMES
30	—	0.00	5
31	9-15-86	–2,600.00	1
32	—	0.00	4
33	11-30-86	–2,400.00	1
34	—	0.00	1
35	12-31-86	169,587.21	1

Now go ahead and key this in as a new list (P5, maybe?). Here are a few hint keystrokes to get you started:

[ ] [MAIN] [FIN] [CFLO] [ ] [CLEAR ALL] [YES] 1,500 [+/–] [INPUT]

Now continue on and finish the list....

...By now, keying in lists should be painfully familiar.

When you have it keyed in, just solve for IRR%. Result: 1.02%

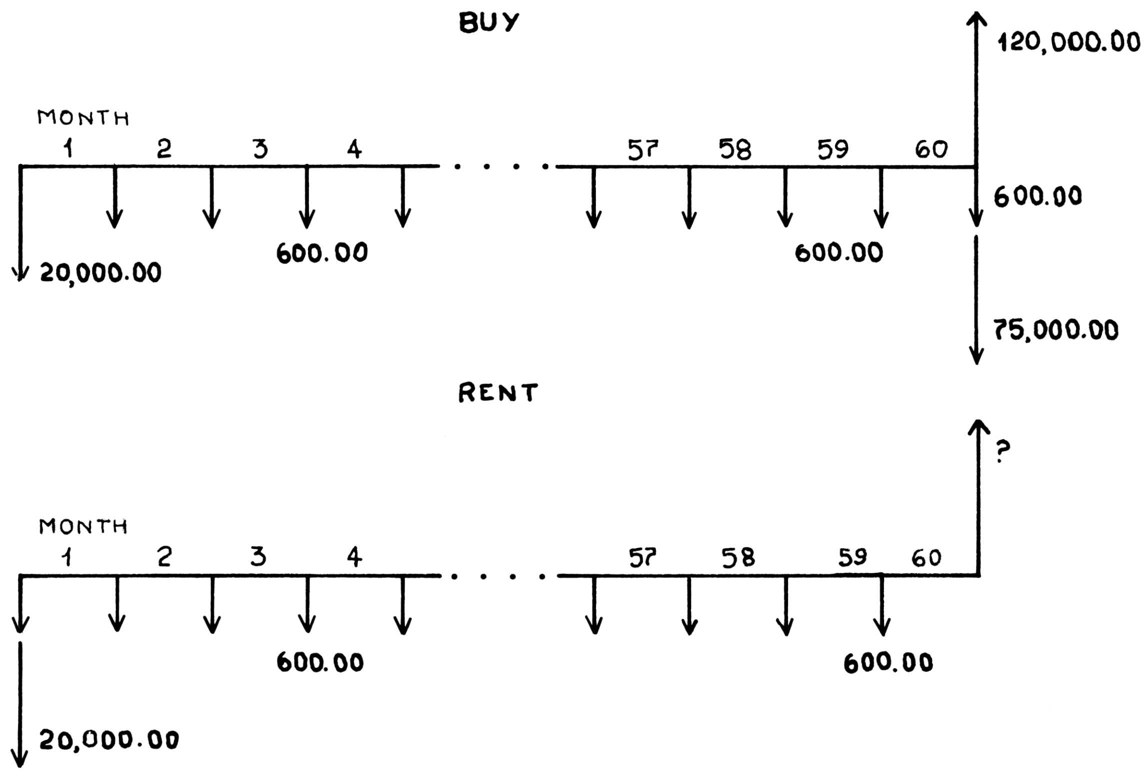
This is a periodic rate, remember, not an annualized one. So annualize it (there are 24 half months in a year):

[×] 24 [=] (Answer: 24.58)

That's better. And that's not too shabby a performance for your mutual funds — congratulations.

6.

A. Here are the two situations, side by side, for comparison. (Do these look like the diagrams you drew?)



The first thing to do is to figure out the final cash-flow in the "rent" picture. How much will $20,000 grow into in 5 years of accrual at 12% A.P.R. compounded monthly? By now this solution ought to be a piece of cake (or easy as pie):

[ ] [MAIN] [FIN] [TVM]

20,000 [+/−] [PV]

60 [N]

12 [I%YR]

0 [PMT]

([OTHER] 12 [#P/Y] [END] [EXIT])

[FV] (Answer: FV = 36,333.93)

[STO] 1

Now the pictures are complete. To compare them, just draw both pictures for your calculator, and ask for the IRR%. The higher "yield" (or the lower cost) is the better choice.

The first thing you may want to do is clear the list named P4 (if it's still in your calculator). To clear it, press [ ] [MAIN] [FIN] [CFLO] [ ] [CLEAR ALL] [YES] [GET] [P4] [ ] [CLEAR ALL] [YES] [YES]. (This menu navigation — old hat, right?)

Now name this list "RENT" and input the "rent" diagram:

[GET] [*NEW]

[NAME] RENT [INPUT]

20,600 [+/−] [INPUT] (Payments at the beginning of the month.)

600 [+/−] [INPUT] 59 [INPUT]

[RCL] 1 [INPUT]

[CALC] [IRR%] [×] 12 [=] Answer: IRR% = −13.32

Now draw the "buy" picture:

[EXIT] [GET] [*NEW] [NAME] BUY [INPUT]

20,000 [+/−] [INPUT]

600 [+/−] [INPUT] 59 [INPUT]

45,000 [−] 600 [INPUT] (Payments at the end of the month.)

[CALC] [IRR%] [×] 12 [=] Answer: IRR% = −6.67

Because of the fact that both pictures show a negative yield, you aren't making money either way. However, you'll be minimizing your "living costs" by BUYING the house.

The key to this problem is in realizing that your $20,000 is going to be an investment in either case, and all you need to do is to compare the yields.

B. Now what if you consider your tax bracket? You've already shown that the "BUY" picture is the best deal; since the major part of the payment is tax-deductible, this should only improve that picture...but just how much?

You are paying out $600.00 a month, and of that, $475.00 is deductible from your taxable income. So look at it like this: if you weren't making that house payment every month, your government would take 40% of the $600.00 per month (about 240.00 per month) that you would otherwise be spending or saving somewhere else. But by making the house payment, your government will take 40% of only $125.00 (600–475) per month (about 50.00).

So you either pay the $600.00 in rent and the 240.00 in taxes for each month, OR you pay the $600.00/month toward buying the house and only $50.00 in taxes. Savings in the buy case: $190.00/month.

So as you already knew, if you're in the 40% tax bracket, buying is clearly the better deal. But for practice, change as necessary the numbers in the RENT and BUY lists so that you ARE considering taxes along this line of reasoning. This means your RENT payment every month jumps to $840.00 (counting the taxes you had to pay just to gather the $600.00 for rent); and the BUY payment jumps to $650.00. Figure the IRR% of THOSE two scenarios.

Answers: RENT: –22.43% (Annualized, of course!)

BUY: –8.44%

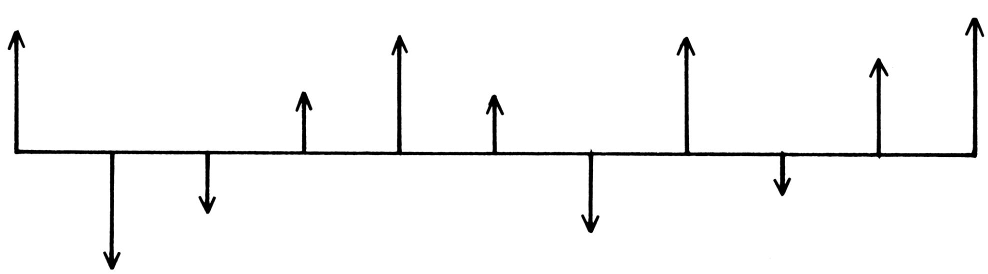
(If this type of investment-comparison-thinking interests you, you may want to spend extra time on the following topics....)

NO SOLUTION TO IRR

What do you do when there's no solution or more than one solution to IRR? Did you realize that could happen? The reason is a mathematical one that says, essentially: "There may be MORE than one interest rate which, when applied to a cash-flow diagram, will produce an NPV of zero (which is, after all the definition of IRR), OR there may no such number at all."

Now, you may shake your head and ask, "How can that be? If I invest some money now and watch the returns come back on several future occasions, there HAS to be just one yield to describe that."

Yes, you're right: for a simple scenario like that, with one (negative) investment up front and all the (positive) returns coming later, the IRR% governing this is indeed unique and easy for your calculator to find. You run into problems, however, when you have investment scenarios such as the one below, where investments and returns are all mixed up all along the timeline. THIS is when you can have more than one correct IRR%:



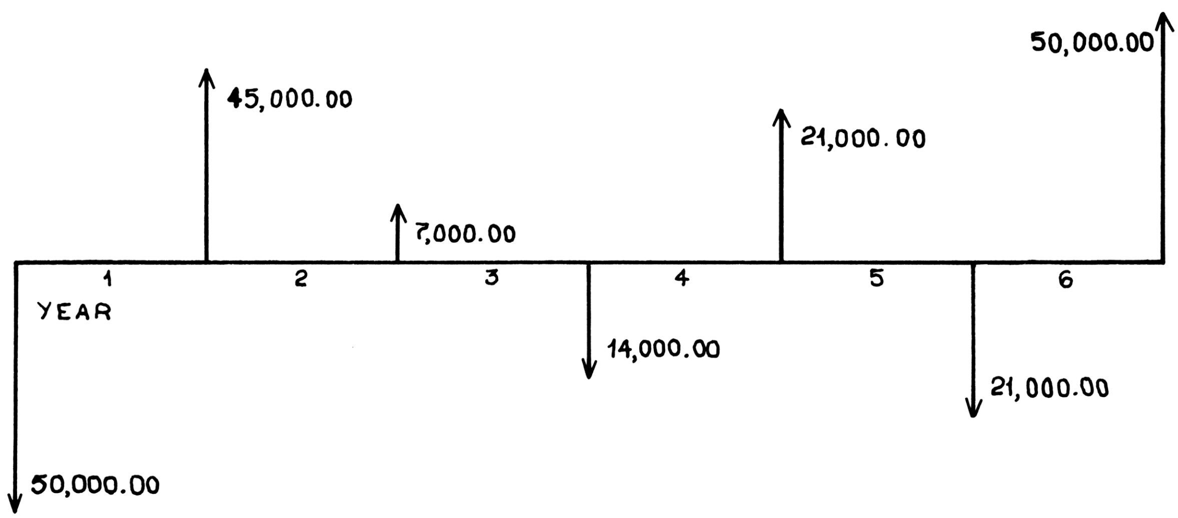
You can usually tell when a situation's numbers may produce such difficulties: Whenever you have several "sign changes" in your cash-flow stream, you might find multiple solutions. That is, when scanning the timeline from left to right, you see the arrows flip-flop back and forth (from positive to negative to positive, etc.) — like the situation above — you're asking for problems.

So if this is truly the kind of scenario you want to analyze, then be alert! Your HP-18C may blithely show you ONE of the possible answers, but it can't warn you that there are others. You have to recognize this possibility yourself, and then give the calculator a good guess — to let it "home in" upon another solution (remember how the guessing technique works when you're using SOLVE? See page 98).

If you've exhausted all those possibilities and still haven't come up with a number that you can believe is your "yield," you could try getting a more practical, down-to-earth line of reasoning, called a Modified Internal Rate of Return (MIRR).

MIRR

Here's a cash-flow situation for which there are probably multiple IRR's:



Now, think about the realities of investment: When you invest money in one place, you are choosing to forego investments in many other places — presumably because your chosen investment will provide the best return for you. And part of the quality of that return may be not only the interest rate but its security and liquidity — how easily you can get your money out when you need it.

Well, imagine that you're offered the preceding picture as an investment opportunity in, say, low-income housing. Notice that it's one where you won't simply be plunking down all your money at once; that is, you will have to invest some, see a few returns, invest some more, see some more returns, etc. (i.e. the kind of multiple-sign-change scenario that leads to problems for the IRR% calculation).

Question: Where are you going to get the money at each of the required dates for the housing investment?

Answer: From some bank account or some other very liquid investment, right? You would be very foolish (and uncomfortable) simply to keep the money under your mattress until it was needed on each of those investment dates.

And wouldn't it be reasonable to be holding this money in the highest-yielding account possible — provided that it was secure AND liquid so that you could withdraw what you needed on each of the investment dates?

OK, suppose you do that. Call that account's yield a "safe" rate.

Next question: Whenever you get returns on this investment situation, what are you going to do with the money until you get ALL your money out of this situation (i.e. at the right-hand end of the timeline)?

Next answer: Well, you could simply salt it away again in your safe-rate bank account. But since the housing scenario was rather risky (as are all investments to some degree), any returns you got from it have already been at some risk greater than that safe account. Clearly, this is money you've been willing to take a chance with. And anyway, at least some of your money will be tied up in the housing until the very end, right? So why not let your earlier returns "ride" in some other equally risky investment, provided that you can liquidate them at the end of the timeline?

So you're going to reinvest your returns in some other instrument that has a risk comparable to your housing investment BUT which allows liquidity at the end of the timeline. Call that instrument's yield your "risk" rate.

See what's going on here? You'll hold all necessary investment money at a safe rate until you invest, but once you get it back, you'll "let it ride" in a higher-yielding ("risk" rate) account somewhere — one which still allows you to liquidate at the end of the housing investment's timeline.

So how do you translate all this into some kind of overall yield called an MIRR?

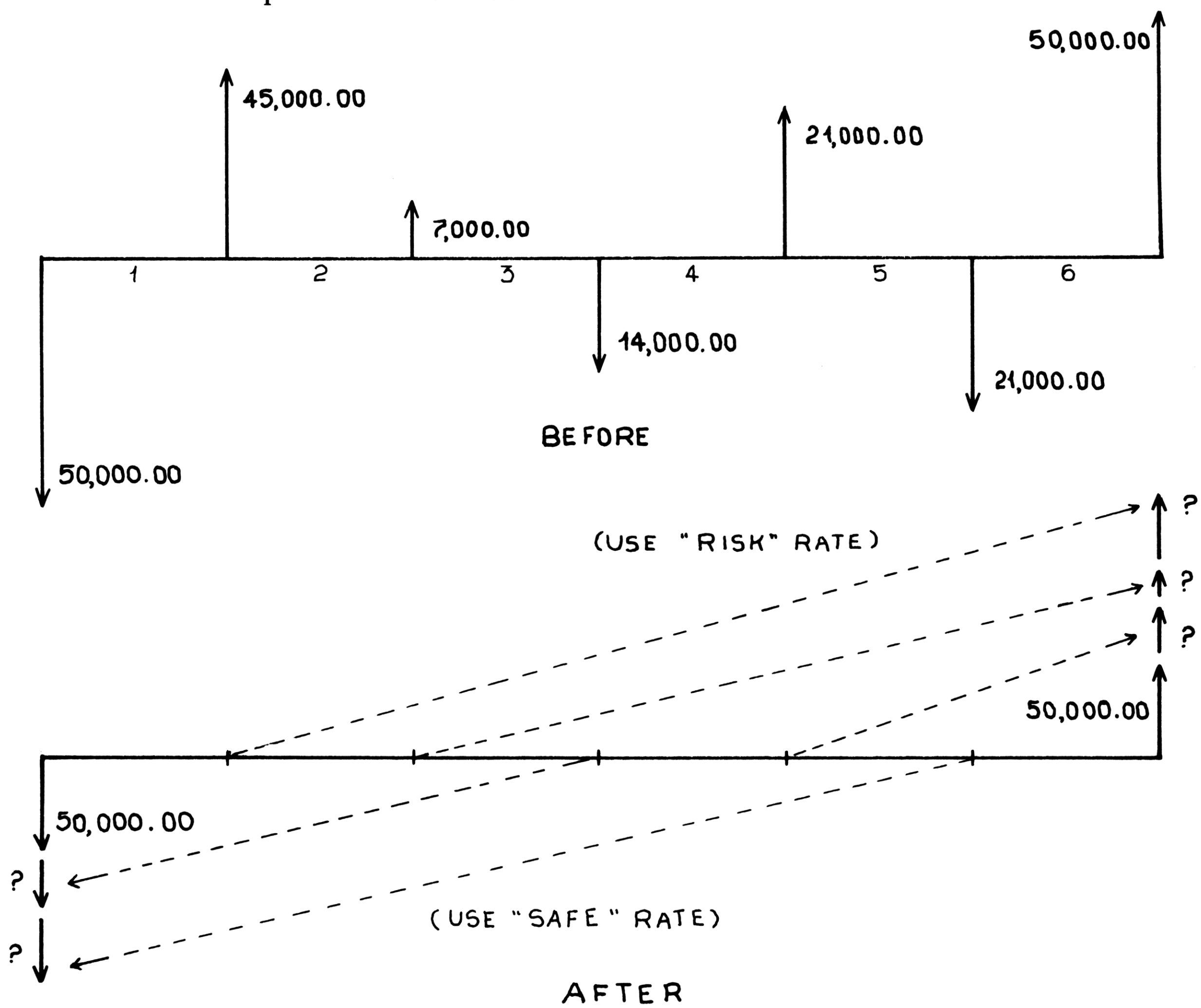
Well, knowing your safe rate/risk rate strategy, what's the very minimum amount of money (MIN) you'll actually have to COMMIT at the very BEGINNING of the housing deal in order to get the ball rolling?

Clearly, it's just enough so that when you deposit it in your safe-rate bank account, it will grow sufficiently to exactly cover all your necessary withdrawals for the housing investments, right?

And what's the maximum amount of money (MAX) you can expect to hold in your hands at the very end of your housing investment scenario? Clearly, it's the value AT THAT TIME of all your earlier returns, which you have immediately reinvested in your risk-rate account.

Aha! What you're saying is this:

Your venture into this housing project is exactly like depositing MIN in your safe-rate bank account at the BEGINNING, and then withdrawing MAX from your risk-rate account at the END. You can model the whole mess as a simple deposit/withdrawal problem...a master stroke!



This is what MIRR does. Its method is to find the NPV of all your investments (negative cash-flows) — using the safe rate; and the NFV of all your returns (positive cash-flows) — using the risk rate. It's just a huge "sliding" procedure that uses two different "governing rates," one for forward, one for backward.

See how useful the sliding concept can be to adjust a complicated cash-flow picture into an easier form?

So this is your MIRR procedure:

1. You discount (slide back) all of the negative cash-flows at the safe rate, say, 8% per year. Use NPV to do this with the safe rate in the I%-register (don't forget to match it to the D.I.P. — one year).

   KEYSTROKES: [ ] [MAIN] [FIN] [CFLO] [GET] [*NEW]

   50,000 [+/–] [INPUT]

   0 [INPUT] 2 [INPUT]

   14,000 [+/–] [INPUT] [INPUT]

   0 [INPUT] [INPUT]

   21,000 [+/–] [INPUT]

   [CALC] 8 [I%] [NPV] (Answer: –75,405.90)

   [STO] 1 (Save for the final calculation)

2. You slide forward, to the far (future) end, all of your positive cash-flows, using the risk rate, say, 18% per year (do you remember how to compute a Net Future Value? Page 186).

   KEYSTROKES: [EXIT] [ ] [CLEAR ALL] [YES]

   0 [INPUT]

   45,000 [INPUT] [INPUT]

   7000 [INPUT] [INPUT]

   0 [INPUT] [INPUT]

   21,000 [INPUT] [INPUT]

   0 [INPUT] [INPUT]

   50,000 [INPUT]

   [CALC] 18 [I%] [NFV] (Answer: 195,760.94)

3. Now, with just one cash-flow at either end of the time-line, use the 5-key solution to compute what periodic rate that represents.

KEYSTROKES: [EXIT] [EXIT] [TVM]

[STO] [FV]

[RCL] 1 [STO] [PV]

6 [N]

0 [PMT]

[OTHER] 1 [#P/Y] [EXIT]

[I%YR]

Answer: 17.23 % APR That's your MIRR.

Notice that if you had decided simply to put your early returns right back in your safe-rate bank account, instead of in a riskier account, then your safe rate and your risk rate would be the same rate — your safe rate. That would lower your MIRR but increase the security of your returns, which makes sense, right?

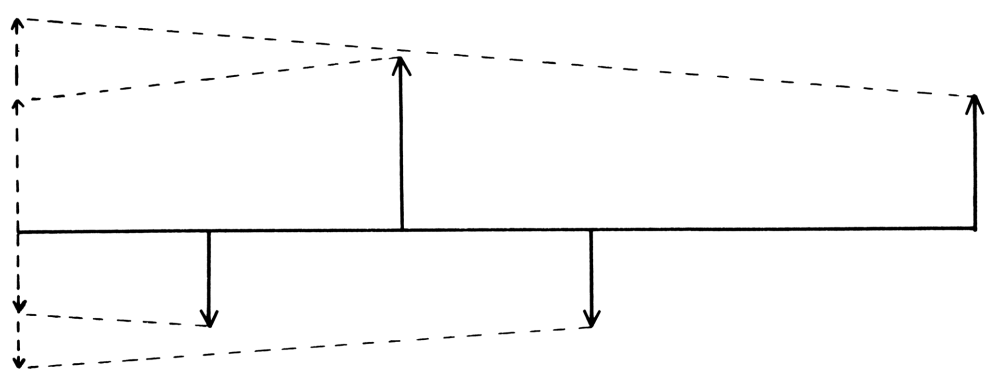
See how much thinking goes into drawing the correct picture for your calculator — and how simple the keystrokes finally are? The machine makes the math easy and lets you concentrate on the common sense and good reasoning.

WHEN IN DOUBT, USE NPV!

What happens when there is absolutely NO number that you can be happy with as a "yield?" Suppose there is none that will produce an NPV of zero — i.e. there's no IRR% — that the IRR% and MIRR are too unrealistic to trust (yes, this can happen) — what do you do?

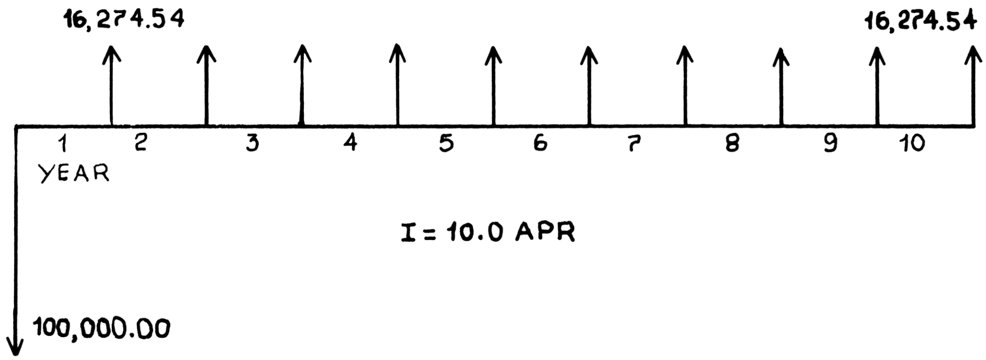
The first thing to do is start asking a better question than "What is my yield?" That's often a wild-goose chase anyway. When you say "yield," you are usually thinking in terms of a return on your money invested. That's fine, but remember that in a situation where you have returns coming back at many different times, your yield is the rate that separately governs each of those little investment/return pairs.

Remember how NPV takes each cash-flow separately and discounts it back to the present?



Well, this is a great picture to keep in mind; if you think about an investment as being broken down into little pieces that each have only one point of return, you'll get a much clearer picture of what's happening with your money.

For example, look at the following investment:

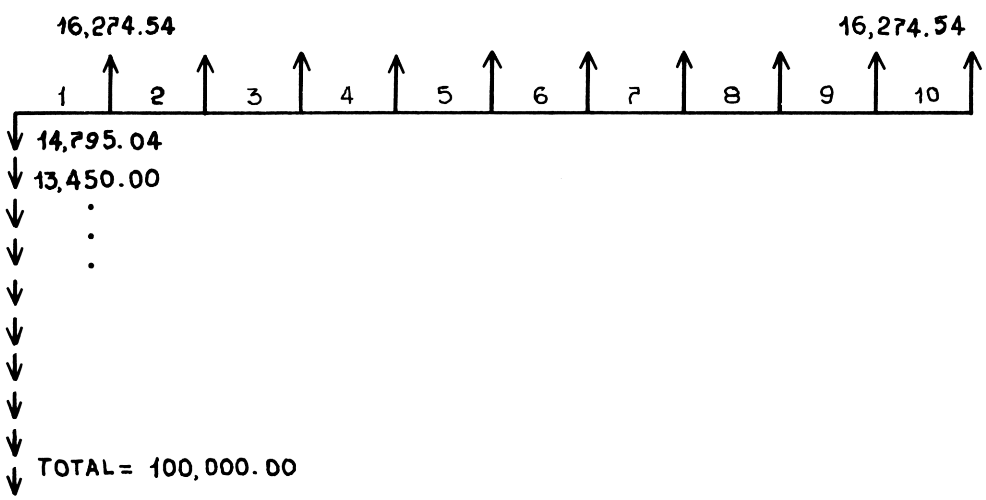


At the beginning, you invested $100,000.00, and over the next 10 years, you received returns on that investment. The IRR% ("yield") for this situation is 10.00%.

So, does that mean that you yielded 10.00% per year for 10 years for the ENTIRE $100,000.00?

No way!

It means that for $14,795.04 of your investment, you let it grow at 10% for ONE year before pocketing the $16,274.54 return (check these numbers if you wish); and for $13,450.03 of your investment, you let it grow at 10% for TWO years before pocketing a return of $16,274.54,... and so on. In other words, the real picture is this:



Here's the point of all this: A "yield" makes no assumptions whatsoever about what you do with your "pocketed returns." It only claims that the growth rate of your investments was 10% per year WHILE IT WAS INVESTED. As far as it's concerned, the minute you got your money back, the growth stopped. This means that only for the portion of your investment that you waited 10 years to collect on — ONLY that portion — actually yielded 10% for the entire 10 years. Each "piece" of any investment only "yields the yield" UNTIL IT IS RETURNED — no longer.

An easy way to illustrate this to yourself is to add up all the (positive) returns on the previous diagram — all the money you "pocket" as it comes back to you. The total is $162,745.39.

Now compare that with a simple $100,000 note, invested for 10 years at 10% per year. Its maturity value is $259,374.25.

Those are vastly different numbers, but in BOTH cases, your yield would be 10% per year. The difference arises in the amount of time you let this yield act. ONLY in the case of the 10-year note can you say that you yielded 10% on your $100,000.00 for the ENTIRE term. Don't ever confuse the term of an entire investment analysis with the term(s) of the actual investment(s).

Remember: If yield is somehow elusive or meaningless, you can ALWAYS compare the relative value of investments by using NPV (because you can always find exactly one NPV). This is really the bottom line of investment analysis:

If you're in any doubt about the value of any investment, then find the Net Present Value of that entire scenario, using as a discount rate some reasonable interest rate that you would LIKE to "yield." If the answer is a positive number, you'll probably do even better than you hoped; if the answer is negative, you probably won't do as well as you would like.

Well, that's about it. This page is the Lower Right-Hand Corner you've been waiting for — it's the end of our little tour of your HP Business Consultant calculator. We hope you enjoyed it.

Of course, you noticed that there are quite a few things about the HP-18C that we didn't even mention, but these are topics we thought would be fairly clear and straightforward to you — right out of the HP manual — once you were comfortable with "the basics." So this book was about "the basics," basically.

As you've also noticed, in presenting all this, we tried to steer clear of the jargon that sometimes confuses the issues in some other manuals. We can learn (and talk) about even such technical subjects as programming (and let's not kid ourselves — you DID do some programming here; that's what those formulas really are), but in doing so, there's no need to resort to computer language when we're simply trying to communicate person-to-person. In fact, the only time most of us ever need to use computer language is when we're trying to talk to a computer, right? So we strongly believe that if we just sit down and take some time to talk together — one to one this way, using just every-day language and examples — it makes learning a lot more fun and interesting, and (surprisingly) quicker and more long-lasting than a faster-paced approach.

Do you agree or disagree? What aspects bothered you about this approach? How about the content? What topics do you think we should have included among "the basics?" Should we have omitted some? ("Why or why not?....Give 3 examples....") Or did you find any mistakes, typos or other mysteries we ought to know about (yep, we usually make a few innocent-looking little boo-boos. Did any of them jump out from their hiding places and grab you by the lapels)? Please let us know your comments; we always read our mail!

Anyway, thanks for going along with us. We hope that when all is said and done, this book has said and done a lot of it, helping you and your HP-18C become good business partners — and stay good friends.

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