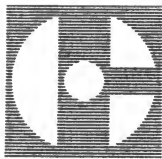


THE SEMANTIC CALCULATOR USER'S MANUAL



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PART I A PERSPECTIVE ON PROBLEM SOLVING

I-1

A NOTE OF INTRODUCTION

The Semantic Calculator (**SemCalc**) is a microcomputer program that adapts for elementary and secondary school mathematics a problem solving strategy traditionally used in physics and engineering. **SemCalc** enables both students and teachers to use the computer as a tool to help them solve "word" or "story" problems and estimation problems.

SemCalc is not a smart computer program that "knows" answers to questions that a child does not know answers to. Such programs can be dangerous for at least two reasons. First, they promote the making of false inferences about computers. And second, the price paid by a student whose response is misunderstood or misinterpreted by the program is large.

In a broad sense, **SemCalc** is an example of a different approach to using computers in education. Its premise is that computers are tools to be used by those who are engaged in the intertwined processes of teaching and learning.

MOST NUMBERS REFER TO SOMETHING

Several years ago there appeared in the New Yorker magazine a cartoon showing a roadside sign outside a small town. On the sign was written

Entering HILLSVILLE	
Founded	1802
Altitude	620
Population	3700

Total	6122

The absurdity of the sign and its humor derive from the fact that the numbers we use in our lives almost always refer to **something**. The number 3700 refers to a number of people, the number 620 refers to the elevation (presumably in feet!) of Hillsville above sea level and the 1802 refers to a number of years. And to paraphrase an old piece of folk wisdom, "you can't add people and feet and years. All of us have seen students do the equivalent of adding people and feet and years, namely, manipulating numbers without attending to the referents of the numbers.

SemCalc was designed to help students learn and teachers teach:

how to capitalize on the known semantic properties of the referents of the numbers to narrow their search for problem solutions, and

how to **avoid** inappropriate computations.

In order to think about the problem of teaching problem solving, one needs to have a theory of problems. By a theory, I mean at the very least one needs to be able to say why and how two problems are similar or not. Traditional ways of categorizing problems as rate problems, mixture problems, age problems, interest problems, etc., have not been helpful. Is there another way?

Research on the foundations of mathematics and in cognitive psychology in the last quarter century leads to quite different ways of classifying problems. Those readers who wish to pursue this question in somewhat greater depth will find these issues discussed in Part IV of this manual.

HOW SEMCALC USES SOME OF THESE IDEAS

When we both pose and solve problems about the world around us, we use quantities that have both a magnitude and a referent. For example, **32 children**, where **32** is the magnitude and **children** is the referent. Other examples include:

4.6 lbs, 3 hours and 47 minutes, 14.7 meters, \$10/lb, \$10/hr, \$10/yard, 2.5 children/family, .4 families/child and on and on.

Most teachers ask children to present the result of their computing about real things in such a way as to answer the two questions, 'how many?' and 'what?'. But the strategy of paying attention to the referents of the numbers can produce dividends from the very beginning of the problem solving exercise. In fact, if one pays attention to the referents of the numbers, it is possible to avoid making any of a large class of errors.

THE SEMCALC PROGRAM: THE PRODUCTS OF MULTIPLICATION

SemCalc is a program that allows the user to compute with both the magnitudes and the referents of relevant quantities. When the program is loaded and run, a display something like a notepad appears on the screen. The pad has two columns, the first labeled HOW MANY? and the second labeled WHAT? The user enters all the quantities that may be pertinent to any given problem. Suppose, after entering

	HOW MANY?	WHAT?
A	330	MILES/HR
B	3	HR

the user wishes to multiply the two quantities. The program responds with

THE UNITS OF THE ANSWER ARE

MILES

and offers the user the option of proceeding or restarting the calculation. If the user is satisfied that the units of the answer being sought indeed ought to be MILES and chooses to

proceed, the program responds with

$$330 \text{ MILES/HR} * 3 \text{ HR} =$$

990 MILES

and adds the quantity 990 MILES to the pad for possible further use. Had the user chosen to divide 330 MILES/HR by 3 HR, the program would have responded with

THE UNITS OF THE ANSWER ARE

$$\frac{\text{MILES}}{\text{HR} * \text{HR}}$$

At this point, it is up to the user to recognize that this particular computation will not be helpful in answering the question of how far the airplane traveled and to rethink his/her strategy. On the other hand, a user who is satisfied that the units of the answer being sought are miles per square hour may choose to proceed. In that case, the program will respond with

$$330 \text{ MILES/HR} / 3 \text{ HR} =$$

$$\frac{110 \text{ MILES}}{\text{HR} * \text{HR}}$$

The result is the correct response to a **different** problem. As is the case with any calculator, the result is the correct answer to the question posed. If the question is not appropriate, the answer is not likely to be.

It is here that we begin to see both the power of the approach and the central role the computer plays in implementing this approach. If we can get people who need to manipulate quantities to pay attention to the referents of the numbers, then they can use that information to help them avoid a very large class of inappropriate computations, namely those that lead to answers whose units are not the desired ones. Paying attention to the units does not guarantee a correct solution to a problem, but it does guarantee that a large class of incorrect solutions can be avoided.

At this point, the reader might be tempted to ask, why not build enough intelligence into the program so that the student would be prevented from dividing 330 MILES/HR by 3 HR? The answer is a simple one. One cannot anticipate what kinds of computations the user may wish to do. Suppose the problem the user wished to solve was:

What is the acceleration of a tropical storm that at noon is moving northward at 30 MILES/HR and at 3 PM on that same afternoon is moving northward at 360 MILES/HR?

In this case, one indeed wants to divide 330 MILES/HR by 3 HR!

There are other subtleties that derive from the mathematical structure of the quantities being multiplied. Consider the following two problems:

How many eggs in 5 dozen eggs?

My aunt has 12 blouses and 5 skirts. How many different outfits can she put together?

Both problems require for their solution a multiplication of the numbers 5 and 12. In the case of the first problem

5 DOZEN * 12 EGGS/DOZEN =

60 EGGS

while in the second case

5 SKIRTS * 12 BLOUSES =

60 SKIRTS*BLOUSES

The label SKIRTS*BLOUSES is really what we mean by an outfit. It is, however, often the case that one ends up with unwieldy labels, and, therefore, we have built into the **SemCalc** program the ability to rename quantities. (For example, a KILOGRAM*METER/SEC*SEC is usually renamed a NEWTON.)

In addition, because people commonly forget how intermediate or even final results were arrived at, the **SemCalc** program keeps notes on each. When the notes on any given quantity are recalled, the user can see a record of the computation that gave rise to the quantity and whether or not the units of the quantity were renamed or converted (from lb. to oz., say). Users can also add notes of their own to the record for future reference.

APPLES AND ORANGES WITH SEMCALC

Let us examine how the program works when we wish to add or subtract. Assume the following quantities have been entered onto the pad :

	HOW MANY?	WHAT?
A	5	METERS
B	37	CENTIMETERS

and the user wishes to add the two quantities. The program responds with

Can METERS be converted to CENTIMETERS

or

can CENTIMETERS be converted to METERS?

(YES or NO)

If the user responds by pressing Y, the program returns with

In order to proceed you must specify

A) how many METERS in one CENTIMETERS

or

B) how many CENTIMETERS in one METERS

ENTER A or B

Suppose the user responds by pressing A. The program returns

How many METERS in one CENTIMETERS?

Let us assume that the user is sufficiently comfortable with the metric system to type in (correctly) .01. The program responds with

5 METERS + (37 * .01) METERS =

5.37 METERS

and adds the result to the pad for possible further use.

Contrast the previous case of adding two lengths with the following case in which a user attempts to add discrete rather than continuous quantities.

	HOW MANY?	WHAT?
A	3	APPLES
B	5	ORANGES

The user instructs the program to add the two quantities. The program responds with

Can APPLES be converted to ORANGES

or

can ORANGES be converted to APPLES?

(YES or NO)

If the user responds by pressing N, the program returns with

APPLES and ORANGES are both what?

If the user responds with the word FRUIT, the program returns

3 FRUIT + 5 FRUIT = 8 FRUIT

and enters the quantity 8 FRUIT as the third item on the notepad. Had the user responded to the question by claiming that APPLES and ORANGES were both DINOSAURS, the program would have responded with

3 DINOSAURS + 5 DINOSAURS = 8 DINOSAURS !

The program itself has no semantic knowledge and will respond, as does any calculator, with the correct answer to the question posed. If an inappropriate question is posed, the answer will be both correct and inappropriate.

SEMCALC AS AN EXAMPLE OF A DIFFERENT APPROACH TO COMPUTERS IN EDUCATION

SemCalc is an example of a computer program that has no curricular agenda of its own. It is a tool much the way a screwdriver, a typewriter or an automobile is a tool.

Because we can program tools such as **SemCalc** and other intellectual tools, the computer, somewhat Zeus-like, can appear to us in many different guises: sometimes as a tool for writing and editing; sometimes as a tool for graphic, mechanical or electrical design; sometimes as a tool for storing, and selectively retrieving, vast amounts of information. In no instance does the tool direct the interaction with the user. It is, rather, the user who controls the tool. Tools can be used imaginatively, or prosaically, or inadequately or even inappropriately. Physical tools, used well, can beneficially amplify mankind's physical prowess. Similarly, intellectual tools, used well, can beneficially amplify mankind's intellectual prowess. It is the expansion of human intellectual prowess, both individually and collectively, that is the fundamental challenge for education. The thoughtful use of the computer as tool can help to answer that challenge.

PART II HOW TO USE THE SEMCALC PROGRAM

II-1

GETTING STARTED

With the computer turned off, insert the **SemCalc** diskette in the disk drive. Turn on the computer (and the monitor if it has its own switch). You will hear the disk drive running and will see the edc/Center for Learning Technology logo appear on the screen, followed by a copyright notice.

When the program is loaded and ready to run, the screen will look like this:

WILL YOU BE USING A PRINTER?

(YES or NO)

If you have a printer connected to your computer and you wish to print out the results of your computations, type Y (For Yes). Otherwise, type N (For No).

As soon as you type your response, the screen will look like this:

DO YOU NEED HELP IN USING SEMCALC?

(YES or NO)

If you press Y, the program will present you with a condensed version of this manual. You can refer to this manual at any time while using the program. However, you will probably find it useful to use this printed manual until you become more familiar with the program.

If you press N, your screen will look like this:

HOW MANY?	WHAT?

A	
B	
C	
D	
E	
F	
G	
H	
I	

CTRL Operation	Erase Rename Note Save ?

Please note that if you had answered No when you were asked about using a printer, the bottom line of the screen would not contain the word **Save**.

You are now ready to begin using the Semantic Calculator.

ENTERING QUANTITIES ON THE PAD

In order to use **SemCalc**, you must enter the quantities you want to work with. Note that the cursor (the flashing square) is in the HOW MANY? column. To enter the quantity

5 APPLES

type the number.

5

then press the RETURN key. When you press RETURN the cursor will move to the WHAT? column. Now type

APPLES

and press RETURN. The cursor will move back to the HOW MANY? column, one line lower down.

Continue in this way to enter all the quantities you might need.

After you have entered 9 items and filled the first page of the pad, the words **CTRL Page** will flash in the upper right-hand corner of the screen. There is a second page on the pad, which you may get to by entering CTRL P. (This means you must hold down CTRL and press the P).

You may enter numbers in the HOW MANY? column in the following forms:

WHOLE NUMBERS such as 5 and 329,

numbers in DECIMAL representation such as 3.14159 and .000623,

SCIENTIFIC NOTATION such as 1.2E4 for 12,000 and 3.56E-2 for .0356.

large numbers with commas such as 1,000,000, and

FRACTIONS such 2/7 or 63/365.

You may enter the referents of the numbers in the WHAT? column in the following forms:

any word such as APPLES or MILES or SECONDS or KILOMETERS (it is recommended that you use abbreviations such as HR for HOURS and FT for FEET;)

any "per" quantity such as MI/HR or \$/LB or CHILDREN/FAMILY;

any product unit with up to 8 factors such as CM*CM*CM for cubic centimeters. (You may, of course, enter CU CM for cubic centimeters. However, **SemCalc** will leave the quantity CU CM/CM in that form, but will reduce CM*CM*CM/CM to CM*CM.

any "per" quantity with up to 8 factors in either the numerator and/or the denominator of the quantity.

Please note that the phrase METERS per SECOND per SECOND must be entered in the form METERS/SECOND*SECOND (or using abbreviation M/SEC*SEC).

COMPUTING WITH THE QUANTITIES ON THE PAD

In order to compute with the quantities you have entered on the pad, enter CTRL 0. The top of the screen will then look like this:

QUANTITY	OPERATION	QUANTITY
----------	-----------	----------

with the cursor under the word QUANTITY on the left. Suppose that you wish to divide 180 MILES by 4 HOURS and that on your pad you have a line that looks like:

G	180	MI
---	-----	----

and another line that looks like:

C	4	HR
---	---	----

The quantity 180 MILES appears on the pad with the label G and the quantity 4 HOURS appears on the pad as the quantity C. In order to divide these two quantities, type G. The cursor will then move over to a position under the word OPERATION. Type /. The cursor will then move over to a position under the word QUANTITY on the right. Type C and then press RETURN.

The words

EVALUATING

180	MI
-----	----

DIVIDED BY

4	HR
---	----

PRESS ANY KEY TO CONTINUE will appear on the screen. The screen will change to:

THE UNITS OF THE ANSWER ARE

<u>MI</u>
HR

PRESS CTRL 0 TO START OVER

PRESS ANY KEY TO CONTINUE

The point of this response is to get the user to consider, without the distraction of the numerical value of the result, whether or not the units of the answer are the ones being sought. Since, in the present case, you are looking for an answer having the units of

MI/HR

you can press RETURN. The screen changes to:

180 MI / 4 HR =

45 $\frac{\text{MI}}{\text{HR}}$

PRESS ANY KEY TO CONTINUE

Pressing any key results in a return to the pad with the result of the computation entered on the pad and available for further computing just as if you had entered it directly.

ERASING QUANTITIES FROM THE PAD

You can erase quantities from the pad in either of two ways. In one erase mode, you can selectively erase any selected set of entries on the pad. In the other erase mode, you can erase the entire pad and replace it with a fresh one.

Suppose the pad contains the entries:

A	4.6	HR
B	128	MI
C	7	COWS

and you wish to erase 4.6 HR. In order to do this, enter CTRL E (Remember to hold the CTRL key and press the E key).

The top of the screen will then look like this:

```
-----  
ERASE WHAT?      (ESC = NEW PAD)  
-----
```

Since you want to erase the quantity 4.6 HR which carries the label A, enter A and then press RETURN.

If you had wanted to erase the quantities 4.6 HR and 7 COWS which carry the labels A and C, enter AC (or CA) in response to the question ERASE WHAT?

The erase function takes a bit of time. Please be patient.

If you want to erase the entire pad and replace it with a new one, simply press the ESC key on the upper left hand corner of the keyboard. Again, the erase function takes a bit of time. Please be patient.

RENAMING QUANTITIES

Suppose you discover that you made a mistake in entering a number on the pad. You can use the RENAME function to fix it. In order to do so, enter CTRL R. The top of the screen will then look like:

```
-----  
RENAME WHAT ?  
-----
```

Type the label of the quantity you wish to rename. For example, suppose you entered:

```
      H      7      APPPLES
```

on the pad and you wish to change the spelling of APPPLES to APPLES. If you type the label attached to the quantity 7 APPPLES in response to the question RENAME WHAT ? the screen will look like:

```
PRESS ESC FOR NO CHANGE
```

```
RENAME      NEW NAME
```

```
7
```

```
APPLES
```

The cursor will appear by the 7. Since you don't want to change the 7, press ESC. The cursor will then move over by the word APPPLES. Simply type in the new name, APPLES, and then press RETURN.

There is another case in which you can use the RENAME function. Suppose you get more digits than you care to have as a result of a computation. You can use RENAME to change

```
16.333333 to 16.33
```

or

```
3.14159265 to 3.1416
```

The following problem illustrates a third circumstance in which the RENAME function is useful.

Jane has 4 SKIRTS and 6 BLOUSES. How many different outfits can Jane make?

If you multiply 4 SKIRTS by 6 BLOUSES using **SemCalc**, you will get

24 SKIRTS BLOUSES

What is a SKIRT BLOUSE? If you think about it for a bit, you'll realize that a SKIRT BLOUSE is exactly what you mean by an OUTFIT. You can use RENAME to change SKIRTS BLOUSES to OUTFITS.

A fourth example in which RENAME is useful:

A boat travels 45 NAUTICAL MILES in 5 HOURS. What is its average speed?

If you divide 45 NAUTICAL MILES by 5 HOURS using **SemCalc**, you'll get

9	<u>NAUTICAL MILES</u>
	 HOUR

However, the unit NAUTICAL MILE/HOUR is what is commonly referred to as a KNOT. You can use RENAME here, too.

NOTES

SemCalc keeps notes about each of the quantities on the pad.

If the quantity is a result of a computation that you have done, **SemCalc** will keep a record of that computation.

If you rename a quantity, **SemCalc** will keep a record of the old quantity and what it was changed to.

If you convert units in the course of a computation, say CENTIMETERS to METERS or DAYS to YEARS, **SemCalc** will keep a record of both the old and the new units.

In order to see the notes that **SemCalc** has kept on any quantity on the pad, press CTRL N.

SemCalc will ask

NOTE ON WHICH QUANTITY?

Type the label of the quantity you are interested in, and then press RETURN.

If you wish to enter a note of your own about the quantity just go ahead and type a note. When you finish, press RETURN to go back to the pad. The next time you ask to see the note on that quantity, you will find the note you entered along with the notes **SemCalc** kept.

PRINTING THE PAD

If you have a printer, you can print a copy of the pad you are working with.

In order to print the pad:

- the printer must be connected to the computer, switched on and turned to the ONLINE position;
- you must have answered yes when asked at the beginning of the program if you were using a printer.

Press CTRL S. The printer will print the contents of the pad as well as all the notes on each of the quantities.

USING THE HELP FUNCTION

If, while you are using the **SemCalc** program, you find yourself confused about the running of the program, or about how to do a particular kind of problem, you may find it helpful to use the HELP function of the program.

Whenever you see a question mark (?) on the menu at the bottom of the screen, you can press ? for help. Doing so will cause a HELP menu to appear on the screen. Press the number of the topic you want help with. The disk drive will spin for a bit and the first screen of a short tutorial on that subject will appear.

Across the bottom of the screen will be a menu that looks like:

< BACK GO ON > CTRL PAD RESTART 1/7

Pressing either > or the right arrow key will take you to the next page of the tutorial. (In the event that you press > when you are on the last page of a section of the tutorial, you will be returned to the pad.)

Pressing either < or the left arrow key will take you to the previous page of the tutorial. (In the present example you are on page 1 of 7 pages. Pressing < will take you back to the pad.)

Pressing CTRL P will take you back to the pad, where you may try a computation and then return to the place at which you left the tutorial.

Pressing CTRL R will take you back to the HELP menu.

PART III PROBLEMS, PROBLEMS. . .

III-1

In this part of the manual, we present a collection of examples of word problems that have been worked out using **SemCalc**. For simplicity, we have limited ourselves to single operation word problems.

We hope that this part will be useful to you in two ways:

- that it will help you to use the **SemCalc** program more effectively, and
- that it will help you to think about the nature of word problems and what makes one problem like or unlike another.

The problems are presented in the form of a dialogue between a user identified as PS (for problem solver) and the **SemCalc** program.

The symbol < RETURN > is used to indicate the pressing of the RETURN key.

ADDITION AND SUBTRACTION PROBLEMS

Here are four problems involving addition and subtraction. The numbers in the problems refer to APPLES or ORANGES or PIECES OF FRUIT. In order to do the problems correctly, one must take into account that:

APPLES are not ORANGES.

ORANGES are not APPLES.

APPLES are PIECES OF FRUIT.

PIECES OF FRUIT are not necessarily APPLES.

ORANGES are PIECES OF FRUIT.

PIECES OF FRUIT are not necessarily ORANGES.

If John has 14 APPLES and Jorge has 29 APPLES, how many APPLES do they have altogether?

PS:

```
14 < RETURN >
APPLES < RETURN >
29 < RETURN >
APPLES < RETURN >

CTRL O  A + B < RETURN >
```

(We assume here and throughout this part of the manual that the first quantity entered is on line A of the pad and the second is on line B of the pad. If you don't ERASE the pad between examples, that will not be the case. You can, however, use the proper line labels instead of A and B.)

SemCalc:

14 APPLES + 29 APPLES =

43 APPLES

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

Jorge has 29 APPLES and Sarah has 32 ORANGES. How many PIECES OF FRUIT do they have altogether?

PS:

29 < RETURN >
 APPLES < RETURN >
 32 < RETURN >
 ORANGES < RETURN >

 CTRL O A + B < RETURN >

SemCalc:

Can APPLES be converted to ORANGES

or

can ORANGES be converted to APPLES?

(YES or NO)

PS:

N <RETURN>

SemCalc:

APPLES and ORANGES

are both what ?

CTRL O to start over

PS:

PIECES OF FRUIT < RETURN >

SemCalc:

29 PIECES OF FRUIT + 32 PIECES OF FRUIT =

61 PIECES OF FRUIT

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

There are 30 children in the class. Each one has 1 PIECE OF FRUIT. Exactly 12 of the children have ORANGES. How many PIECES OF FRUIT other than ORANGES are there?

PS:

30 < RETURN >
PIECES OF FRUIT < RETURN >
12 < RETURN >
ORANGES < RETURN >

CTRL O A - B < RETURN >

SemCalc:

Can PIECES OF FRUIT be converted to ORANGES

or

can ORANGES be converted to PIECES OF FRUIT?

(YES or NO)

PS:

N <RETURN>

SemCalc:

PIECES OF FRUIT and ORANGES

are both what ?

CTRL O to start over

PS:

PIECES OF FRUIT < RETURN >

SemCalc:

30 PIECES OF FRUIT - 12 PIECES OF FRUIT =

18 PIECES OF FRUIT

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

In a large bowl of fruit, there are 13 APPLES and 8 ORANGES. How many more APPLES than ORANGES are there in the bowl?

PS:

13 < RETURN >
APPLES < RETURN >
8 < RETURN >
ORANGES < RETURN >

CTRL O A - B < RETURN >

SemCalc:

Can APPLES be converted to ORANGES

or

can ORANGES be converted to APPLES?

(YES or NO)

PS:

N <RETURN>

SemCalc:

APPLES and ORANGES

are both what?

CTRL O to start over

PS:

PIECES OF FRUIT < RETURN >

SemCalc:

13 PIECES OF FRUIT - 8 PIECES OF FRUIT =

5 PIECES OF FRUIT

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

A WORD OF CAUTION

You have to be careful when you add or subtract quantities to make sure that the sets of things referred to by the numbers do not overlap. For example, consider the problem:

There are 4 blue boats and 8 double-masted boats in the harbor. How many boats are in the harbor?

or the problem:

There are 3 people in our family who like soft-boiled eggs and 2 people in our family who like spinach. How many people are there in our family?

The only answer one can legitimately give in the first case is "at least 8 boats," and in the second case, "at least 3 people."

MORE ADDITION AND SUBTRACTION PROBLEMS

Here are some more problems involving addition and subtraction. The numbers in the problems refer to FEET or INCHES. In order to do the problems correctly, one must take into account that:

a FOOT is not an INCH,

an INCH is not a FOOT,

FEET and INCHES are both measures of distance,

FEET can be converted to INCHES,

INCHES can be converted to FEET.

A pine tree near the school was 38 FEET tall in 1980. Two years later it was 3 FEET taller. How tall was it in 1982?

PS:

38 < RETURN >

FT < RETURN >

3 < RETURN >

FT < RETURN >

CTRL O A + B < RETURN >

SemCalc:

38 FT + 3 FT =

41 FT

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

A pine tree was 18 FEET tall at the beginning of the growing season. At the end of the season, it was 18 INCHES taller. How tall was it at the end of the season?

PS:

18 < RETURN >

FT < RETURN >

18 < RETURN >

IN < RETURN >

CTRL O A + B < RETURN >

SemCalc:

Can FT be converted to IN

or

can IN be converted to FT?

(YES or NO)

PS:

Y < RETURN >

SemCalc:

In order to proceed you must specify

A) How many FT in one IN

or

B) how many IN in one FT

ENTER A or B

CTRL O to start over

PS:

B < RETURN >

SemCalc:

How many IN in one FT?

PS:

12 < RETURN >

SemCalc:

$(18 * 12) \text{ IN} + 18 \text{ IN} =$

234 IN

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

A pine tree was 18 FEET tall at the beginning of the growing season. At the end of the season, it was 18 INCHES taller. How tall (in FEET) was it at the end of the season?

PS:

18 < RETURN >
 FT < RETURN >
 18 < RETURN >
 IN < RETURN >

CTRL O A + B < RETURN >

SemCalc:

Can FT be converted to IN
 or
 can IN be converted to FT?

(YES or NO)

PS:

Y < RETURN >

SemCalc:

In order to proceed you must specify

A) How many FT in one IN
 or
 B) how many IN in one FT

ENTER A or B

CTRL O to start over

PS:

A < RETURN >

SemCalc:

How many FT in one IN?

PS:

1/12 < RETURN >

SemCalc:

18 FT + (18 * 1/12) FT =

19.5 FT

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

DIVIDING WITH SEMCALC

Here are four different kinds of problems, each of which involves a single division. The numbers in these problems will refer to

MILES,

HOURS,

GALLONS,

MILES PER HOUR,

MILES PER GALLON,

HOURS PER MILE,

HOURS PER GALLON,

GALLONS PER MILE,

GALLONS PER HOUR,

In Part IV of this manual, you will find a discussion of the underlying differences in these problems.

Frequently, one needs to handle quantities that refer to MILES **PER** HOUR or to \$ **PER** LB or to LBS **PER** CU FT. It is important to realize how these "**PER**" quantities come about. They can be thought of as resulting from a division as in the next problem:

Marie-Francoise and Maria Francesca went on a bicycle trip of 840 MILES. During the week they were on the road, they spent a total of 60 HOURS actually riding. What was their average speed in MILES PER HOUR?

PS:

840 < RETURN >
 MI < RETURN >
 60 < RETURN >
 HR < RETURN >

CTRL O A / B < RETURN >

SemCalc:

EVALUATING

840 MILES

DIVIDED BY

60 HOURS

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

$\frac{\text{MI}}{\text{HR}}$

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

840 MI / 60 HR =

$14 \frac{\text{MI}}{\text{HR}}$

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

See what happens if you divide 60 HR by 840 MI!

Juan Pablo and Jean-Paul also went on a bicycle trip. They travelled 90 MILES at an average speed of 12 MILES/HOUR. How long were they on the road?

PS:

90 < RETURN >
MI < RETURN >
12 < RETURN >
MI/HR < RETURN >

CTRL O A / B < RETURN >

SemCalc:

EVALUATING

90 MILES

DIVIDED BY

12 MI/HR

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

HR

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

90 MI / 12 MI/HR =

7.5 HR

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

A large water storage tank is leaking at the rate of 84 GALLONS/HOUR. If you assume that it took 4 HOURS to reach this rate of water loss, how fast did the rate of loss change?

PS:

84 < RETURN >
 GAL/HR < RETURN >
 4 < RETURN >
 HR < RETURN >

CTRL O A / B < RETURN >

SemCalc:

EVALUATING

84 GAL/HR

DIVIDED BY

4 HR

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

$\frac{\text{GAL}}{\text{HR HR}}$

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

84 GAL/HR / 4 HR =

$21 \frac{\text{GAL}}{\text{HR HR}}$

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

Try multiplying 84 GAL/HR by 4 HR and see what happens!

If your average speed on the highway is 55 MILES/HOUR and your car gets 22 MILES/GALLON, how many GALLONS/HOUR do you burn?

PS:

55 < RETURN >
 MI/HR < RETURN >
 22 < RETURN >
 MI/GAL < RETURN >
 CTRL O A / B < RETURN >

SemCalc:

EVALUATING

55 MI/HR

DIVIDED BY

22 MI/GAL

PRESS ANY KEY TO CONTINUE

PS: < RETURN >

SemCalc:

THE UNITS OF THE ANSWER ARE

GAL
 HR

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

55 MI/HR / 22 MI/GAL =

2.5 GAL
 HR

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

See what happens if you try dividing 22 MI/GAL by 55 MI/HR.

See what happens if you try multiplying 55 MI/HR by 22 MI/GAL.

MULTIPLYING WITH SEMCALC

Here are three different kinds of problems, each of which involves a single multiplication. In Part IV of this manual, you will find a discussion of the underlying differences in these problems.

On the twelfth floor of a large office building, there are 20 OFFICES. There are 3 DESKS/OFFICE. How many DESKS are there on that floor of the building?

PS:

20 < RETURN >
 OFF < RETURN >
 3 < RETURN >
 DSK/OFF < RETURN >

CTRL O A * B < RETURN >

SemCalc:

EVALUATING

20 OFF

MULTIPLIED BY

3 DSK/OFF

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

DSK

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

20 OFF * 3 DSK/OFF =

60 DSK

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

If there are 2 filing cabinets for each desk, and 5 drawers in each filing cabinet, how many file drawers are there for each desk?

PS:

2 < RETURN >
 FilCab/Desk < RETURN >
 5 < RETURN >
 FilDrw/FilCab < RETURN >

 CTRL O A * B < RETURN >

SemCalc:

EVALUATING

2 FilCab/Desk

MULTIPLIED BY

5 FilDrw/FilCab

PRESS ANY KEY TO CONTINUE

PS:

<RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

$$\frac{\text{FilDrw}}{\text{Desk}}$$

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

2 FilCab/Desk * 5 FilDrw/FilCab =

$$10 \frac{\text{FilDrw}}{\text{Desk}}$$

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

If a large bookkeeping job takes

12 PERSONS a total of 2 MONTHS to do
 8 PERSONS a total of 3 MONTHS to do
 6 PERSONS a total of 4 MONTHS to do
 4 PERSONS a total of 6 MONTHS to do
 3 PERSONS a total of 8 MONTHS to do
 2 PERSONS a total of 12 MONTHS to do

can you think of a way of describing how large a job it is?

PS:

6 < RETURN >
 PERSON < RETURN >
 4 < RETURN >
 MONTH < RETURN >

 CTRL O A * B < RETURN >

SemCalc:

EVALUATING

6 PERSON

MULTIPLIED BY

4 MONTH

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

PERSON MONTH

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

6 PERSON * 4 MONTH =

24 PERSON MONTH

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

PART IV THREE IMPORTANT IDEAS

IV-1

AN OBSERVATION AT THE OUTSET

The **SemCalc** program is built on a number of ideas that in one form or another are present in the foundations of mathematics, the philosophy of physics, cognitive psychology and linguistics. This is not the appropriate place to analyze in detail either the intellectual tapestry or the individual disciplinary threads that are here interwoven. Suffice it to say that there are three notions that played a strong role in the development of **SemCalc**. The following sections will introduce them.

QUANTITY AS NOUN AND QUANTITY AS ADJECTIVE

Consider the sentences

Two and two are four.

and

Two books and two books are four books.

What part of speech is the word **two**? the word **four**? In the first sentence these words are nouns. In the second sentence these words are adjectives. Are numbers nouns, or are numbers adjectives?

Numbers can be either nouns or adjectives. However, when we use numbers as part of our description of the quantitative aspects of the world about us, they are adjectives.

SemCalc is based on the idea that the quantities we use to model the real world are adjectival in nature. This idea is a generalization of an idea (known as dimensional analysis) that is quite common in the teaching of science and engineering, namely that measured quantities have units such as meters, seconds, lb/sq in, etc.

The arithmetic of adjectival quantities (quantities with units) is interesting. In fact one can make use of the referents of the adjectives to constrain what operations do or do not make sense in terms of the arithmetic model of the world that one is manipulating. Thus it may be entirely reasonable to multiply

10 CM by 10 CM

to obtain

100 CM*CM

because the entity 100 CM*CM itself has an area as a referent. On the other hand, suppose one multiplies

10 HR by 10 HR

to obtain

100 HR*HR

What is the referent of 100 HR*HR?

This is not to say that one cannot be sufficiently inventive as to imagine a situation in which it would be useful to attach a numerical measure to the product of two times. It does, however, mean that one must deliberately invest the results of one's computations with meaning. Further the meaning that one attaches to the results of one's computations must be semantically consistent with the meanings that were attached to the separate quantities that went into the computation.

COUNTED QUANTITIES AND MEASURED QUANTITIES

There is an old Groucho Marx story that goes as follows:

Groucho: If you had ten apples and you wanted to divide them among six people, what would you do?

Gummo: Make applesauce.

Apples are counted. Applesauce is measured, either by volume or by weight. Things that are counted, such as people, buildings, tractors, jackets, etc., come only in whole numbers. That is, one can have

6 people
71 buildings
9 tractors
1 jacket

but not

6.248 people
17.003 buildings
.0123 tractors
3.14159 jackets

On the other hand, one **can** imagine

6.248 meters
17.003 kilograms
.0123 hours
3.14159 pounds

SemCalc is based on the premise that the ideas of dimensional analysis can be generalized to include not only measured quantities, but counted quantities as well. If you look back now to Part III of the manual, you will no doubt realize that all the addition and subtraction problems on pages III-2 to III-5 deal with the arithmetic of counted (discrete) quantity, while the addition and subtraction problems on pages III-7 to III-9 deal with the arithmetic of measured (continuous) quantity.

“PER” QUANTITIES AND “NON-PER” QUANTITIES

Suppose you have a 5 lb pile of coffee beans on the table in front of you.

Suppose, further, that the pile of coffee beans costs \$15.

Clearly, you can deduce that the coffee costs \$3./lb (if you make the assumption that there is no quantity discount!)

Thus, there are three different quantities that refer to the coffee. They are

5 lb

\$15.

\$3./lb

The first quantity, 5 lb, refers to the entire pile of coffee. It is a measure of the weight of the entire pile.

The second quantity, \$15., refers to the entire pile of coffee. It is a measure of the cost of the entire pile.

The third quantity, \$3./lb, does **not** necessarily refer to the entire pile of coffee. It is a measure of a property of part or all of the pile of coffee.

The quantity \$3./lb is an example of a “per” quantity.

So is the quantity 30 MI/HR. You can travel at 30 MI/HR even if you don’t travel 30 miles and don’t travel for one hour.

So is the quantity 2.5 children/family. A community can have an average of 2.5 children/family even though there are many families and no family has 2.5 children.

“Per” quantities arise in a natural way from the arithmetic operations of division and multiplication of adjectival quantities. Go back to the sections in Part III of the manual that deal with division and multiplication problems and see if you can follow what happens to “per” quantities and “non-per” quantities as the arithmetic operations are carried out.

**PART V USING SEMCALC WITH YOUR
PRESENT MATH TEXTBOOKS**

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WORKING WITH THE APPLE II PLUS

1. Turn on the television or monitor.
2. Insert the diskette into the disk drive with the label facing up and on the right.
3. Close the door to the disk drive.
4. Turn on the Apple II. (The on-off switch is on the back left side of the computer.)
5. You will see a red light on the disk drive turn on. If the disk drive light does not turn off in about 10 seconds, turn the Apple off and make sure your diskette is placed correctly in the disk drive.
6. Follow the directions given in the program.

SHUTTING OFF THE SYSTEM

1. Remove the diskette from the disk drive and return it to its place of storage.
2. Turn off the Apple.
3. Turn off the television or monitor.

WORKING WITH THE TRS-80

1. Insert the diskette into the disk drive with the label facing up and on the right.
2. Close the door to the disk drive.
3. Turn on the TRS-80.
4. You will see a red light on the disk drive turn on. If the disk drive light does not turn off in about 15 seconds, turn off the TRS-80 and make sure your diskette is placed correctly in the disk drive.
5. Follow the instructions on the diskette.

SHUTTING OFF THE SYSTEM

1. Remove the diskette from the disk drive and return it to its place of storage.
2. Turn off the TRS-80.

WORKING WITH THE ATARI

TURNING ON THE COMPUTER:

1. Turn on the television or monitor.
2. The disk drive must be turned on before the computer. Turn on the disk drive using the switch on the front. Two lights will come on, the "PWR ON" light and the disk "BUSY" light. After about 10 seconds the BUSY light should go off.
3. Press the rectangular release button below the disk drive door and the door will open. Insert a diskette with the exposed oval "window" inserted first and the label side up.
4. Close the door on the disk drive.
5. Follow the instructions in the program.

TURNING OFF THE COMPUTER:

1. Remove the diskette.
2. Turn off the disk drive, television and the Atari.

WORKING WITH THE ATARI

TURNING ON THE COMPUTER:

1. Turn on the television or monitor.
2. The disk drive must be turned on before the computer. Turn on the disk drive using the switch on the front. Two lights will come on, the "PWR ON" light and the disk "BUSY" light. After about 10 seconds the BUSY light should go off.
3. Press the rectangular release button below the disk drive door and the door will open. Insert a diskette with the exposed oval "window" inserted first and the label side up.
4. Close the door on the disk drive.
5. Follow the instructions in the program.

TURNING OFF THE COMPUTER:

1. Remove the diskette.
2. Turn off the disk drive, television and the Atari.

“WHAT HAPPENS IF. . .?—SUNBURST COURSEWARE AND WARRANTY

1. What happens if a program will not load or run?

Call us on our toll-free number (800-431-1934) and we'll send you a new diskette.

2. What if I find an error in the program?

We have thoroughly tested the programs that **SUNBURST** carries so we hope this does not happen. But if you find an error, please note what you did before the error occurred. Also, if a message appears on the screen, please write the message down. Then fill out the evaluation form or call us with the information. We will correct the error and send you a new diskette.

3. What happens if the courseware is accidentally destroyed?

SUNBURST has a lifetime guarantee on its courseware. Send us the product that was damaged and we will send you a new one.

4. Can I copy this diskette?

The material on this diskette is copyrighted. You **should not** copy the courseware. You have been provided a back-up copy of the diskette.