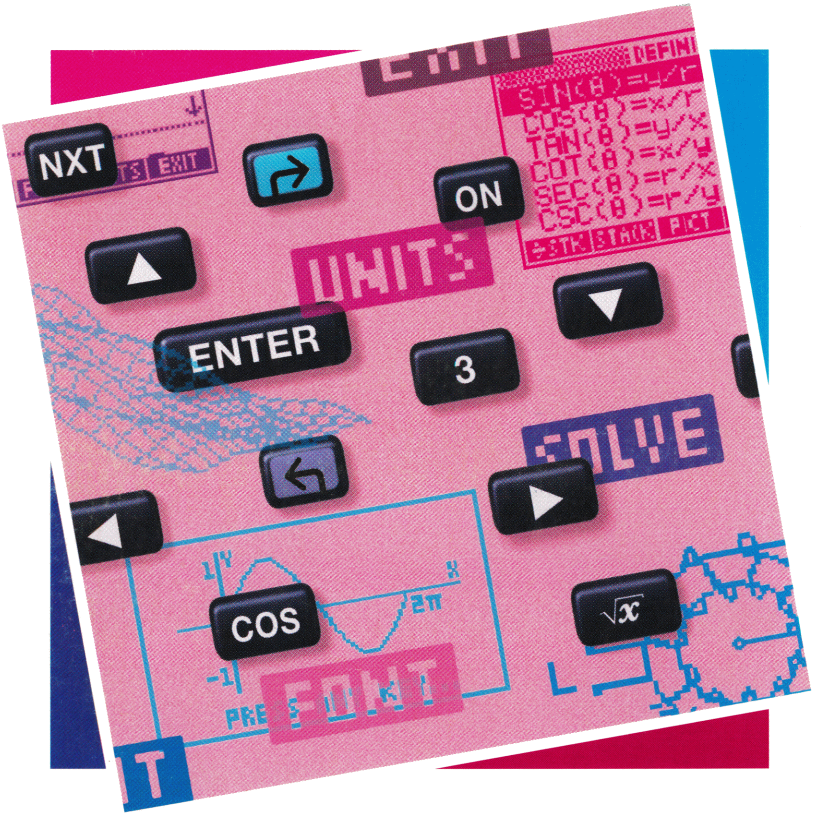
CalcWare™

Application Software for HP 48G Series Calculators



Physics Series

Optics, Waves & Relativity

PN 12057-1A

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Physics Series

Optics, Waves & Relativity

Serial Number: 15471015535

CalcWare™
User's Guide

SPARCOM CORPORATION

Physics Series

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PN 12057-1A

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Printing History

Edition 1 December 1994

Software Reorder No. 12057-1A

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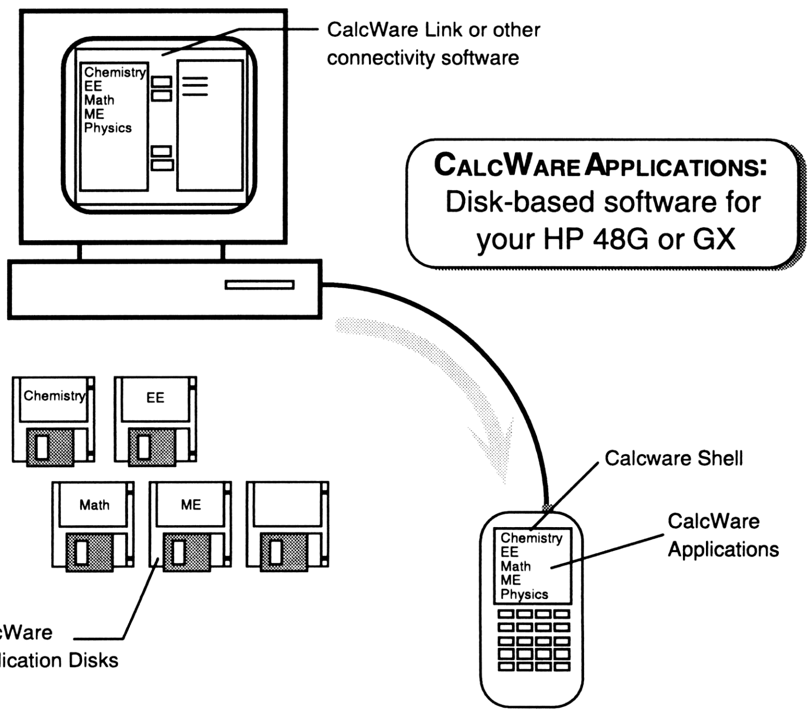
Introduction to CalcWare



1 Getting Started

This chapter covers:

- ❑ System Requirements
- ❑ Manual Conventions
- ❑ Copying CalcWare to your Computer
- ❑ Installing CalcWare onto your HP 48
- ❑ Using CalcWare
- ❑ Deleting CalcWare

System Requirements

Hardware

- Any computer that can run connectivity software and read PC-formatted disks:
  IBM PC or compatible
  Macintosh®

- HP 48G series calculator:
  HP 48G
  HP 48GX

- Serial interface cable

Software

- Any connectivity software:
  CalcWare Link
  HP 48 Serial Interface Kit
  Kermit

- Any CalcWare applications software:
  Chemistry Series
  Electrical Engineering Series
  Mathematics Series
  Mechanical Engineering Series
  Physics Series

- CalcWare shell software
  (included on any CalcWare applications disk)

NOTE	If your computer cannot read PC-formatted disks, contact Sparcom Corporation to inquire about alternate formats.

Manual Conventions

There are a few simple conventions used throughout this manual:

- Keys on the HP 48 keyboard are shown in a boxed typeface, e.g., ENTER.
- The green and purple key labels located above the keys on the HP 48 are also shown in a boxed typeface. For instance, the I/O command is a green label located above the 1 key, and is accessed by pressing the green shift key ↱ then the 1 key. These keystrokes are represented in the following manner: ↱ I/O.
- *Menu keys* are located at the bottom of the HP 48 screen and correspond directly to the top row of keys on the HP 48 keyboard. They are shown in inverse typeface, such as HOME.
- *Field names* are indicated in bold typeface, such as **Result**.
- All examples assume that pressing α α locks the alpha entry mode. If you have set the HP 48 system flag –60, press α instead of α α to lock Alpha entry mode.
- To the right of each heading is a *map* of the path taken to get to that particular application. Each indentation represents a subdirectory and the arrow points to the current application. For example, the Partial Fraction Expansion application is in the Algebraic Functions subdirectory of the Mathematics Series directory in the CalcWare shell.

Partial Fraction Expansion

Mathematics Series
Algebraic Functions
➤ ***Partial Fraction Expansion***

- There are three types of CalcWare applications. These are indicated by the following icons, which appear under the heading of each application:

Analysis Routines	Equation Sets	Reference Tables

- For each example, there is a listing of the mode settings required to obtain the indicated results. To change the modes, press ↱ MODES at any CalcWare screen.

modes

Example

Standard
Degrees
Rectangular

Copying CalcWare to your Computer

PC

1. Insert the CalcWare applications disk into the floppy drive.
2. If you are in Windows, bring up a DOS prompt.
3. At the DOS prompt, type: **`a:`**
   and press ENTER. (If your floppy drive is not **`a:`**, replace "a" with the correct drive letter.)
4. Type: **`install c:`**
   and press ENTER. (If your hard drive is not **`c:`**, replace "c" with the correct drive letter.)
5. When installation is complete, press any key. The CalcWare files will be in the directory **`c:\calcware`** on your hard disk.
6. *Optional*: Exit the DOS prompt and return to Windows.

NOTE	For convenience, the installation creates two exact copies of this CalcWare product on your hard drive: • A hierarchical version organized by topic in subdirectories (e.g., **`math`**) for downloading a few applications; and • A flat version with all the files in one directory (e.g., **`math.all`**) for downloading the entire series at once.

Macintosh

1. Insert the CalcWare applications disk into the floppy drive. If your Macintosh cannot read PC-formatted disks, contact Sparcom Corporation to inquire about alternate formats.
2. Drag the floppy disk icon onto your hard drive icon to continue. If you are using System 6, a dialog box will appear to confirm the operation—click **OK**. This will create a copy of the floppy disk on your hard drive.
3. When copying is complete, the CalcWare files will be in a folder on your hard drive of the same name as the floppy disk. (e.g., MATH1#2_0 or MATH2#2_0 for the Mathematics series.)
4. Rename the newly-created folder to **`calcware`**.
5. *Optional*: If you have multiple CalcWare products, you should combine duplicate folders inside **`calcware`** as necessary. (In DOS, the installation script does this automatically.)

Installing CalcWare onto your HP 48

The instructions below are general instructions for installing the CalcWare shell and applications onto your HP 48 from your computer. These instructions do not provide specific details for using your connectivity software on your computer because of the wide variety of communications packages available.

NOTE	Sparcom Corporation will provide customer support for registered users of CalcWare Link, which is Sparcom's connectivity software for the PC or Macintosh. We cannot provide customer support for any other connectivity software—instead, please refer to the manufacturer's documentation that accompanied the software.

To prepare for installation

HP 48:	Turn on the HP 48.
HP 48:	If necessary, press [CANCEL] to quit any software (such as CalcWare) and return to the HP 48 stack.
Computer:	Start the connectivity software.
Both:	Attach the serial cable to the HP 48 and the computer.

To install the CalcWare shell onto the HP 48

HP 48:	If necessary, press [→] [HOME] to go to the HOME directory of the HP 48.
HP 48:	Press [→] [►] to put the HP 48 into server mode.
Computer:	Change to the `calcware` directory on your hard drive and download the files `setupcw` and `cw.lib` to the HP 48.
HP 48:	When the transfer is complete, press [CANCEL] to exit server mode.
HP 48:	Press [VAR] to display the HP 48 user memory and then SETUP to install the CalcWare shell. (You may need to press [NXT] until SETUP appears in the menu).
HP 48:	When the installation is complete, the HP 48 will turn off. Press [ON] to turn it back on.

NOTE	The HP 48 screen may blink or shift briefly to one side when it is turned on—this is normal.

To install CalcWare applications onto the HP 48

HP 48:	If necessary, press [↱] [HOME] to go to the HOME directory of the HP 48.
HP 48:	Press [↱] [▶] to put the HP 48 into server mode.
Computer:	Change to the subdirectory under `calcware` which contains the desired CalcWare application files and download them to the HP 48. (To determine exactly which files to send, see the diagram at the beginning of the relevant chapter in this manual.)
HP 48:	When the transfer is complete, press [CANCEL] to exit server mode.
HP 48:	Press [↱] [LIBRARY] to display the library menu and then CWAR CW to start CalcWare. All of the CalcWare applications you just downloaded will be installed automatically.

> **NOTE** When you enter the first CalcWare application screen for this product, you will be requested to enter the serial number that appears on the inside front cover of this manual.

To install all CalcWare applications at once

If you have an HP 48GX, you may wish to take advantage of the `.all` directory (e.g., `math.all`) and download all of the CalcWare applications at once. If you have an HP 48G, you will not have enough free memory to do this.

HP 48:	If necessary, press [↱] [HOME] to go to the HOME directory of the HP 48.
HP 48:	Press [↱] [▶] to put the HP 48 into server mode.
Computer:	Change to the `.all` subdirectory (e.g., `math.all`) under `calcware` for the desired series. Download all the CalcWare applications to the HP 48.
HP 48:	When the transfer is complete, press [CANCEL] to exit server mode.
HP 48:	Press [↱] [LIBRARY] to display the library menu and then CWAR CW to start CalcWare. The CalcWare series you just downloaded will be installed automatically.

Using CalcWare

To start CalcWare

1. Press [↱] [LIBRARY] to display the library menu.
2. Press CWAR then CW to start CalcWare, or type [α] [α] CW [ENTER].

NOTE	At any point, you can exit CalcWare and return to the HP 48 stack by pressing [CANCEL] (the [ON] key). You may need to press [CANCEL] more than once.

To move around in CalcWare

The HP 48 arrow keys are your navigation tools for accessing every part of CalcWare. The right arrow [►] takes you to the next screen. The left arrow [◄] takes you to the previous screen. When you have gone as far as you can go in one path with [►], you can return back with [◄]. For example:

[►] Mathematics
    [►] Tutorial
        [►] Trigonometric Functions

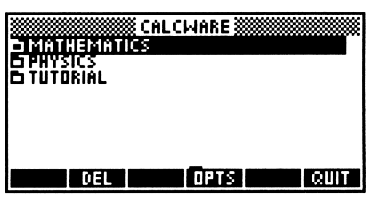
To return back, press:

        [◄] Tutorial
    [◄] Mathematics
[◄] Home Screen

You can also press [↱] [HOME] to return directly to the home screen. The up arrow [▲] and down arrow [▼] allow you to move the highlight bar from one line to another, selecting a new topic or a new field.

To use the home screen

The home screen appears when you start CalcWare for the first time or when you press [↱] [HOME] from any CalcWare screen. It lists the CalcWare series that are currently installed in your HP 48. To select a series, move the highlight bar to the desired series and press [ENTER] or [►].



NOTE	To move back to a previous screen at any time, press [◄] or **UP** or [⬅] [UP]. To return to the home screen at any time, press [➡] [HOME].

DEL Deletes the selected item from the HP 48 user memory. To reinstall the item, download it from the computer again. Refer to "To install CalcWare applications onto the HP 48," page 15.

OPTS Displays the Options menu. Refer to "To use the Options menu," see below.

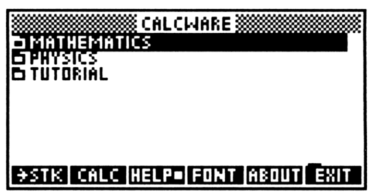
QUIT Exits CalcWare and returns to the HP 48 stack.

At screens other than the home screen, an additional menu key may appear:

UP Goes to the previous screen (the same as pressing [◄] or [⬅] [UP]).

To use the Options menu

The Options menu provides useful utilities and helps you customize settings for CalcWare. These settings apply to CalcWare only, not to the HP 48 stack. To access the Options menu, press **OPTS**. This will display the following menu keys:



→STK Copies the highlighted item to the HP 48 stack without leaving CalcWare.

CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. *For edit fields only*: When you have finished editing the item at the stack, press **OK** to leave the stack and insert the edited item into the current edit field, or press **CANCL** to leave the stack without changing the value of the current edit field. *For all other fields and for reference tables*: Edits made at the stack will not affect the value in the field. Press **EXIT** to leave the stack and return to CalcWare.

HELP Toggles display of help text on the bottom of the screen. When the box inside the key appears (**HELP▪**), help is turned on. Some screens do not have help text.

FONT Toggles font size between large and small. The small font displays information in a proportional, uppercase font. The large font displays information in a monospaced, case-sensitive font.

ABOUT Displays product information and the current version of the active CalcWare application.

EXIT Leaves the Options menu and returns to the regular menu.

To use the Calculator Modes screen

All the examples in this manual list the mode settings required to obtain the indicated results:

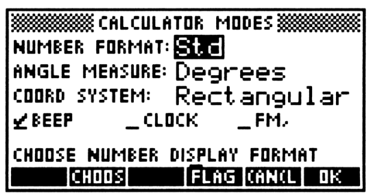
modes

Example

Standard
Degrees
Rectangular

To change the modes on the HP 48, press ⮫ MODES to display the HP 48 Calculator Modes screen. This screen sets the default settings for both CalcWare and the HP 48. Once you exit CalcWare, these settings will remain in effect. The Calculator Modes screen is available throughout CalcWare.

To change any of the settings at the Calculator Modes screen, use the arrow keys to select the desired item and press CHOOS or +/- to step through the choices. When you are finished changing the settings, press OK or ENTER to save the changes. To exit the screen without changing the settings, press CANCL or CANCEL.



NUMBER FORMAT: Press CHOOS or +/- to select Standard, Fixed, Scientific or Engineering. If applicable, enter the desired number of decimal places.

ANGLE MEASURE: Press CHOOS or +/- to select Degrees, Radians, or Grads. This setting determines how angular functions interpret angular inputs and what angle measure is used to display angular outputs.

COORD SYSTEM: (*Coordinate System*) Press CHOOS or +/- to select rectangular, polar or spherical. This setting determines whether complex numbers are displayed as (x,y) or (r,∡θ), and how vector functions interpret inputs and which coordinate system is used to display vector outputs.

From this screen you can also enable the standard beep, display a ticking clock, and change the fraction mark (**FM**) from "." to "," or vice versa. To change any other HP 48 system flags, press FLAG. Refer to the HP 48G Series User's Guide.

Deleting CalcWare

CalcWare is customizable, allowing you to load into your HP 48 just the applications that you need at any given time. Once you are finished with an application, you can easily delete it from your HP 48 user memory to make room for another application. You can also delete the CalcWare shell and all CalcWare applications to free a significant amount of user memory in your HP 48.

To delete a CalcWare application

1. Use the ◄ and ► keys to move to the screen listing the application you wish to delete.
2. Use the ▼ and ▲ keys to select the name of the application you wish to delete.
3. Once the correct application has been selected, press DEL to delete it.

CAUTION	DEL will immediately delete the selected item from your HP 48 user memory. To reinstsall the item, download it from the computer again.

You can delete the following items with DEL:

- A single application, such as Trigonometric Functions
- A group of applications, such as Trigonometry
- An entire series, such as Mathematics

To delete the CalcWare shell and all applications

1. Go to the HP 48 stack. (If you are currently in CalcWare, press CANCEL to exit and return to the stack.)
2. Press ↱ LIBRARY to display the library menu.
3. Press CWAR then DELET to delete CalcWare.

CAUTION	DELET will delete the CalcWare shell and all applications from your HP 48 user memory. The HP 48 screen may blink or shift briefly to one side. This is normal.

4. To reinstall CalcWare, refer to "Installing CalcWare onto your HP 48," page 14.

2 Analysis Routines

This chapter covers:

- ❑ Using an Analysis Routine
- ❑ Example: Trigonometric Functions
- ❑ Descriptions of Analysis Menu Keys

There are three types of CalcWare applications; the first is an *analysis routine*. Analysis routines perform some type of automated calculation and have fields for entering data, choosing inputs, and displaying results.

Using an Analysis Routine

1. Use the arrow keys to navigate to the desired analysis routine screen.
2. Enter values for all *edit* fields and select values for all *choose* fields.
3. Press SOLVE to calculate the results of the analysis, which will be displayed in *result* fields.
4. *Optional*: Press →STK to copy the selected item to the stack for use in further calculations. The item will remain on the stack when you exit CalcWare.
5. When finished, press ◄ or ↰ UP to return to the previous screen or press ↱ HOME to return to the home screen.

Example: Trigonometric Functions

Standard
Degrees
Rectangular

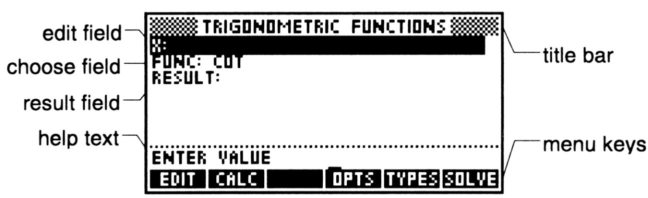
What is the secant of 45°?

This problem can be solved using the Trigonometric Functions analysis routine. To install this application, follow the instructions on page 15, "To install CalcWare applications onto the HP 48," and download the following file:

Computer File Structure		**HP 48 CalcWare Structure**
c:\		
calcware		
tutorial		Tutorial
tutrgfnc.anl	→	Trigonometric Functions

Once the application has been downloaded, if you are not already in CalcWare, press ⮫ LIBRARY CWAR CW to start CalcWare. Then enter the Trigonometric Functions screen by pressing these keys:

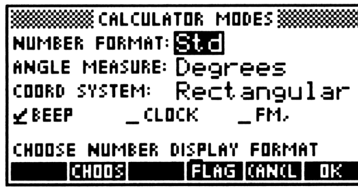
⮫ HOME Home screen
► Tutorial
► Trigonometric Functions



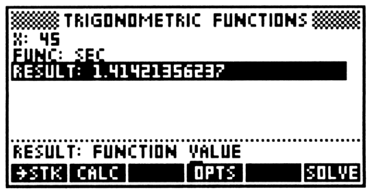
NOTE	When you enter the first CalcWare application screen for this product, you must enter the serial number that appears on the inside front cover of this manual.

Now that the Trigonometric Functions analysis routine has been installed and is running, the problem can be solved:

1. Set the modes (*if necessary*):
   a. Press [→] [MODES] to go to the Calculator Modes screen.
   b. Set the modes as listed in the Example heading above:
      NUMBER FORMAT: Standard
      ANGLE MEASURE: Degrees
      COORD SYSTEM: Rectangular
      BEEP, CLOCK, FM: Your choice



   c. Once the modes are set, press [OK] or [ENTER] to save the mode settings and exit the Calculator Modes screen.
2. Move the highlight bar to the **X** field (an edit field), type 45 and press [ENTER].[1]



3. At the **Func** field (a choose field), press [CHOOS] or [ENTER] to display the choices for the field. Move the highlight bar down to SEC and press [OK] or [ENTER]. Or, you can just press [+/-] at the **Func** field to step through the choices.
4. Press [SOLVE] to calculate **Result,**[2] which is 1.41421356237.
5. *Optional*: At the **Result** field, press [→STK] to copy the result to the stack for use in further calculations, once you exit CalcWare.
6. When finished, press [◄] or [←] [UP] to return to the previous screen (in this case, Tutorial) or press [→] [HOME] to return to the home screen.

---

[1] If the value must be entered in specific units, or if there are special conditions or limits on the input, that information will appear in the help text.

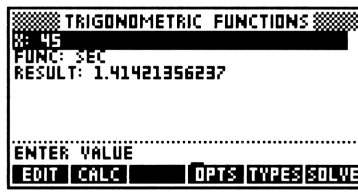
[2] Some analysis routines have too many result fields to display on the input screen; in such cases, a separate output screen is displayed with all the result fields.

Analysis Menu Keys

The menu keys in analysis routine screens change depending on the type of field that is highlighted. Analysis routine screens use three basic types of fields: edit fields, choose fields, and result fields. These fields and their associated menu keys are described below. The **OPTS** and **SOLVE** menu keys are always present, regardless of the field type.

Edit fields

These fields accept values entered from the keyboard. In the example, **X** is an edit field.



EDIT Edits the highlighted item. Press **OK** to save editing changes or **CANCL** to cancel editing.

CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. When you have finished editing the item at the stack, press **OK** to leave the stack and insert the edited item into the current edit field, or press **CANCL** to leave the stack without changing the value of the current edit field.

OPTS Displays the Options menu. Refer to "To use the Options menu," page 17.

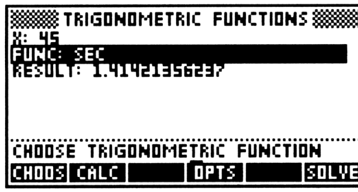
TYPES Displays the allowed object types, such as real number, list, real array, algebraic, etc. (see the table below). Move the highlight bar to the desired input type and press **NEW** to enter a new item of that type, with the appropriate delimiters. Or press **OK** to return to the analysis screen without entering a new item.

To enter a	Such as	Type these keys
Real number	10	1 0
Complex number	(1,2)	[←] [( )] 1 [←] [,] 2
Name	X	[α] X
List	{ 2 2 3 }	[←] [{ }] 2 [SPC] 2 [SPC] 3
Real array	[1 2 3]	[←] [[ ]] 1 [SPC] 2 [SPC] 3
Complex array	[(1,2) (3,2)]	[←] [[ ]] [←] [( )] 1 [←] [,] 2 [►] [←] [( )] 3 [←] [,] 2
Algebraic	'SIN(X)'	['] [SIN] [α] X
Binary integer	#123d	[→] [#] 1 2 3 [α] [←] d

SOLVE Performs a calculation using the entered values. The results are displayed in the result fields. If there are too many result fields to fit on the screen, they will be displayed in a separate result screen.

Choose fields

These fields only accept values from a predefined list that is accessed by pressing **CHOOS**. In the example, **Func** is a choose field.



CHOOS Displays the available choices for a choose field. Scroll through the list of choices by pressing ▲ and ▼ until the desired item is highlighted and press **OK** or ENTER, or press **CANCL** to abort the selection.

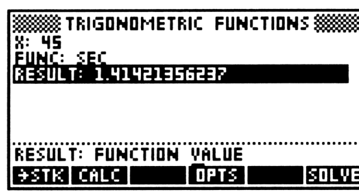
CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. Edits made at the stack will not affect the value in a choose field. Press **EXIT** to leave the stack and return to CalcWare.

OPTS Displays the Options menu. See “To use the Options menu,” page 17.

SOLVE Performs a calculation using the entered values. The results are displayed in the result fields. If there are too many result fields to fit on the screen, they will be displayed in a separate result screen.

Result fields

These fields display the results of a calculation. In the example, **Result** is a result field.



→STK Copies the highlighted item to the HP 48 stack.

CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. Edits made at the stack will not affect the value in a result field. Press **EXIT** to leave the stack and return to CalcWare.

OPTS Displays the Options menu. See “To use the Options menu,” page 17.

SOLVE Performs a calculation using the entered values. The result is displayed in the result fields. If there are too many result fields to fit on the screen, they will be displayed in a separate result screen.

EXIT *(Result screens only)* This key appears when there are too many result fields to fit on the input screen and a separate result screen is needed. **EXIT** returns to the input screen.

NOTE	Pressing ↱ HOME will not work at a result screen. To return to the home screen from a result screen, first press **EXIT** to return to the input screen, then press ↱ HOME.

3 Equation Sets

This chapter covers:

- ❑ Using an Equation Set
- ❑ Example: Right Triangles
- ❑ Overview of Equation Set Screens
- ❑ Equations Screen
- ❑ Solver Screen
- ❑ HP 48 PLOT Application Screen

A second type of CalcWare application is an *equation set*. Equation sets are lists of common related textbook equations which can be solved for unknown variables or plotted. Enter values of known variables and CalcWare will solve either for a specific variable or for all unknown variables. Calcware also provides a link to the HP 48 PLOT application for plotting equations.

Using an Equation Set

1. Use the arrow keys to navigate to the desired equation set screen.
2. Press SOLVR to enter the Solver screen.
3. Enter values for all known variables.
4. Press SOLVE to solve for all unknown variables, or move the highlight bar to an unknown variable and press SOLV1 to solve for that particular unknown variable.
5. When finished, press ◄ or ← UP to return to the previous screen or press → HOME to return to the home screen.

Example: Right Triangle

Standard
Degrees
Rectangular

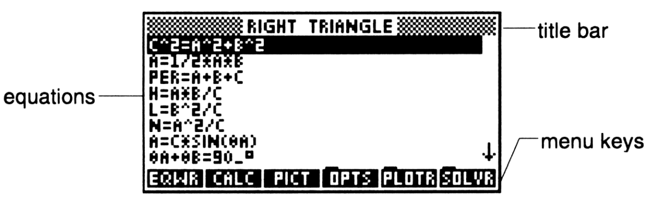
Given that one side of a right triangle measures 5 cm and that the angle opposite that side measures 30 degrees, find the length of the other two sides, the other angle (besides the right angle), the area, and the perimeter of the triangle.

This problem can solved using the Right Triangles equation set. To download this application, follow the instructions on page 15, "To install CalcWare applications onto the HP 48," and download the following file:

Computer File Structure		**HP 48 CalcWare Structure**
c:\		
calcware		
tutorial		Tutorial
turtetri.eqn	→	Right Triangle

Once the application has been downloaded, if you are not already in CalcWare, press ↱ LIBRARY CWAR CW to start CalcWare. Then enter the Right Triangle Equations screen by pressing these keys:

↱ HOME Home screen
 ► Tutorial
  ► Right Triangle



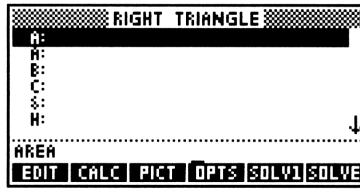
Right Triangle Equations screen

NOTE	When you enter the first CalcWare application screen for this product, you must enter the serial number that appears on the inside front cover of this manual.

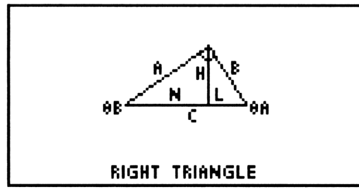
Now that the Right Triangles equation set has been installed and is running, the problem can be solved and plotted:

Solve the equation set

1. At the Equations screen, press **SOLVR** to go to the Solver screen.
2. Reset all the variable values by pressing NXT **RESET** **OK**, then NXT to return to the menu shown.
3. Display the picture by pressing **PICT**. One side is known to be 5 cm and the angle opposite that side is known to be 30°. From the picture, it is apparent that the known side and angle are **a** and θ**a**, or **b** and θ**b**—it makes no difference. Press any key to return to the Solver screen.

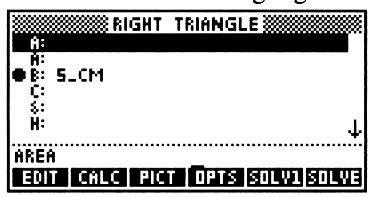


Solver screen



Right triangle picture

4. Enter the values for the known variables **b** and θ**b**. Move the highlight bar to the appropriate variable name, type in the value, then select the units by pressing the indicated menu key:
   Side b: Type 5 and press **CM**
   Angle b: Type 30 and press **°**
   The entered variables are marked as known by ●.



Known variables

5. Press **SOLVE**. The Solver solves for each unknown variable in turn.
6. To view the found variable values at the Solver screen, scroll through the variables list by pressing ▲ and ▼. The found variables are those for which values were calculated and are marked by ⊙. The known variable which were used to solve for the unknowns are now marked by **O**.

Found variables

7. To change the units of a found variable (e.g., to view θ**a** in degrees rather than radians), move the highlight bar to the appropriate variable, press NXT **CONV**, and select the appropriate unit by pressing **°**. The variable will be updated to the converted value and selected units.

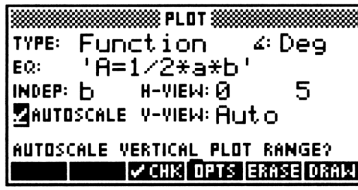
Converted units

8. The results can now be viewed by scrolling through the variable list by by pressing ▲ and ▼. Inspection shows **a** = 8.66 cm, **c** = 10 cm, θ**a** = 60°, **A** = 21.65 cm^2, and **per** = 23.66 cm.

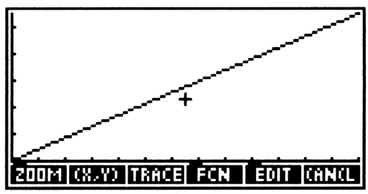
Plot one equation

To plot the variation of the area **A** with respect to the side length **b**, for constant side length **a**:

1. Press EQNS to go to the Equations screen. Press NXT to display EQNS, if necessary.
2. Highlight the A=1/2*a*b equation.
3. Press PLOTR to go to the HP 48 PLOT Application screen.
4. Enter b (α ← B OK) for the independent variable.
5. Enter 0 to 5 for **H-VIEW**.
6. Highlight the **AUTOSCALE** check field for **V-VIEW** and press ✓CHK.
7. Press ERASE to erase any previous plots.
8. Press DRAW to draw the plot. The plot shows the linear relationship between the length of side **b** and the area **A** of the triangle when side **a** is held constant.
9. When finished, press CANCEL CANCEL or CANCL CANCEL to exit the HP 48 PLOT Application and return to the Equations screen.



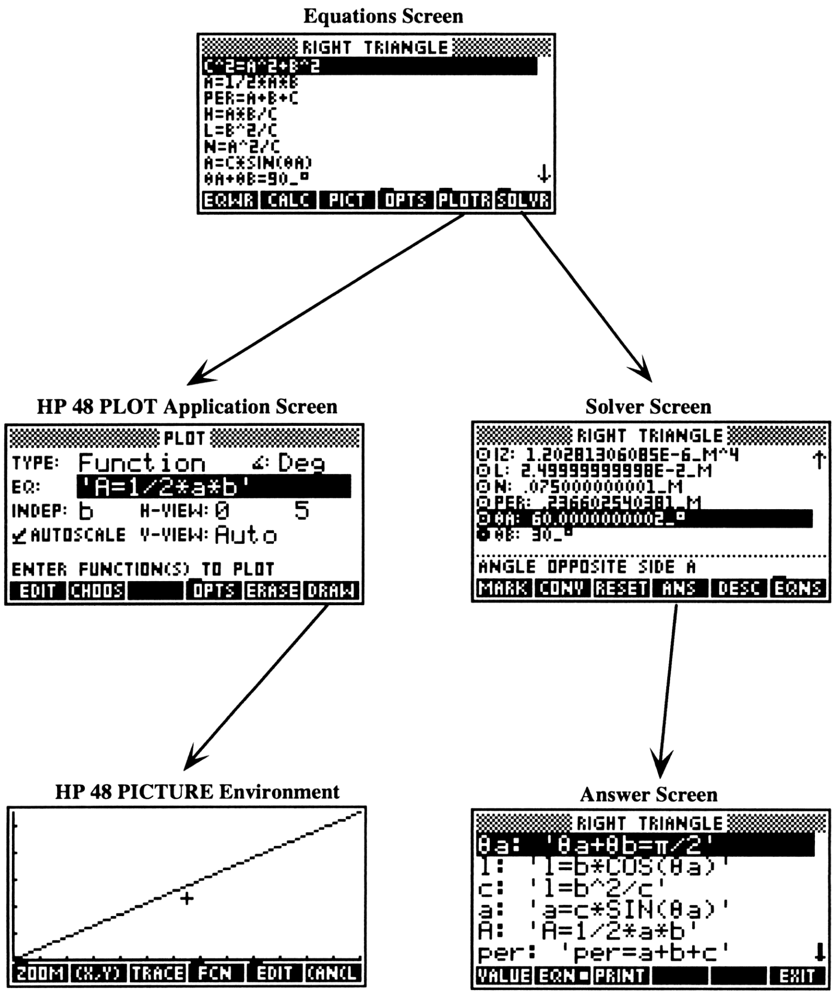
HP 48 PLOT Application screen



Plot of A=1/2*a*b

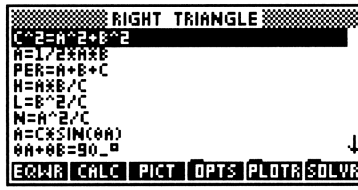
Overview of Equation Set Screens

There are three main screens in equation sets for viewing, solving, and plotting. The Equations screen displays a group of related equations, which can be viewed in the HP 48 EquationWriter or copied to the stack. The Solver screen allows for the entering and converting of values, then solving for unknowns. The Plotter screen displays the HP 48 PLOT application which plots the selected equation. The relationship of these screens and several additional screens are indicated in the following diagram.



Equations Screen

The Equations screen is the first screen seen when an equation set is entered. Equation screens display a list of related equations which can be graphically viewed or selected for solving. The screen to the right is the Equations screen for Right Triangles.

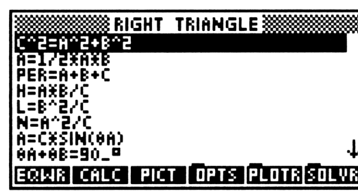


Right Triangle Equations screen

The Equations screen plays a central role in the CalcWare equation set application environment. From the Equations screen both the Solver screen and the HP 48 PLOT application are accessible. To enter the Solver from the Equations screen, press SOLVR; to return to the Equations screen, press EQNS. Similarly, the HP 48 PLOT application may be entered from the Equations screen by pressing PLOTR; to return to the CalcWare Equations screen press [CANCEL], or press [NXT], then CANCL or OK. Note that the Solver is not directly accessible from the HP 48 PLOT application, nor vice versa.

Equations menu keys

These are descriptions of the menu keys available at the Equations screen:



Right Triangle Equations screen

EQWR Displays the highlighted equation in the HP 48 EquationWriter. Refer to “Viewing equations,” page 31.

CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. Edits made at the stack will not affect the equation in the Equations screen. Press EXIT to leave the stack and return to CalcWare.

PICT *(if available)* Displays a picture. This menu key will not appear for equation sets which do not have a picture. Refer to “Displaying a picture,” page 31.

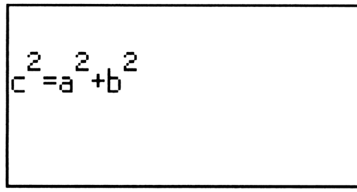
OPTS Displays the Options menu. Refer to “To use the Options menu,” page 17.

PLOTR Goes to the HP 48 PLOT application. Refer to “HP 48 PLOT Application Screen,” page 37.

SOLVR Goes to the Solver screen. Refer to “Solver Screen,” page 31.

Viewing equations

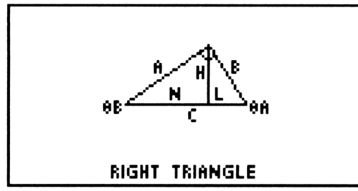
To display an equation in a graphics view using the HP 48 EquationWriter, move the highlight bar to the desired equation and press **EQWR**. Press [CANCEL] [CANCEL] to return to the Equations screen.



Right Triangle EquationWriter screen

Displaying a picture

Most equation sets have a diagram to illustrate the relationship of the variables. To display the diagram for the current equation set, press **PICT**. This menu key appears in both the Equations and Solver screens when available. Press any key to return to the previous screen.



Right Triangle Picture screen

NOTE	The sides of the right triangle shown above are represented by lowercase letters in the equation set, but appear as uppercase letters in the Picture screen. Variable names in pictures are always displayed in the uppercase small font, regardless of their case in the equations.

Solver Screen

The Solver screen allows for the input of values for each variable in the equation set. Variables can also be edited, copied to the stack, or converted to different units. Once the known variable values have been entered, the user can have the Solver solve for a single unknown variable, or for all unknown variables in the equation set. When the equation set is solved, any unknown variables which can be found are solved for, while the unknown variables which *cannot* be found from the information given are left blank. The Solver screen is accessible from the Equations screen by pressing **SOLVR**.

Comments about the Solver

If an equation has multiple roots, the Solver will only find the first one it encounters, although you can direct its search by entering a guess near the expected result. To use a guess, enter a value for the desired variable near the expected result, and then press MARK to make sure the variable is *not* marked as known. The solver will use the current value of the variable as the starting point of its search.

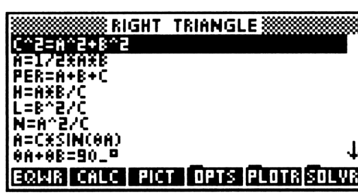
The Solver can handle only real numbers or unit objects as inputs or results; complex numbers can only be used in analysis routines. If an equation has only complex roots, the Solver will probably halt at an extremum and return an incorrect real result. This is commonly indicated by the message, "Extremum," which appears during solving.

In general, apply common sense when interpreting any result returned by the Solver. When examining an important result, ask yourself: "Does this answer make physical sense?" If the Solver has come up with a negative area or an angle of 9000°, it has probably found a non-principal solution to the equation and needs assistance with a guess.

For more information, refer to the Equation Sets section of the Troubleshooting chapter.

Solving an equation

Below are general instructions for using Solver screens. For a detailed example using Right Triangles, see page 26.



Right Triangle Solver screen

1. Go to the Solver screen by pressing SOLVR from the Equations screen.
2. Enter the known values:
   a. Move the highlight bar to the desired variable.
   b. Type in the value for the variable and press a unit menu key, or press ENTER to accept the default SI unit, which is always listed as the first menu key. The variable is now known and marked by ●.
3. Solve for unknown variables:
   - One variable: To solve for one variable, move the highlight bar to the desired unknown variable and press SOLV1.
   - All variables: To solve for all the unknown variables press SOLVE.

4. The found variables are indicated by ⊙, and the known variables which were used to find them are indicated by **O**. Refer to "Solver icons," page 34.
5. *Optional*: To see which equations were used to solve for the found variables, go to the Answer screen by pressing NXT **ANS**. Then press **EQNS** to display the equations used. Refer to "Answer screens," page 36. When you are finished, press **EXIT** to return to the Solver screen,
6. *Optional*: Press ◄ to return to the previous screen or press ➦ HOME to return to the home screen.

Changing the value of a variable

To *edit* the existing value of a variable:

1. Move the highlight bar to the desired variable and press ENTER or **EDIT** to place it on the edit line.
2. Edit the value.
3. After you have finished editing the value, press a unit menu key (or ENTER to accept the default SI unit) to change the value or CANCEL to cancel the change.

To *replace* the value of a variable:

1. Move the highlight bar to the variable.
2. Type in the new value.
3. Press ENTER or a unit menu key to complete the entry.

Any time you edit or change a value, that variable becomes known, and indicated by ●. Refer to "Solver icons," page 34.

Resetting variables

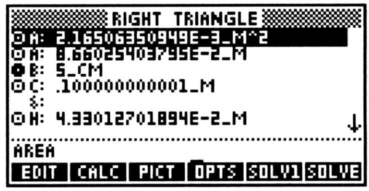
To reset the values of variables, press NXT **RESET**. This will clear the values of all variables at the Solver screen and purge the variables from user memory.

Converting a value

Once a variable value has been entered or solved for, it can easily be converted to different units. To do this, highlight the desired variable and press **CONV**. The value is placed on the edit line and the units available for the highlighted variable are displayed as menu keys (press NXT for more units, if appropriate). Press a unit menu key to convert the value to the new unit, or press CANCEL to cancel the conversion.

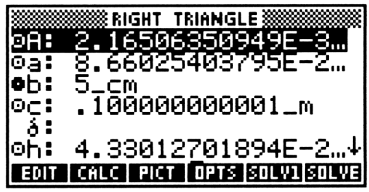
Changing the font size

The small font shows variables only in uppercase, which makes it difficult to distinguish between an **a** and an **A**. However, it does allow more data to be displayed on the screen, making it easier to see your results. To change the font:



Small font, help text on

1. Press OPTS FONT to switch to the larger font, which is case-sensitive. Also, pressing HELP to turn help text off provides more room on the screen so that more of the variables can be displayed at once.
2. Press EXIT to leave the Options menu and return to the Solver screen.



Large font, help text off

Solver icons

There are several different symbols or icons used to identify different kinds of variables.

● **Known Variables**

A solid circle (●) indicates that a variable is known. The values of known variables are never changed by the Solver, because those variables are considered user-defined. Every time you enter a value for a variable, the variable is automatically marked as known. To remove the known icon from a variable, move the highlight bar to the variable and press MARK (if necessary press NXT first) and the solid circle will disappear, which means the variable is unknown.

⊙ **Found Variable**

A circle with a dot in the middle (⊙) indicates that a solution was found for the variable by the Solver during the most recent solve operation.

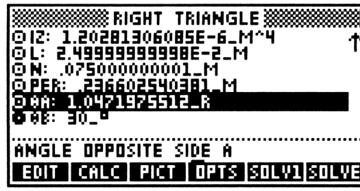
O **Used Variable**

A black circle with a white dot in the middle (**O**) indicates that this known variable was used by the Solver in finding answers for the found variables during the most recent solve operation.

Solver screen menu keys

These are descriptions of the menu keys available at the Solver screen:

EDIT Edits the highlighted variable. Press ENTER to save edit changes or CANCEL to cancel editing.



CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. When you have finished editing the item at the stack, press **OK** to leave the stack and insert the edited item into the current edit field, or press **CANCL** to leave the stack without changing the value of the current edit field.

PICT *(if available)* Displays a picture. This menu key will not appear for equation sets which do not have a picture.

OPTS Displays the Options menu. Refer to "To use the Options menu," page 17.

SOLV1 Solves for the *highlighted variable only* using the known variables. Refer to "Solving an equation," page 32.

SOLVE Solves for all the unknown variables using the known variables. Refer to "Solving an equation," page 32.

Press NXT for the following menu keys:

MARK Marks or unmarks the highlighted variable as known. Refer to "Known Variables," page 34.

CONV Converts the value of the highlighted variable to a different unit. Refer to "Converting a value," page 33.

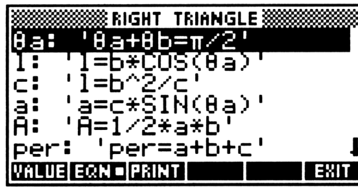
RESET Resets all of the variables. Refer to "Resetting variables," page 33.

ANS Goes to the Answer screen. Refer to "Answer screens," page 36.

EQNS Goes to the Equations screen. Refer to "Equations Screen," page 30.

Answer screens

After the Solver finishes solving for the unknown variables, the equations used for solving may be viewed in the Answer screen. To enter the Answer screen from the Equations screen, press **ANS**. Only the found variables are displayed at the Answer screen, initially with their numerical values. To view the equations used to find each variable, press **EQNS**.When you are finished, press **EXIT** to return to the Solver screen.



Answer screen menu keys

These are descriptions of the menu keys available at the Answer screen:

VALUE Displays the numerical values of the found variables. When the values are displayed, the menu key is **VALU▪**.

EQNS Displays the equations which the Solver used to compute the found variable values from the known variables. When the equations are displayed, the menu key is **EQN▪**.

PRINT Prints the Answer screen via the IR or the serial port. Refer to the HP 48G Series User's Guide.

EXIT Returns to the Solver screen.

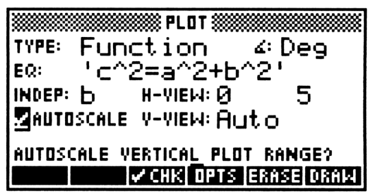
HP 48 PLOT Application Screen

The HP 48 PLOT application screen enables you to plot any of the equations listed in the Equations screen. A variety of plot parameters can be specified. The HP 48 PICTURE environment is used to display the plots.

Below are general instructions for using the HP 48 PLOT Application. For a detailed example using Right Triangles, see page 26.

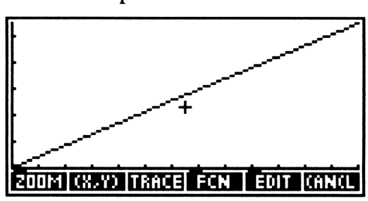
Plotting an equation

1. Set the values of any extra variables at the Solver screen. Only the independent and dependent variables will vary as the equation is plotted, so all other variables must have values.
   a. Press **SOLVR** to go to the Solver screen.
   b. Move the highlight bar to each of the extra variables in turn and enter values for them.
   c. Press **EQNS** to return to the Equations screen.
2. Highlight the desired equation and press **PLOTR** to go to the HP 48 PLOT application.
3. Move the highlight bar to the **INDEP** field and type in the independent variable.
4. Move the highlight bar to the **H-VIEW** field and enter values for the range of the horizontal axis in the plot.



HP 48 PLOT Application screen

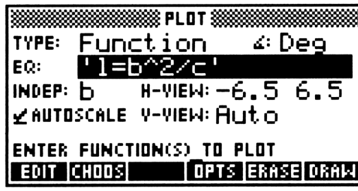
5. Set the vertical range or choose autoscale.
   - To set the vertical range: Move the highlight bar to the **V-VIEW** field and enter values for the range of the vertical axis in the plot.
   - To autoscale the plot: Move the highlight bar to the **AUTOSCALE** field and press **✓CHK**.
6. Press **ERASE** to erase any previous plots. You can overlay multiple plots by pressing **DRAW** more than once with different parameters without pressing **ERASE** between plots.
7. Press **DRAW** to plot the equation.
8. Press **CANCL** to return to the HP 48 PLOT application.
9. When finished, press [CANCEL] or [NXT] **CANCL** to exit the plot application and return to the Equations screen.



HP 48 PLOT Application DRAW screen

HP 48 PLOT Application fields

These are descriptions of each of the fields which appear in the HP 48 PLOT application. Refer to the HP 48G Series User's Guide.



TYPE: *(Plot type)* This field must always be set to Function.

∡: (*Angle measure*) Press CHOOS to select Degrees, Radians, or Grads.

EQ: (*Equation to plot*) This is the equation to be plotted.

INDEP: (*Independent variable*) Enter the independent variable, which varies across the horizontal axis.

H-VIEW: (*Horizontal range*) Enter the minimum and maximum values of the independent variable view, which is plotted along the horizontal axis.

V-VIEW: (*Vertical range*) Enter the minimum and maximum values of the dependent variable view, which is plotted along the vertical axis.

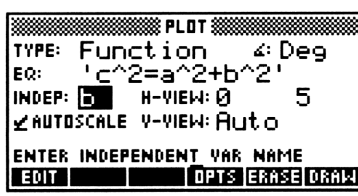
AUTOSCALE: (*Autoscale vertical axis*) Press ✓CHK to autoscale the plot. If autoscale is checked (✓), the values for **V-VIEW** are changed to Auto.

HP 48 PLOT Application menu keys

The menu keys in the PLOT Application screen change depending on the type of field that is highlighted. HP 48 PLOT Application screens use three basic types of fields: edit fields, choose fields, and check fields. These fields and their associated menu keys are outlined below. The OPTS, ERASE and DRAW menu keys are always present, regardless of the field type.

Edit Fields

These fields accept values entered from the keyboard. **INDEP**, **H-VIEW**, and **V-VIEW** are edit fields.



EDIT Edits the highlighted item. Press OK to save edit changes or CANCL to cancel editing.

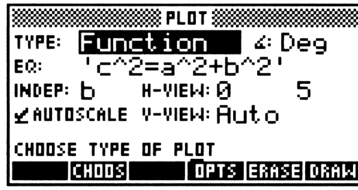
OPTS Displays the Plot Options screen. Refer to "Plot Options screen," page 40.

ERASE Erases any previous plots.

DRAW Plots the current equation.

Choose Fields

These fields only accept values from a pre-defined list that is accessed by pressing **CHOOS**. **TYPE** and ∡ are choose fields.



EDIT (*for* **EQ** *only*) Edits the highlighted item. Press **OK** to save edit changes or **CANCL** to cancel editing.

CHOOS Displays the possible choices for a choose field. Highlight the desired value and press ENTER or **OK**, or press **CANCL** to abort the selection.

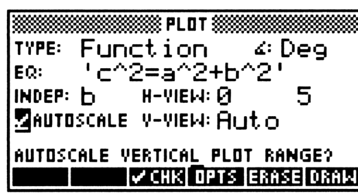
OPTS Displays the Plot Options screen. Refer to "Plot Options screen," page 40.

ERASE Erases any previous plots.

DRAW Plots the current equation. You can overlay multiple plots by pressing **DRAW** more than once with different parameters without pressing **ERASE** between plots.

Check Fields

These fields are toggle fields. A ✓ in front of the field turns that specific control on. **AUTOSCALE** is a check field.



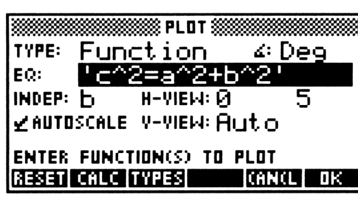
✓CHK Toggles a check mark.

OPTS Displays the Plot Options screen. Refer to "Plot Options screen," page 40.

ERASE Erases any previous plots.

DRAW Plots the current equation.

In all fields, press NXT for these menu keys:



RESET Resets the values for the plot parameters, or resets the plot.

CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. When you have finished editing the item at the stack, press **OK** to leave the stack and insert the edited item into the current edit field, or press **CANCL** to leave the stack without changing the value of the current edit field.

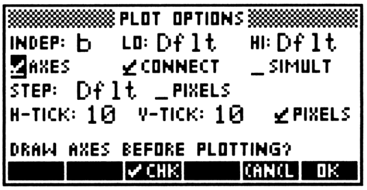
TYPES Displays the allowed object types, such as real number, list, real array, algebraic, etc. (see the table on page 23). Move the highlight bar to the desired input type and press **NEW** to enter a new item of that type, with the appropriate delimiters. Or press **OK** to return to the the PLOT application screen without entering a new item.

CANCL Returns to the previous screen *without* saving any parameter changes.

OK Saves any parameter changes and returns to the previous screen.

Plot Options screen

Additional plot parameters can be set in the Plot Options screen. These plot parameters should be left at their default settings when using CalcWare, with the exceptions noted below. To get to this screen, press **OPTS** at the Plotter screen. Refer to "Function Plots" in the HP 48G Series User's Guide.



AXES: (*Draw axes*) Press **✓CHK** to determine whether the coordinate axes are drawn with the plot. If **AXES** is checked (✓), the axes are drawn.

CONNECT: (*Connect plot points*) Press **✓CHK** to determine whether the plot points are connected by short line segments. If **CONNECT** is checked (✓), the points are connected.

STEP: (*Independent variable increments*) Enter the horizontal distance between plotted points, which determines the resolution of the plot.

PIXELS: (*"Step" units are pixels*) Determines whether the value in **STEP** is interpreted as pixels or units. If **PIXELS** is checked (✓), the **STEP** values are interpreted as pixels.

H-TICK: (*Horizontal tick spacing*) Enter the distance between tick marks on the horizontal axis.

V-TICK: (*Vertical tick spacing*) Enter the distance between tick marks on the vertical axis.

PIXELS: (*"Tick" units are pixels*) Press **✓CHK** to determine whether the values in **H-TICK** and **V-TICK** are interpreted as pixels or units. If **PIXELS** is checked (✓), the **TICK** values are interpreted as pixels.

4 Reference Tables

This chapter covers:

- ❑ Using a Reference Table
- ❑ Example: SI Prefixes
- ❑ Descriptions of Reference Menu Keys

A third type of CalcWare application is a *reference table*. Reference tables display information organized in the same manner as a printed reference book. The information may consist of data, equations, text, or a combination of these types. Some reference tables are more advanced and can perform calculations, much like analysis routines.

Using a Reference Table

1. Use the arrow keys to navigate to the desired reference table screen.
2. Choose parameters (*if appropriate*). Some reference tables have choose fields which control the specific data to be displayed, while other reference tables consist of only one table of data.
3. Locate the specific item of interest using the arrow keys. With some reference tables, you can press **DESC** to toggle the positions of the reference data and the help text, which may make it easier to find the desired item.
4. *Optional*: Press **→STK** to copy the selected item to the stack for use in further calculations. The item will remain on the stack when you exit CalcWare.
5. *Optional*: Press **CALC** [▼] to view the selected equation in the HP 48 EquationWriter; press [CANCEL] [CANCEL] to exit the EquationWriter to the HP 48 stack, then **EXIT** to return to CalcWare.
6. When finished, press [◄] or [↰] [UP] to return to the previous screen or press [↱] [HOME] to return to the home screen.

For more advanced reference tables which perform calculations, the basic steps are similar to those used in analysis routines, as described in "Using an Analysis Routine" page 20. Solving reference tables will always have a **SOLVE** menu key.

Example: SI Prefixes

Standard
Degrees
Rectangular

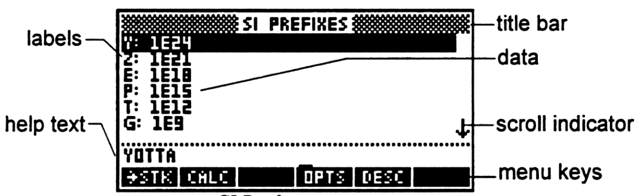
What is the SI prefix for a bigillion?

This problem can be solved using the SI Prefixes reference table. To install this application, follow the instructions on page 15, "To install CalcWare applications onto the HP 48," and download the following file:

Computer File Structure		**HP 48 CalcWare Structure**
c:\		
calcware		
tutorial		Tutorial
tusipref.ref	→	SI Prefixes

Once the application has been downloaded, if you are not already in CalcWare, press [→] [LIBRARY] CWAR CW to start CalcWare. Then enter the SI Prefixes screen pressing these keys:

[→] [HOME] Home screen
  [►] Tutorial
    [►] SI Prefixes



SI Prefixes screen

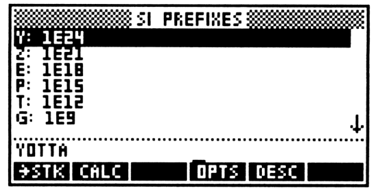
NOTE	When you enter the first CalcWare application screen for this product, you must enter the serial number that appears on the inside front cover of this manual.

Now that the SI Prefixes reference table has been installed and is running, the problem can be solved:

1. Scroll through the reference table by pressing [▲] and [▼].
2. Each line shows an SI prefix and the power of ten which it represents.
3. The full name of the highlighted prefix is shown in the help text.
4. To browse the prefixes by name instead of powers of ten, press DESC. Each line now shows the SI prefixes and the full name, while the help text displays the power of ten represented.
5. Careful inspection shows that Z (zetta) is the prefix for 10^{21} and Y (yotta) represents 10^{24}. Although these numbers are very large, they're not quite large enough. It can only be speculated that the standards committee ran out of capital letters before they got to a bigillion....

Reference Menu Keys

These are descriptions of the menu keys available at reference table screens:



→STK Copies the highlighted item to the HP 48 stack.

CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. Edits made at the stack will not affect the data in the reference table. Press **EXIT** to leave the stack and return to CalcWare.

PICT (*if available*) Displays a picture. This menu key will not appear for reference tables which do not have a picture.

OPTS Displays the Options menu. Refer to "To use the Options menu," page 17.

DESC (*if available*) Toggles positions of the reference data and the help text. This menu key will not appear for reference tables which do not contain switchable information.

SOLVE (*if available*) Performs a custom calculation using the data in the reference table. This menu key will not appear for reference tables which do not have a custom solving routine. The details of the calculation will be explained in the relevant chapter.

Part 2

Physics Series

Optics, Waves & Relativity

- Mathematics
  - Algebraic Functions
    - Taylor Polynomial
  - Coordinate Systems
    - XY $\leftrightarrow$ Polar
    - XYZ $\leftrightarrow$ Cylindrical
    - XYZ $\leftrightarrow$ Spherical
  - Hyperbolics
    - Hyperbolic Functions
  - Special Functions
    - Bessel Functions
    - Beta Function
    - Error Functions
    - Gamma Function
  - Trigonometry
    - Trigonometric Functions
  - Vectors
    - Vector Functions
    - Cross Products
    - Curl
    - Del Operator
    - Divergence
    - Dot Products
    - Gradient
    - Laplacian

- Physics
  - Astronomy
    - Solar System Data
  - Electromagnetic Waves
    - Electric and Magnetic Fields
    - Energy Flow
    - Polarization
    - Radiation Pressure
    - Maxwell's Equations
  - Optics
    - Brewster's Law
    - Circular Aperture Diffraction
    - Multiple-Slit Diffraction
    - Reflection and Refraction
    - Single-Slit Diffraction
    - Spherical Mirrors
    - Spherical Refraction
    - Thin Lenses
    - Two-Slit Interference
  - Oscillations
    - Mass-Spring System
    - Pendulum (Conical)
    - Pendulum (Simple)
    - Pendulum (Torsional)
    - Simple Harmonic Motion
    - Two-Body System
  - Quantum Mechanics
    - Angular Momentum and Spin
    - Bohr Model
    - de Broglie Wavelength
    - Photoelectric Effect
    - Photons
    - Uncertainty Principle
  - Special Relativity
    - Doppler Effect
    - Energy, Mass, and Momentum
    - Gallilean Transform
    - Length Contraction
    - Lorentz Transform
    - Time Dilation
  - Waves
    - Basics of Waves
    - Doppler Effect
    - Organ Pipes
    - Shock Waves
    - Sound Waves

5 Algebraic Functions

This chapter covers:
- ❑ Taylor Polynomial

To install Algebraic Functions

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing [→] [LIBRARY] CWAR CW and go to the Algebraic Functions screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 math		Mathematics
🗁 algebra		Algebraic Functions
🖹 taylorx.anl	→	Taylor Polynomial

Taylor Polynomial

Mathematics Series
Algebraic Functions
➢ ***Taylor Polynomial***

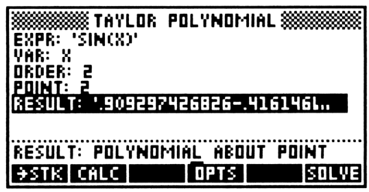
This application computes the *Taylor polynomial* of a function to the specified order about a given point.

Example

Standard
Radians
Rectangular

What is the 2nd-order Taylor polynomial of $\sin(x)$ about the point $x = 2$?

1. Enter 'SIN(X)' for **Expr** by typing ['] [SIN] [α] X [ENTER].
2. If necessary, enter X for **Var**.
3. Enter 2 for **Order** and 2 for **Point**. (Note: Press [→] [MODES] if you need to set the angle measure to radians.)
4. Press **SOLVE** to calculate **Result**.



This application extends the built-in HP 48 routine TAYLR to allow for expansion of the Taylor polynomial about *any* point. The built-in HP 48 routine actually does a Maclaurin series expansion about the point 0.

6 Coordinate Systems

This chapter covers:

- ❑ XY ↔ Polar
- ❑ XYZ ↔ Cylindrical
- ❑ XYZ ↔ Spherical

To install Coordinate Systems

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮣ LIBRARY CWAR CW and go to the Coordinate Systems screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 math		Mathematics
🗁 coord_sys		Coordinate Systems
🖹 xypolar.eqn	→	XY ↔ Polar
🖹 xyzcyln.eqn	→	XYZ ↔ Cylindrical
🖹 xyzsphr.eqn	→	XYZ ↔ Spherical

Variables

The table below lists all the variables used in this chapter, along with a brief description and the default SI unit.

Variable	Description	SI Unit
Ø	azimuthal angle	r
θ	polar angle	r
r	radial distance	unitless
x	abscissa	unitless
y	ordinate	unitless
z	z-axis distance	unitless

Example: XY ↔ Polar

Standard
Degrees
Rectangular

Example: What is the location of the Cartesian point (7,13) in polar coordinates?

Given: $x = 7$
$y = 13$

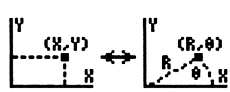
Results: $r = 14.76$
$\theta = 1.07\ r$
$= 61.7°$

XY ↔ Polar

Mathematics Series
Coordinate Systems
➢ *XY ↔ Polar*

Y =

These equations describe the relationship between Cartesian and polar coordinates in two dimensions. The first two equations define **x** and **y** coordinate values in terms of **r** and θ. The last two equations show the inverse relationship between **r**, θ and **x**, **y**. When solving for θ, an appropriate initial guess may help the solver find a solution in the desired quadrant.



$$x=r\cdot\cos(\theta) \qquad y=r\cdot\sin(\theta)$$

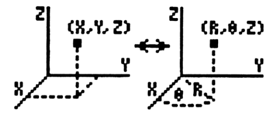
$$r=\sqrt{x^2+y^2} \qquad \theta=\mathrm{ASIN}\left(\frac{y}{r}\right)$$

XYZ ↔ Cylindrical

Mathematics Series
Coordinate Systems
➤ *XYZ ↔ Cylindrical*

Y =

These equations describe the relationship between Cartesian and cylindrical coordinates in three dimensions. The first three equations define the relationship between the Cartesian coordinates **x**, **y** and **z** and the cylindrical coordinates **r**, θ and **z**. The last two equations show the inverse relationship between **r**, θ and **x**, **y**. When solving for θ, an appropriate initial guess may help the solver find a solution in the desired quadrant.



$$x=r\cdot COS(\theta) \qquad y=r\cdot SIN(\theta) \qquad z=z$$

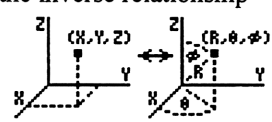
$$r=\sqrt{x^2+y^2} \qquad \theta=ASIN\left(\frac{y}{r}\right)$$

XYZ ↔ Spherical

Mathematics Series
Coordinate Systems
➤ *XYZ ↔ Spherical*

Y =

These equations describe the relationship between Cartesian and spherical coordinates. The first three equations show the relationship between the Cartesian coordinates **x**, **y** and **z** and the spherical coordinates **r**, θ and ϕ. The last three equations show the inverse relationship between **r**, θ and ϕ and **x**, **y** and **z**. When solving for θ or ϕ, an appropriate initial guess may help the solver find a solution in the desired quadrant.



$$x=r\cdot COS(\theta)\cdot SIN(\phi) \qquad y=r\cdot SIN(\theta)\cdot SIN(\phi) \qquad z=r\cdot COS(\phi)$$

$$r=\sqrt{x^2+y^2+z^2} \qquad \theta=ATAN\left(\frac{y}{x}\right) \qquad \phi=ACOS\left(\frac{z}{\sqrt{x^2+y^2+z^2}}\right)$$

7 Hyperbolics

This chapter covers:

❑ Hyperbolic Functions

To install Hyperbolics

1. Send the files marked with "🗎" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮫ LIBRARY CWAR CW and go to the Hyperbolics screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 math		Mathematics
🗁 hyperbol		Hyperbolics
🗎 hyprfunc.anl	→	Hyperbolic Functions

Hyperbolic Functions

This application covers the hyperbolic functions and their inverses:

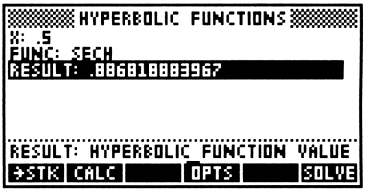
• SINH	• ASINH
• COSH	• ACOSH
• TANH	• ATANH
• COTH	• ACOTH
• SECH	• ASECH
• CSCH	• ACSCH

Example

Standard
Degrees
Rectangular

What is the hyperbolic secant of 0.5?

1. Enter 0.5 for **X**.
2. Choose SECH for **Func**.
3. Press SOLVE to calculate **Result**.



8 Special Functions

This chapter covers:

- ❑ Bessel Functions
- ❑ Beta Function
- ❑ Error Functions
- ❑ Gamma Function

To install Special Functions

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮡ LIBRARY CWAR CW and go to the Special Functions screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 math		Mathematics
🗁 spcl_fcn		Special Functions
🖹 bessel.anl	→	Bessel Functions
🖹 beta.anl	→	Beta Function
🖹 error.anl	→	Error Functions
🖹 gamma.anl	→	Gamma Function

Bessel Functions

Mathematics Series
Special Functions
➢ ***Bessel Functions***

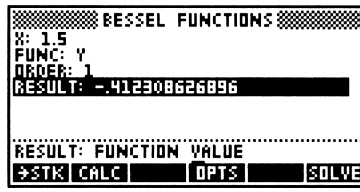
The Bessel functions application[3] computes the numerical values for the Bessel functions of the first and second kind, $J_n(X)$ and $Y_n(X)$.

Example

Standard
Degrees
Rectangular

What is the value of $Y_1(1.5)$?

1. Enter 1.5 for **X**.
2. Choose Y for **Func**.
3. Enter 1 for **Order**.
4. Press **SOLVE** to calculate **Result**, which is –.412308626896.



Beta Function

Mathematics Series
Special Functions
➢ ***Beta Function***

The beta function application computes the numerical value for a beta function of two real arguments. The definition of the beta function is:

$$\beta(x, y) = \int_0^1 t^{x-1}(1-t)^{y-1}\,dt \quad x > 0 \quad y > 0$$

The beta function relates to the classical gamma function as follows:

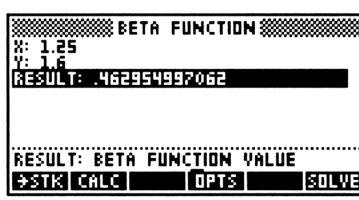
$$\beta(x, y) = \frac{\Gamma(x)\Gamma(y)}{\Gamma(x+y)}$$

Example

Standard
Degrees
Rectangular

What is the value of β(1.25,1.6)?

1. Enter 1.25 for **X** and 1.6 for **Y**.
2. Press **SOLVE** to calculate **Result**, which is .462954997062.



[3] The Bessel functions are based on algorithms in Press, William H., et al., *Numerical Recipes in C*, Cambridge University Press, Cambridge, 1989, §6.4.

Error Functions

Mathematics Series
Special Functions
➢ ***Error Functions***

The error functions application computes the numerical values for the error function and complementary error functions of one real argument. The definitions of the error function and complementary error function are:

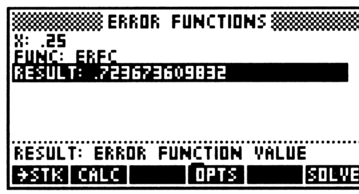
$$erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt \qquad erfc(x) \equiv 1 - erf(x) = \frac{2}{\sqrt{\pi}} \int_x^\infty e^{-t^2} dt$$

Example

Standard
Degrees
Rectangular

What is the value of erfc(.25)?

1. Enter .25 for **X**.
2. Choose ERFC for **Func**.
3. Press **SOLVE** to calculate **Result**, which is .723673609832.



Gamma Function

Mathematics Series
Special Functions
➢ ***Gamma Function***

This application computes the numerical value for a gamma function of one real argument. The definition of the gamma function is:

$$\Gamma(x) = \int_0^\infty t^{x-1} e^{-1} dt \qquad x > 0$$

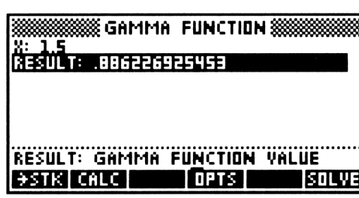
The gamma function relates to the factorial function as follows: $\Gamma(x+1) = x!$

Example

Standard
Degrees
Rectangular

What is the value of $\Gamma(1.5)$?

1. Enter 1.5 for **X**.
2. Press **SOLVE**. The **Result** is .886226925453.



9 Trigonometry

This chapter covers:
- ❑ Trigonometric Functions

To install Trigonometry

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮫ LIBRARY CWAR CW and go to the Trigonometry screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 math		Mathematics
🗁 trig		Trigonometry
🖹 trigfunc.anl	→	Trigonometric Functions

Trigonometric Functions

This application covers the trigonometric functions and their inverses:

- SIN
- COS
- TAN
- COT
- SEC
- CSC

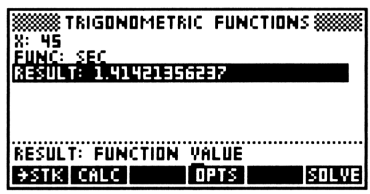
- ASIN
- ACOS
- ATAN
- ACOT
- ASEC
- ACSC

Example

Standard
Degrees
Rectangular

What is the secant of 45°?

1. Enter 45 for **X**.
2. Choose SEC for **Func**.
3. Press SOLVE to calculate **Result**. If your result differs, press ↱ MODES to set the angle measure to degrees and re-solve.



10 Vectors

This chapter covers:

- ❑ Vector Functions
- ❑ Vectors

To install Vectors

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing [→] [LIBRARY] CWAR CW and go to the Vectors screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 math		Mathematics
🗁 vectors		Vectors
🖹 vectfunc.anl	→	Vector Functions
🖹 vectcros.ref	→	Cross Products
🖹 vectcurl.ref	→	Curl
🖹 vectdel.ref	→	Del Operator
🖹 vectdiv.ref	→	Divergence
🖹 vectdot.ref	→	Dot Products
🖹 vectgrad.ref	→	Gradient
🖹 vectlapl.ref	→	Laplacian

Vector Functions

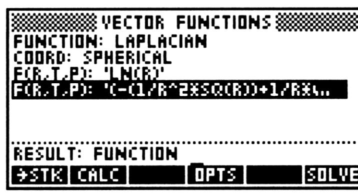
This application covers several vector functions:

- Gradient
- Curl
- Divergence
- Laplacian

Example

Standard
Degrees
Rectangular

What is the Laplacian of ln(R) in spherical coordinates?



1. Choose Laplacian for **Function.**
2. Choose Spherical for **Coord.**
3. Enter 'LN(R)' for **F(R,T,P)** by typing ['] [→] [LN] [( ] R [ENTER].
4. Press **SOLVE** to calculate **F(R,T,P)**, (the result).
5. Simplify the result at the stack. To do this, move the highlight bar to the last field and press **CALC**. Then press [←] [SYMBOLIC] **COLCT**. The simplified result is $1/R^2$.
6. Press [CANCEL] to return to CalcWare.

NOTE	Changing **Coord** will affect the mode setting of the HP 48. To return to the previous mode setting, press [→] [MODES] to enter the Calculator Modes screen and reset the coordinate system.

Vectors

There are several Vectors reference tables, all of which contain information that can be viewed or copied to the stack:

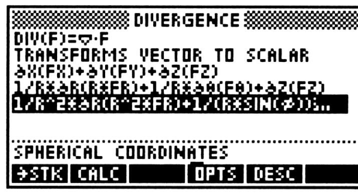
- Cross Product
- Curl
- Del Operator
- Divergence
- Dot Product
- Gradient
- Laplacian

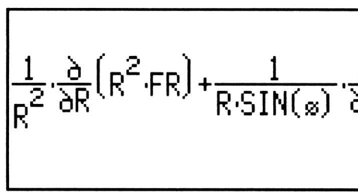
Example

Standard
Degrees
Rectangular

What is the formula for divergence in spherical coordinates?

1. Move the highlight bar to Divergence and press ENTER or ►. The fifth formula is the answer.
2. *Optional*: To view the formula in the EquationWriter, press CALC then ▼. If necessary, press ◄ and ► to scroll to the right and left. When you have finished viewing the formula, press CANCEL CANCEL and then EXIT to exit the EquationWriter and return to CalcWare.





In these equations, the vector components of the function F are indicated by **FX**, **FY**, **FR**, **F**θ, etc. These correspond to the standard notation F_X, F_Y, F_R, F_θ, etc. Also, the convention used is that θ is the polar angle, while Ø is the azimuthal angle.

11 Astronomy

This chapter covers:
- ❑ Solar System Data

To install Astronomy

1. Send the files marked with "🗎" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮡ LIBRARY CWAR CW and go to the Astronomy screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 astronmy		Astronomy
🗎 solarsys.ref	→	Solar System Data

Solar System Data

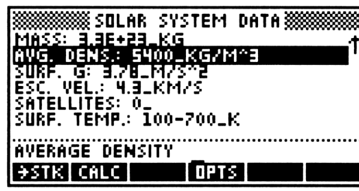
The Solar System Data reference table contains information about the sun, the planets, and the Earth's moon. The information can be viewed or copied to the stack.

Example

Standard
Degrees
Rectangular

What is the average density of Mercury?

1. Move the highlight bar to **BODY**, press CHOOS, highlight Mercury, and press OK.
2. Scroll through the data list by pressing ▲ and ▼ until you find the **AVG. DENS.** field (the tenth item in the list).
3. The value shown is the answer.



12 Electromagnetic Waves

This chapter covers:

- ❑ Electric and Magnetic Fields
- ❑ Energy Flow
- ❑ Polarization
- ❑ Radiation Pressure
- ❑ Maxwell's Equations

To install Electromagnetic Waves

1. Send the files marked with "🗎" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing [↱] [LIBRARY] [CWAR] [CW] and go to the Electromagnetic Waves screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 em_waves		Electromagnetic Waves
🗎 emfields.eqn	→	Electric and Magnetic Fields
🗎 enrgflow.eqn	→	Energy Flow
🗎 polarize.eqn	→	Polarization
🗎 radipres.eqn	→	Radiation Pressure
🗎 maxwell.ref	→	Maxwell's Equations

Variables

The table below lists all the variables used in this chapter, along with a brief description and the default SI unit.

Variable	Description	SI Unit
A	area	m^2
B	magnetic field	T
Bm	magnetic field amplitude	T
E	electric field	V/m
Em	electric field amplitude	V/m
f	frequency	Hz
Fa	radiation force (absorption)	N
Fr	radiation force (reflection)	N
I	intensity	W/m^2
I′	polarized intensity	W/m^2
k	angular wave number	r/m
Pa	radiation pressure (absorption)	N/m^2
Pr	radiation pressure (reflection)	N/m^2
T	period	s
t	time	s
x	x position	m
θ	angle	r
λ	wavelength	m
ω	angular velocity	r/s

Example: Polarization

Standard
Degrees
Rectangular

An unpolarized light beam passes through two polarizing filters, with the second filter's polarization axis being at 27° with respect to the first one. What fraction of the intensity comes out of the filter combination? (Ignore any drop off of intensity with distance).

Given: $\theta = 27°$
I $= 0.5\ W/m^2$

Result: **I′** $= 0.397\ W/m^2$

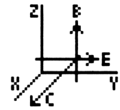
Since we are interested only in the fraction going through, we can set I = 0.5 W/m^2, because the first filter cuts the intensity in half. After passing through the second filter, the intensity drops again by $\cos(27°)^2$. The final fraction is read as the numerical value of I′.

Electric and Magnetic Fields

Physics Series
Electromagnetic Waves
➢ ***Electric and Magnetic Fields***

Y =

The first two equations give **E** and **B**, the sinusoidally-varying electric and magnetic fields of an electromagnetic wave of wavelength λ travelling in the **x** direction. The directions of **E** and **B** are perpendicular to the **x** direction and to each other. The third equation relates the field amplitudes **Em** and **Bm** using **c**, the speed of light. This could also be written as $Bm = \sqrt{\varepsilon 0 \mu 0}$. The remaining equations give the basic identities relating wavelength, wavenumber, frequency, and period.



$$E=Em\cdot\sin(k\cdot x-\omega\cdot t) \qquad B=Bm\cdot\sin(k\cdot x-\omega\cdot t) \qquad Bm=\frac{Em}{c}$$

$$k=\frac{2\cdot\pi}{\lambda} \qquad \omega=2\cdot\pi\cdot f \qquad T=\frac{1}{f}$$

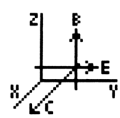
$$c=\lambda\cdot f \qquad c=\frac{\omega}{k}$$

Energy Flow

Physics Series
Electromagnetic Waves
➢ ***Energy Flow***

Y =

These equations give the intensity, or energy flow, in a travelling electromagnetic wave, in terms of the maximum electric and magnetic field amplitudes, **Em** and **Bm**. The last equation relates the field amplitudes **Em** and **Bm** using **c**, the speed of light. This could also be written as $Bm = \sqrt{\varepsilon 0 \mu 0}$.

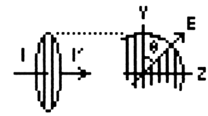


$$I=\frac{1}{2\cdot\mu 0}\cdot Em\cdot Bm \qquad I=\frac{1}{2}\cdot c\cdot\varepsilon 0\cdot Em^{2}$$

$$I=\frac{1}{2\cdot\mu 0}\cdot c\cdot Bm^{2} \qquad Bm=\frac{Em}{c}$$

Polarization

Y = This equation gives **I′**, the intensity of a polarized electromagnetic wave with original intensity **I**, after it passes through a polarizing filter oriented at an angle θ with respect to the incoming wave's electric field vector, or polarization axis. It is known as the law of Malus. If a completely unpolarized beam passes through a polarizing filter, its intensity is cut in half regardless of the filter angle.



$$I' = I \cdot \cos(\theta)^2$$

Radiation Pressure

Y = These equations give the radiation pressure and force when an incoming electromagnetic wave of intensity **I** impinges on a surface of area **A**. If the radiation is totally absorbed, the pressure and force are given by **Pa** and **Fa**; if it is totally reflected, they are given by **Pr** and **Fr**, which are twice the absorption values.

$$Pa = \frac{I}{c} \qquad Fa = \frac{I \cdot A}{c}$$

$$Pr = \frac{2 \cdot I}{c} \qquad Fr = \frac{2 \cdot I \cdot A}{c}$$

Maxwell's Equations

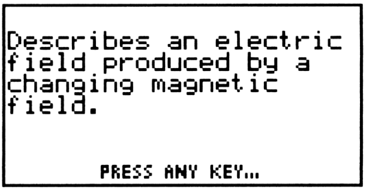
The Maxwell's Equations reference table illustrates Gauss' Laws for Electricity and Magnetism, Faraday's Law, and the Ampere-Maxwell Law. The equations may only be viewed.

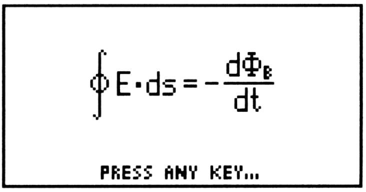
Example

Standard
Degrees
Rectangular

What is Faraday's Law?

1. Move the highlight bar to Faraday's Law and press [ENTER] or [►].
2. A description of the law is shown. Press any key to continue.
3. The equation is shown. Press any key to return to the previous screen.





13 Optics

This chapter covers:

- ❑ Brewster's Law
- ❑ Circular Aperture Diffraction
- ❑ Multiple Slit Diffraction
- ❑ Reflection and Refraction
- ❑ Single Slit Diffraction
- ❑ Spherical Mirrors
- ❑ Spherical Refraction
- ❑ Thin Lenses
- ❑ Two-Slit Interference

To install Optics

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing [→] [LIBRARY] [CWAR] [CW] and go to the Optics screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 optics		Optics
🖹 brewster.eqn	→	Brewster's Law
🖹 circaper.eqn	→	Circular Aperture Diffraction
🖹 multslit.eqn	→	Multiple Slit Diffraction
🖹 reflrefr.eqn	→	Reflection and Refraction
🖹 snglslit.eqn	→	Single Slit Diffraction
🖹 sphrmirr.eqn	→	Spherical Mirrors
🖹 sphrrefr.eqn	→	Spherical Refraction
🖹 thinlens.eqn	→	Thin Lenses
🖹 twoslit.eqn	→	Two-Slit Interference

Variables

The table below lists all the variables used in this chapter, along with a brief description and the default SI units.

Variable	Description	SI Unit
a	slit width	m
D	dispersion, diffraction grating	r/m
d	slit spacing	m
F	focal length	m
I	image distance	m
I0	initial intensity	W/m^2
Im	maximum intensity	W/m^2
I′	intensity	W/m^2
mag	lateral magnification	unitless
mag′	longitudinal magnification	unitless
N	number of slits	unitless
n	index of refraction	unitless
n1	index of refraction 1	unitless
n2	index of refraction 2	unitless
P	object distance	m
R	resolving power	unitless
r	curvature radius	m
r1	curvature radius 1	m
r2	curvature radius 2	m
v1	light velocity in 1	m/s
v2	light velocity in 2	m/s
ym	interference maximum position	m
ø	phase	r
α	half of phase angle	r
Δθ	diffraction line width	r
θ	angle	r
θ1	angle in 1	r
θ2	angle in 2	r
θb	Brewster's angle	r
θc	critical angle	r
θmax	angle of maxima	r
θmin	angle of minima	r
θR	Raleigh's angle	r
λ	wavelength	m
λ0	wavelength in vacuum	m
λ1	wavelength in 1	m
λ2	wavelength in 2	m

Example: Two-Slit Interference

Standard
Degrees
Rectangular

Light of wavelength 550 nm passes through two narrow slits 0.5 mm apart. On a screen 2.2 m from the slits, how far will the third interference maximum appear from the beam axis?

Given:
λ = 550 nm
m = 3
d = 0.5 mm
r = 2.2 m

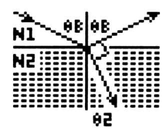
Results:
ym = 7.26 mm
θmax = 0.0033 r
= 0.19°
θmin = 0.00385 r
= 0.22°

Brewster's Law

Phyics Series
Optics
➢ ***Brewster's Law***

Y =

These equations express Brewster's Law, in which an incoming ray at angle **θb** with the vertical is refracted through the angle **θ2**, making an angle of 90° with the incoming ray.



$$\tan(\theta b) = \frac{n2}{n1} \qquad \theta b + \theta 2 = 90^\circ$$

Circular Aperture Diffraction

Phyics Series
Optics
➢ ***Circular Aperture Diffraction***

Y =

This equation covers the diffraction pattern established when an incoming plane wave of wavelength λ passes through a small circular aperture of diameter **d**. It involves **θR**, the Rayleigh angle, which gives the minimum angular separation two objects can have if they are to be individually resolved. This angle gives the position of the first diffraction minimum for the aperture.

$$\sin(\theta R) = \frac{1.22 \cdot \lambda}{d}$$

Multiple Slit Diffraction

Phyics Series
Optics
➢ ***Multiple Slit Diffraction***

Y =

These equations cover the diffraction pattern established when an incoming plane wave of wavelength λ passes through **N** narrow slits spaced a distance **d** apart in a diffraction grating. Principal maxima are observed at angles θ, for **m** = 0, 1, 2, ... The angular widths of the maxima are given by Δθ. The dispersion is given by **D** and the resolving power by **R**.

$$d \cdot \sin(\theta) = m \cdot \lambda \qquad \Delta\theta = \frac{\lambda}{N \cdot d \cdot \cos(\theta)}$$

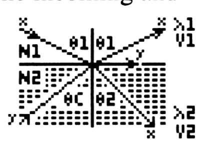
$$D = \frac{m}{d \cdot \cos(\theta)} \qquad R = N \cdot m$$

Reflection and Refraction

Phyics Series
Optics
➢ ***Reflection and Refraction***

Y =

These equations cover Snell's Law and the basics of reflection and refraction of a light ray encountering a plane surface boundary between media possessing differing indices of refraction. The incoming and outgoing wavelengths and velocities can also be found, as can the critical angle at which total internal reflection occurs. (The expression for **θc** requires **n1 ≤ n2**).



$$n1 \cdot \sin(\theta 1) = n2 \cdot \sin(\theta 2) \qquad n1 = \frac{c}{v1} \qquad n2 = \frac{c}{v2}$$

$$\lambda 1 = \frac{\lambda 0}{n1} \qquad \lambda 2 = \frac{\lambda 0}{n2} \qquad \theta c = \operatorname{ASIN}\left(\frac{n1}{n2}\right)$$

Single Slit Diffraction

Phyics Series
Optics
➢ ***Single Slit Diffraction***

Y =

These equations cover the diffraction pattern established when an incoming plane wave of wavelength λ passes through a narrow slit of width **a**. The observed intensity **I′** is given as a function of α, which is half the relative phase angle between the bottom and top of the slit, and depends on the angle of observation θ. The **m**th minimum will appear at angle **θmin**, while the **m**th maximum will appear approximately at the angle **θmax**, for **m** = 0, 1, 2, ... The intensity at the maxima is given by **Im**.

$$Int=Im\cdot\left(\left(\frac{SIN(\alpha)}{\alpha}\right)^2\right) \qquad \alpha=\frac{\pi\cdot a}{\lambda}\cdot SIN(\alpha)$$

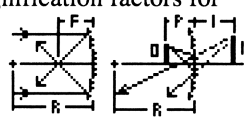
$$a\cdot SIN(\theta min)=m\cdot\lambda \qquad a\cdot SIN(\theta max)=\left(m+\frac{1}{2}\right)\cdot\lambda$$

Spherical Mirrors

Phyics Series
Optics
➢ ***Spherical Mirrors***

Y =

These equations relate **P**, **I**, and **F**, the object, image and focal distances, to **mag** and **mag′**, the lateral and longitudinal magnification factors for spherical mirrors. A positive (negative) value of **r**, the radius of curvature, should be used for concave (convex) mirrors.

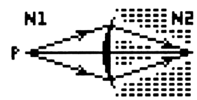


$$\frac{1}{P}+\frac{1}{I}=\frac{1}{F} \qquad F=\frac{1}{2}\cdot r \qquad \frac{1}{P}+\frac{1}{I}=\frac{2}{r}$$

$$mag=\frac{-I}{P} \qquad mag'=-mag^2$$

Spherical Refraction

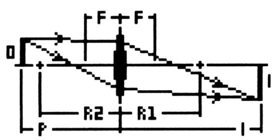
Y = These equations relate **P** and **I**, the object and image distances, to **mag** and **mag′**, the lateral and longitudinal magnification for spherical refraction between two media possessing differing indices of refraction, **n1** and **n2**. A positive (negative) value of **r** is used when the surface between the two media is convex (concave) with respect to the incoming light ray.



$$\frac{n1}{P}+\frac{n2}{I}=\frac{(n2-n1)}{r} \qquad m'=\frac{n2}{n1}\cdot m^2 \qquad m=\frac{-\left(\frac{n1}{n2}\right)\cdot P}{I}$$

Thin Lenses

Y = These equations are the standard thin lens approximations, relating **P**, **I**, and **F**, the object, image and focal distances, to **mag** and **mag′**, the lateral and longitudinal magnification factors. For each lens surface, a positive (negative) value of **r1** or **r2** is used when the lens surface is convex (concave) with respect to the incoming light ray.



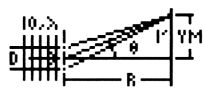
$$\frac{1}{P}+\frac{1}{I}=\frac{1}{F} \qquad \frac{1}{F}=(n-1)\cdot\left(\frac{1}{r1}-\frac{1}{r2}\right)$$

$$mag=\frac{-I}{P} \qquad mag'=-mag^2$$

Two-Slit Interference

Y =

These equations cover the interference pattern established when an incoming plane wave of intensity **I0** and wavelength λ passes through two narrow slits separated by a distance **d**. The observed intensity **I′** is given as a function of the phase **Ø**, which depends on the angle of observation θ. If the observation is made a distance **r** from the slits (where it is assumed **r** >> **d** and the slit widths), for **m** = 0, 1, 2, ..., the **m**th maximum and minimum will appear at angles **θmax** and **θmin**. The **m**th maximum will appear a distance **ym** above the central axis.



$$d \cdot \sin(\theta max) = m \cdot \lambda \qquad d \cdot \sin(\theta min) = \left(m + \frac{1}{2}\right) \cdot \lambda \qquad I' = 4 \cdot I0 \cdot \cos\left(\frac{\varnothing}{2}\right)^2$$

$$\varnothing = \frac{2 \cdot \pi \cdot d}{\lambda} \cdot \sin(\theta) \qquad ym = \frac{m \cdot \lambda \cdot r}{d}$$

14 Oscillations

This chapter covers:

- ❑ Mass-Spring System
- ❑ Pendulum (Conical)
- ❑ Pendulum (Simple)
- ❑ Pendulum (Torsional)
- ❑ Simple Harmonic Motion
- ❑ Two-Body System

To install Oscillations

1. Send the files marked with "🗎" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮫ LIBRARY CWAR CW and go to the Oscillations screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 oscilate		Oscillations
🗎 massprng.eqn	→	Mass-Spring System
🗎 pendconc.eqn	→	Pendulum (Conical)
🗎 pendsmpl.eqn	→	Pendulum (Simple)
🗎 pendtors.eqn	→	Pendulum (Torsional)
🗎 smplharm.eqn	→	Simple Harmonic Motion
🗎 twobody.eqn	→	Two-Body System

Variables

The table below lists all the variables used in this chapter, along with a brief description and the default SI units.

Variable	Description	SI Unit
a	acceleration	m/s^2
E	total energy	J
F	force	N
f	frequency	Hz
Fc	centripetal force	N
H	cone height	m
I	moment of inertia	$kg\ m^2$
K	torsional constant	N m
k	spring constant	N/m
kp	torsional constant	N m
l	length	m
m	mass	kg
m1	mass 1	kg
m2	mass 2	kg
r	radius	m
T	period	s
t	time	s
U	potential energy	J
v	velocity	m/s
x	displacement	m
xm	maximum displacement (amplitude)	m
Ø	phase constant	r
θ	angle	r
μ	reduced mass	kg
τ	torque	N m
ω	angular frequency	r/s

Example: Pendulum (Simple)

Standard
Degrees
Rectangular

To make a simple pendulum with a one second period, how long should the rod be?

Given: **T** = 1 s   **Result:** **l** = 24.8 cm

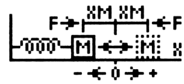
T is independent of the mass, which enters only into the equation for the restoring force.

Mass-Spring System

Phyics Series
Oscillations
➢ ***Mass-Spring System***

Y =

These equations include Hooke's Law for the restoring force and explain the behavior of a mass-spring system. The mass position **x**, kinetic energy **K**, and potential energy **U**, all depend on the frequency of oscillation θω and the spring constant **k**. The inital phase is given by the phase constant **Ø**.



$$F=-k\cdot x \qquad \omega=\sqrt{\frac{k}{m}} \qquad x=xm\cdot\cos(\omega\cdot t+\emptyset)$$

$$K=\frac{1}{2}\cdot k\cdot xm^2\cdot\sin(\omega\cdot t+\emptyset)^2 \qquad U=\frac{1}{2}\cdot k\cdot xm^2\cdot\cos(\omega\cdot t+\emptyset)^2$$

$$E=\frac{1}{2}\cdot k\cdot xm^2 \qquad \omega=2\cdot\pi\cdot f \qquad T=\frac{1}{f}$$

Pendulum (Conical)

Phyics Series
Oscillations
➢ ***Pendulum (Conical)***

Y =

These equations describe the motion of a conical pendulum with a bob of mass **m** suspended from a cord of length **l** which makes a cone angle of θ with the vertical.

$$\omega=\sqrt{\frac{g}{H}} \qquad Fc=m\cdot\omega^2\cdot r \qquad H=l\cdot\cos(\theta)$$

$$r=l\cdot\sin(\theta) \qquad \omega=2\cdot\pi\cdot f \qquad T=\frac{1}{f}$$

Pendulum (Simple)

Phyics Series
Oscillations
➢ ***Pendulum (Simple)***

Y =

These equations describe the motion of a simple pendulum with a bob mass **m** and rod length **l**.

$$\omega=\sqrt{\frac{g}{l}} \qquad F=-m\cdot g\cdot\sin(\theta) \qquad \omega=2\cdot\pi\cdot f \qquad T=\frac{1}{f}$$

Pendulum (Torsional)

Phyics Series
Oscillations
➢ ***Pendulum (Torsional)***

Y = These equations describe the motion of a torsional pendulum of moment of inertia **I**, possessing a torsional constant **kp** which depends on the material properties of the shaft. The restoring torque is given by τ.

$$\omega=\sqrt{\frac{kp}{I}} \qquad \omega=2\cdot\pi\cdot f \qquad \tau=-kp\cdot\theta \qquad T=\frac{1}{f}$$

Simple Harmonic Motion

Phyics Series
Oscillations
➢ ***Simple Harmonic Motion***

Y = These equations describe simple harmonic motion of amplitude **xm** and angular frequency ω.

$$x=xm\cdot COS(\omega\cdot t+\emptyset) \qquad v=-\omega\cdot xm\cdot SIN(\omega\cdot t+\emptyset) \qquad a=-\omega^2\cdot xm\cdot COS(\omega\cdot t+\emptyset)$$

$$\omega=2\cdot\pi\cdot f \qquad T=\frac{1}{f}$$

Two-Body System

Phyics Series
Oscillations
➢ ***Two-Body System***

Y = These equations describe an oscillating system of two bodies connected by a spring, in terms of the reduced mass μ and oscillation frequency ω.

$$\mu=\frac{m1\cdot m2}{m1+m2} \qquad \omega=\sqrt{\frac{k}{\mu}} \qquad \omega=2\cdot\pi\cdot f \qquad T=\frac{1}{f}$$

15 Quantum Mechanics

This chapter covers:

- ❑ Angular Momentum and Spin
- ❑ Bohr Model
- ❑ de Broglie Wavelength
- ❑ Photoelectric Effect
- ❑ Photons
- ❑ Uncertainty Principle

To install Quantum Mechanics

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing [↱] [LIBRARY] CWAR CW and go to the Quantum Mechanics screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 quantum		Quantum Mechanics
🖹 angmspin.eqn	→	Angular Momentum and Spin
🖹 bohrmodl.eqn	→	Bohr Model
🖹 debrogle.eqn	→	de Broglie Wavelength
🖹 photoele.eqn	→	Photoelectric Effect
🖹 photons.eqn	→	Photons
🖹 uncrtain.eqn	→	Uncertainty Principle

Variables

The table below lists all the variables used in this chapter, along with a brief description and the default SI units.

Variable	Description	SI Unit
E	energy	J
E1	energy of first Bohr orbital	J
Ef	energy of final orbital	J
Ei	energy of initial orbital	J
En	energy of nth Bohr orbital	J
f	frequency	Hz
f0	threshold frequency	Hz
K	kinetic energy	J
L	angular momentum	kg m^2/s
l	orbital quantum number	unitless
Lz	angular momentum, z-axis	kg m^2/s
m	mass	kg
ml	magnetic quantum number	unitless
ms	spin quantum number	unitless
n	principal quantum number	unitless
p	momentum	kg m/s
rn	radius of nth Bohr orbital	m
S	spin angular momentum	kg m^2/s
Sz	spin angular momentum, z-axis	kg m^2/s
v	velocity	m/s
W0	work function	J
Z	atomic number	unitless
ΔE	energy uncertainty	J
Δp	momentum uncertainty	kg m/s
Δt	time uncertainty	s
Δv	velocity uncertainty	m/s
Δx	position uncertainty	m
λ	wavelength	m

Example: Uncertainty Principle

Standard
Degrees
Rectangular

A particle has an uncertainty in its position of 12 pm (picometers). What is minimum uncertainty in its momentum?

Given: **Δx** = 12 pm **Result:** **Δp** = 4.39E–24 kg m/s

Angular Momentum and Spin

Phyics Series
Quantum Mechanics
➢ ***Angular Momentum and Spin***

Y = These equations express the quanitization of angular momentum and spin for a fundamental particle such as the electron or proton. The angular momentum **L** can only take on values given by the first equation, where the orbital quantum number **l** can have the values **l** = 0, 1, 2, ..., **n**, where **n** is the principal quantum number. Its projection along the z-axis, **Lz** is given by the second equation, which involves the magnetic quantum number **ml** (**ml** = 0, 1, 2, ..., **l**). The second pair of equations involve the particle's "spin" (which has nothing to do with classical ideas about spinning balls), which always has a constant magnitude. S can have either up or down projections along the z-axis, given by the spin quantum number **ms**, which can have either the value **ms** = +1/2 or **ms** = –1/2.

$$L=\sqrt{l\cdot(l+1)}\cdot hbar \qquad Lz=ml\cdot hbar$$

$$S=\frac{1}{2}\cdot hbar \qquad Sz=ms\cdot hbar$$

Bohr Model

Y = These equations describe the Bohr Model for a hydrogen-like atom with a nucleus of **Z** elemental charges (**Z** = 1 for hydrogen). The radius and energy of the **n**th orbital, **rn** and **En**, are given in terms **a0** and **E1**. These are the quantities for the first orbital of the hydrogen atom: **a0** = .529 angstroms is the Bohr radius, and **E1** = –13.6 eV is determined by the third or fourth equation. The next two equations give the frequency **f** and wavelength λ of a photon which is emitted or absorbed when an atom changes to state "f" from state "i". If "f" is a higher state (i.e., **n** is greater), the photon is absorbed; otherwise, it is emitted. The last two equations give the electron's quantized orbital angular momentum **L** in the **n**th orbital, and express it in terms of its velocity **v**, radius **rn**, and mass **me**, which is known from the constant library.

$$rn=\frac{n^2}{Z}\cdot a0 \qquad En=\frac{E1}{n^2} \qquad E1=\frac{-Z^2\cdot q^4\cdot me}{(4\cdot\pi\cdot\varepsilon 0)^2\cdot hbar^2\cdot 2}$$

$$E1=-Z^2\cdot h\cdot c\cdot R\infty \qquad f=\frac{(Ef-Ei)}{h} \qquad \lambda=\frac{h\cdot c}{Ef-Ei}$$

$$L=n\cdot hbar \qquad L=me\cdot v\cdot rn$$

de Broglie Wavelength

Y = These equations give the de Broglie wavelength of a particle of momentum **p**. The second equation gives the particle's momentum in terms of its mass and velocity. These equations illustrate the wave-particle duality, in which a particle may be viewed as a wave of wavelength λ, which is most often useful when working at length scales on the order of λ or smaller.

$$\lambda=\frac{h}{p} \qquad p=m\cdot v$$

Photoelectric Effect

Physics Series
Quantum Mechanics
➢ ***Photoelectric Effect***

Y =

These equations describe the photoelectric effect, or photoemission. A light beam of frequency **f** ejects electrons of mass **me** and charge **q** (both known from the constant library) from the surface of a material with work function **W0**. The electrons are ejected with kinetic energy **K** and velocity **v**. The threshold frequency **f0** required to eject electrons is given by the last equation.

$$h \cdot f = W0 + K \qquad K = me \cdot v^2 \qquad f0 = \frac{W0}{h}$$

Photons

Physics Series
Quantum Mechanics
➢ ***Photons***

Y =

These equations give the momentum **p**, energy **E**, and frequency **f**, of a photon of electromagnetic radiation (such as light or radio waves) with wavelength λ. These equations express the wave-particle duality, which implies electromagnetic waves may be considered to be composed of photon particles when working at length scales greater than or equal to λ.

$$p = \frac{h}{\lambda} \qquad E = p \cdot c \qquad f = \frac{c}{\lambda}$$

Uncertainty Principle

Y =

These equations express Heisenberg's uncertainty principle. The first equation says that upon measurement, the product of the momentum uncertainty $\Delta\mathbf{p}$ and the postition uncertainty $\Delta\mathbf{x}$ must be at least hbar/2. The second equation says that upon measurement, the product of the energy uncertainty $\Delta\mathbf{E}$ and the time uncertainty $\Delta\mathbf{t}$ must also be at least hbar/2. In these two relations, the "=" sign should be interpreted to mean approximately greater than, as these are the *minimum* uncertainties. The precise factor usually does not matter, as it is typically orders of magnitude which are important. The uncertainties are not properties of the measuring method or apparatus, but are due to unavoidable laws of nature. The third equation relates the momentum uncertainty $\Delta\mathbf{p}$ to the velocity uncertainty $\Delta\mathbf{v}$ for the case of a particle of mass **m**. It should not be used for massless photons (light), or for relativistic velocities (for which cases the first two equations will still apply).

$$\Delta p \cdot \Delta x = \frac{hbar}{2} \qquad \Delta E \cdot \Delta t = \frac{hbar}{2} \qquad \Delta p = m \cdot \Delta v$$

16 Special Relativity

This chapter covers:

- ❑ Doppler Effect
- ❑ Energy, Mass, and Momentum
- ❑ Gallilean Transform
- ❑ Length Contraction
- ❑ Lorentz Transform
- ❑ Time Dilation

To install Special Relativity

1. Send the files marked with "🗎" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮡ LIBRARY CWAR CW and go to the Special Relativity screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 spcl_rel		Special Relativity
🗎 dopprelt.eqn	→	Doppler Effect
🗎 enrgmass.eqn	→	Energy, Mass, and Momentum
🗎 galilean.eqn	→	Gallilean Transform
🗎 lencontr.eqn	→	Length Contraction
🗎 lrntztrn.eqn	→	Lorentz Transform
🗎 timedila.eqn	→	Time Dilation

Variables

The table below lists all the variables used in this chapter, along with a brief description and the default SI units.

Variable	Description	SI Unit
E	total energy	J
E0	rest mass energy	J
f	proper frequency	Hz
fl	longitudinal frequency	Hz
ft	transverse frequency	Hz
K	relativistic kinetic energy	J
Kcl	classical kinetic energy	J
l	length, observer frame	m
l′	(proper) length, object frame	m
m	relativistic mass	kg
m0	rest mass	kg
p	relativistic momentum	kg m/s
pcl	classical momentum	kg m/s
t	time, observer frame	s
t′	(proper) time, object frame	s
v	velocity of object frame	m/s
vx	x velocity, observer frame	m/s
vx′	x velocity, object frame	m/s
vy	y velocity, observer frame	m/s
vy′	y velocity, object frame	m/s
vz	z velocity, observer frame	m/s
vz′	z velocity, object frame	m/s
x	x position, observer frame	m
x′	x position, object frame	m
γ	Lorentz factor	unitless

Example: Length Contraction

Standard
Degrees
Rectangular

An object of proper length 1.0 m is travelling at a speed of 0.93 c with respect to a fixed observer. How long would it appear to be to the fixed observer?

Given: **v** = 0.93 c
l′ = 1.0 m

Results: **l** = 0.37 m
γ = 2.72

Doppler Effect

Phyics Series
Special Relativity
➢ ***Doppler Effect***

Y = These equations present the shift in longitudinal and transverse frequencies, **fl** and **ft**, due to the relativistic Doppler effect, for reference frames moving at longitudinal velocity **v** with respect to each other.

$$\gamma=\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \qquad fl=f\cdot\sqrt{\frac{\left(1-\frac{v}{c}\right)}{1+\frac{v}{c}}} \qquad ft=\frac{f}{\gamma}$$

Energy, Mass, and Momentum

Phyics Series
Special Relativity
➢ ***Energy, Mass, and Momentum***

Y = These equations provide the relativistic defintitions of mass, momentum, kinetic energy and potential energy, together with their classical counterparts, in terms of the Lorentz factor γ.

$$\gamma=\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \qquad m=\gamma\cdot m0 \qquad pcl=m0\cdot v$$

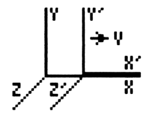
$$p=m\cdot v \qquad Kcl=\frac{1}{2}\cdot m0\cdot v^2 \qquad E0=m0\cdot c^2$$

$$K=(\gamma-1)\cdot E0 \qquad E=\gamma\cdot E0 \qquad E^2=(p\cdot c)^2+E0^2$$

Gallilean Transform

Phyics Series
Special Relativity
➢ ***Gallilean Transform***

These equations describe the Gallilean (or Newtonian) transform of an object from the observer frame to the object (primed) frame. The two frames are moving with respect to each other at a constant *non-relativistic* velocity **v** where **v** << **c**. Only **v** and **vx** change under a Gallilean transformation—the quantities **t**, **y**, **z**, **vy**, **vz**, **ax**, **ay**, and **az** all remain unchanged.

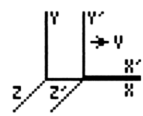


$$x' = x - v \cdot t \qquad vx' = vx - v$$

Length Contraction

Phyics Series
Special Relativity
➢ ***Length Contraction***

These equations describe length contraction. The proper length **l′** is the length of the object as measured in the object (primed) frame. The contracted length **l** is that seen by an observer with respect to whom the object is moving.

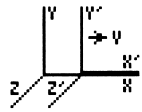


$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad l = \frac{l'}{\gamma}$$

Lorentz Transform

Phyics Series
Special Relativity
➢ ***Lorentz Transform***

Y = These equations describe the Lorentz transformation of an object from the observer frame to the object (primed) frame. The two frames are moving with respect to each other at a constant *relativistic* velocity **v**. Only the quantities **y**, **z**, **ax**, **ay**, and **az** remain unchanged during a Lorentz transformation.



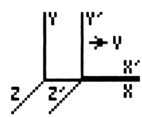
$$\gamma=\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}\qquad x'=(x-v\cdot t)\cdot\gamma\qquad t'=\left(t-\frac{v\cdot x}{c^2}\right)\cdot\gamma$$

$$vx'=\frac{(vx-v)}{1-\frac{v\cdot vx}{c^2}}\qquad vy'=\frac{vy}{1-\frac{v\cdot vx}{c^2}}\cdot\left(\frac{1}{\gamma}\right)\qquad vz'=\frac{vz}{1-\frac{v\cdot vx}{c^2}}\cdot\left(\frac{1}{\gamma}\right)$$

Time Dilation

Phyics Series
Special Relativity
➢ ***Time Dilation***

Y = These equations describe time dilation. The proper time **t′** is measured in the object (primed) frame, while the dilated time **t** is measured in the observer frame.



$$\gamma=\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}\qquad t=t'\cdot\gamma$$

17 Waves

This chapter covers:

- ❑ Basics of Waves
- ❑ Doppler Effect
- ❑ Organ Pipes
- ❑ Shock Waves
- ❑ Sound Waves

To install Waves

1. Send the files marked with "🖹" below from the computer to the HP 48. See "To install CalcWare applications onto the HP 48," page 15.
2. Start CalcWare by pressing ⮣ LIBRARY CWAR CW and go to the Waves screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 waves		Waves
🖹 bascwave.eqn	→	Basics of Waves
🖹 doppwave.eqn	→	Doppler Effect
🖹 orgnpipe.eqn	→	Organ Pipes
🖹 shockwav.eqn	→	Shock Waves
🖹 soundwav.eqn	→	Sound Waves

Variables

The table below lists all the variables used in this chapter, along with a brief description and the default SI units.

Variable	Description	SI Unit
B	bulk modulus of elasticity	N/m^2
f	frequency	Hz
f1	frequency 1	Hz
f2	frequency 2	Hz
fb	beat frequency	Hz
fc	closed pipe frequency	Hz
fo	organ pipe frequency	Hz
f′	doppler frequency	Hz
I	sound intensity	W/m^2
k	angular wave number	r/m
l	pipe length	m
M	Mach number	unitless
nc	1, 3 ,5, ...	unitless
no	1, 2, 3, ...	unitless
s	longitudinal displacement	m
sm	longitudinal amplitude	m
T	period	s
t	time	s
v	wave velocity	m/s
vd	detector velocity	m/s
vs	source velocity	m/s
vsnd	sound velocity	m/s
x	x position	m
y	transverse displacement	m
ym	transverse amplitude	m
β	sound level	dB
ΔPm	maximum pressure change	N/m^2
θs	mach cone angle	r
λ	wavelength	m
ρ	density	kg/m^3
ω	angular frequency	r/s

Example: Shock Waves

Standard
Degrees
Rectangular

Find the Mach number of a shock wave if a Mach cone angle of 15° is observed.

Given: $\theta s = 15^\circ$
vsnd = 1.0 m/s

Result: **M** = 3.86

Since we only need the ratio **v/vsnd**, we are at liberty to set one of them equal to anything, and we choose **vsnd** =1.0 m/s.

Basics of Waves

Phyics Series
Waves
➢ ***Basics of Waves***

Y =

These equations describe transverse and longitudinal waves of wavelength λ and frequency **f** moving in the **x** direction at wave velocity **v**. The wave number and angular velocity are given by **k** and ω. The maximum transverse and longitudinal amplitudes are given by **ym** and **sm**.

$$y=ym\cdot SIN(k\cdot x-\omega\cdot t) \qquad s=sm\cdot COS(k\cdot x-\omega\cdot t) \qquad k=\frac{2\cdot\pi}{\lambda}$$

$$\omega=2\cdot\pi\cdot f \qquad T=\frac{1}{f} \qquad v=\lambda\cdot f$$

Doppler Effect

Phyics Series
Waves
➢ ***Doppler Effect***

Y =

This equation describes the frequency shift from **f** to **f'** due to the Doppler effect. The sign convention is that **vs** and **vd** are positive when the source and detector are approaching each other.

SIGN CONVENTION
− ← VS → + + ← VD → −
SOURCE DETECTOR

$$f'=\frac{f\cdot(vsnd+vd)}{vsnd-vs}$$

Organ Pipes

Phyics Series
Waves
➢ ***Organ Pipes***

Y = These equations describe resonant frequencies for an organ pipe of length **l** carrying sound waves of velocity **vsnd**. The first equation describes a pipe open at both ends, and **no** can take on the values **n0** = 1, 2, 3, ... The second equation describes a pipe closed at one end and open at the other, and **nc** can take on the values **nc** = 1, 3, 5, ...

$$fo=\frac{vsnd\cdot no}{2\cdot l} \qquad fc=\frac{vsnd\cdot nc}{4\cdot l}$$

Shock Waves

Phyics Series
Waves
➢ ***Shock Waves***

Y = These equations describe the motion of an object at a supersonic speed **v** through a medium with sound speed **vsnd**, where **v** > **vsnd**. A shock wave is produced at half angle, or Mach cone angle, **θs**. Also given is **M**, the Mach number, which describes supersonic motion.

$$SIN(\theta s)=\frac{vsnd}{v} \qquad M=\frac{v}{vsnd}$$

Sound Waves

Phyics Series
Waves
➢ ***Sound Waves***

Y = These equations describe the fundamentals of sound waves. Comparing the base 10 logarithm of intensity **I** to a reference intensity **I0** = 10^{-12} W/m^2 (found in the constant library) gives the intensity level β in decibels. The sound speed **vsnd** is expressed in terms of the properties of the material and its density ρ.

$$vsnd=\sqrt{\frac{B}{\rho}} \qquad I=\frac{1}{2}\cdot\rho\cdot vsnd\cdot\omega^2\cdot sm^2 \qquad \beta=10\cdot LOG\left(\frac{I}{I0}\right)$$

$$\Delta Pm=vsnd\cdot\rho\cdot\omega\cdot sm \qquad \omega=2\cdot\pi\cdot f \qquad fb=f1-f2$$

Appendices and Index

A Troubleshooting

This appendix lists the most common questions about CalcWare. Scan this list before calling customer support—you might save yourself a phone call!

This appendix covers:

- ❑ General
- ❑ Analysis Routines
- ❑ Equation Sets
- ❑ Reference Tables

General

These are the most commonly asked questions about general features of CalcWare.

Q Why is there a 'CalcWare' directory in my HP 48 user memory? (The directory appears as CALC when you press VAR to display the variables in your HP 48 user memory.)

A The 'CalcWare' directory is where CalcWare applications are installed in your HP 48 when you run the CalcWare shell. This directory may appear to be empty, but that is to protect it from files being accidentally deleted, which would cause erratic behavior. CalcWare applications should be deleted from inside CalcWare by pressing DEL, *not* from the HP 48 stack.

Q What do the three dots (...) mean at the end of an item on the screen?

A They mean that the item is too wide to fit on the screen. To view the entire item, highlight it and press CALC to take it to the HP 48 stack, where it will be shown on multiple lines. If the item is an equation, it can be viewed in the EquationWriter by pressing ▼ at the stack.

Q I downloaded a CalcWare application, but was interrupted by an "Insufficient Memory" error during the transfer. What can I do?

A Either delete an installed CalcWare application (using DEL from inside CalcWare) or purge other objects from your HP 48 user memory. See "To delete a CalcWare application," page 19, or see your HP 48G User's Guide for more information about purging HP 48 objects. You should have at least 3K to 4K of free memory in your HP 48 to run

CalcWare, but you will need more free memory if you want to install additional CalcWare applications. To check the bytes of free memory in your HP 48, press ← MEMORY MEM.

Q I pressed CW, but got an "Insufficient Memory" error. What can I do?

A Purge some objects from your HP 48 user memory or delete the CalcWare shell and all CalcWare applications and reinstall a smaller number of CalcWare applications. The CalcWare shell typically needs at least 3K to 4K of free memory to run. If you do not have 3K to 4K free memory, you may be unable to run the CalcWare shell, which means you will also be unable to delete individual CalcWare applications by pressing DEL from within CalcWare. The only solution to this is to either free up enough user memory by purging other objects or delete all of CalcWare and reinstall the CalcWare shell and a smaller number of CalcWare applications.

Analysis Routines

These are the most commonly asked questions about CalcWare applications which are analysis routines. Analysis routine applications are indicated by the icon shown at left.

Q I'm solving a problem involving a trigonometric function, and the result isn't the value I expected. What could be wrong?

A Your HP 48 angle measure mode setting is probably the cause. Press → MODES to display the Calculator Modes screen and check the angle measure setting. For proper evaluation of trigonometric derivatives and integrals, make sure your HP 48 angle measure is set to radians.

Q I pressed SOLVE and got an expression with $\pi/180$ in it. What does that mean?

A Your HP 48 is in degrees mode and the solution involves a trigonometric function, so the result includes the conversion factor $\pi/180$ to convert between degrees and radians. Press → MODES to enter the Calculator Modes screen, set your HP 48 angle measure to radians, and re-solve.

Q When I press SOLVE, I'm getting a symbolic result but want a numeric result or vice versa. What could be wrong?

A Your HP 48 symbolic results mode setting is probably the cause. Press ⮡ MODES to display the Calculator Modes screen. Then press FLAG to display the system flags screen. For numeric outputs, make sure flag 03 reads, "Function –> num" and has a check mark in front of it. For symbolic outputs, make sure flag 03 reads, "Function –> symb" and has no check mark in front of it. After changing the setting, press OK OK to save the flag settings and exit the Calculator Modes screen.

If you are getting symbolic results and want numeric results, it is also possible that one or more of the variables in the result may not be defined numerically, which means you will need to enter a numeric value for it.

If you are getting numeric results and want symbolic results, it is also possible that one or more of the variables in the result have values stored in them in your HP 48 user memory outside CalcWare. If a variable exists in your HP 48 user memory, its value may have been substituted into the result, giving a numeric answer. To purge the variable from your HP 48 user memory, press CALC to go the HP 48 stack and press ⮡ HOME to go to the HOME directory, which is the most likely location of the variable. Enter the name of the variable you want to purge by typing ' α α, followed by the name of the variable (e.g. X) and then ENTER. Then press ⮢ PURGE to purge the variable. Finally, press EXIT to return to CalcWare and re-solve the problem.

Q When I press SOLVE, I get the message, "Undefined Name." Why?

A Your HP 48 symbolic results mode setting is probably the cause. Your HP 48 is attempting to find a numeric result but one or more of the variables is undefined and cannot be evaluated to a number. Press ⮡ MODES to display the Calculator Modes screen. Then press FLAG to display the system flags screen. For symbolic outputs, make sure flag 03 reads, "Function –> symb" and has no check mark in front of it. After changing the setting, press OK OK to save the flag settings and exit the Calculator Modes screen. Then re-solve the problem.

Equation Sets

Y =

These are the most commonly asked questions about CalcWare applications which are equation sets. Equation set applications are indicated by the icon shown at left.

Q I entered values for some variables and pressed SOLVE, but I get the error "Too Many Unknowns." Why?

A Sometimes the Solver doesn't have enough information (i.e., enough known variables) to solve for all the remaining, unknown variables You will have to enter more known values and re-solve.

Q There are already values stored in some of my variables. How do I clear those values?

A The values remain from previous solving operations. It is okay to ignore the values, because as long as they aren't marked as known, they will be overwritten by new solutions. If you want to reset the variables, press RESET to clear one or all of the variables.

Q The solution to my problem is clearly wrong! (An angle might be negative or unreasonably large.) Why?

A This is most likely to happen when angles are involved in the equations you are solving. What has happened is that the HP 48 has found a non-principal solution to your equation.

Example: Imagine solving the equation $\sin(x) = 0.5$. Solutions include: 30°, 390°, –330°, 750°, etc., but the *principal* solution is 30°.

If a non-principal solution is found, it may then be used to solve other equations, leading to strange results.

Example (cont.): Now imagine solving the equation $x + y = 90°$. If x is 30°, then y should be 60°. But if a non-principal solution for x was found, such as 750°, then the value of y will be –660°, which although technically correct, is also not a principal solution.

The way to fix this problem is to put in an initial guess for angle variables.

Example (cont.): Before solving for *x*, enter the value 45° for *x* and then press MARK to unmark *x* as known. Now, when you press SOLVE to solve for *x*, the guess of 45° will be used, and it is close enough to the principal solution of 30° that the solver is very likely to find the principal solution.

Q CalcWare seems to be taking a long time to go from the Equations screen to the Solver screen. Why?

A The number of equations in an equation set affects how long it takes to get to the Solver screen, so CalcWare needs more time to get to the Solver screen for large equation sets. Additionally, if the HP 48 has less than 3K to 4K of memory free, CalcWare will run slowly.

Q When I try to solve for a variable, I get an answer which is wrong and the message, "Extremum." What does this mean?

A CalcWare relies on the built-in HP 48 numerical solver, which has several limitations. One limitation is that it cannot handle complex numbers as input or output, and when the solution to an equation is complex, the Solver may ge stuck at an extremum while attempting to find a real solution. Try entering a guess near the expected solution for the troublesome variable and re-solve.

For more information about the Solver, refer to "Comments about the Solver," page 32.

Q When I try to solve an equation which has two possible answers, only one is displayed. Why?

A Because the Solver only returns the first root it finds. A second- or higher-order equation may have more than one root, but the Solver will only find one. To assist the Solver to find the desired root (e.g., if both positive and negative roots are possible, and the positive root is the only one with physical meaning), try entering a guess near the expected solution and re-solve.

For more information about the Solver, refer to "Comments about the Solver," page 32.

Reference Tables

These are the most commonly asked questions about CalcWare applications which are reference tables. Reference table applications are indicated by the icon shown at left. If your question relates to a solving feature of a reference table, see also the above section, "Analysis Routines."

Q How do I copy the help text to the stack?

A You can't. Only reference data can be copied to the stack.

Q I want to solve an equation in a reference table but there's no SOLVE key in the menu. How do I solve the equation?

A If the SOLVE key does not appear in the menu, then the CalcWare application does not have a custom solving routine for that reference table. To try to solve an equation from that reference table, highlight the equation and press CALC to take the item to the stack. Then type ['] ['] STEQ [ENTER] to store the equation. Finally, enter the HP solver by typing [→] [SOLVE] then [ENTER]. For more information about the HP solver, see your HP 48G User's Guide.

Q I copied an equation to the stack that the HP 48 won't solve. What could the problem be?

A Some reference equations use mathematical functions or operators that the HP 48 does not accept. After copying the equation to the stack, if it begins and ends with single quotes ('), the HP solver should have no trouble with it. However, if the equation begins and ends with double quotes ("), then the equation is *not* a valid expression and the HP 48 cannot solve it. The latter type of equations are intended only for reference information and cannot be solved.

B Service and Warranty

Technical Support

You can get answers to your questions about CalcWare from Sparcom Corporation. Contact us in one of the following ways:

- **E-Mail**
  Internet: support@sparcom.com
  Compuserve: >Internet:support@sparcom.com
  FidoNet: To:support@sparcom.com

- **Standard Mail**
  Sparcom Corporation
  Attn: Technical Support Department
  P.O. Box 927
  Corvallis, OR 97339, USA

- **Telephone**
  (503) 757–8416
  Monday to Friday, 9 a.m. to 12 noon, Pacific Time

- **Facsimile**
  (503) 753–7821

Shipping Instructions

If your disk requires service

1. Call Sparcom Corporation for a Return Merchandise Authorization (RMA) number.
2. Ship the products back to Sparcom Corporation in the following manner:
   - Include your return address, phone number and a detailed description of the problem.
   - INCLUDE YOUR **RMA** NUMBER WITH THE MERCHANDISE. The RMA number must be written on the outside of the package, or the package will be returned to you unopened.
   - If the product is still under warranty, include the proof of purchase date.
   - Include a check, purchase order, or credit card number and expiration date (VISA or MasterCard) to cover the estimated charge.
   - Should the disk require further service, Sparcom Corporation will notify you of the additional repairs and charges.
   - Ship your disk, postage prepaid, in protective packaging adequate to prevent damage. Ship the package to:

     Sparcom Corporation
     RMA # __________
     897 NW Grant Avenue
     Corvallis, OR 97330, USA
   - We highly recommend that you insure the shipment.

Products are usually serviced and reshipped within five working days.

Service Charge for Out-of-Warranty Disk

Charges for out-of-warranty repairs are individually determined based on time and material. These charges are subject to your local sales or value-added tax, wherever applicable.

Disk: Limited 90-Day Warranty

What is covered

The disk is warranted by Sparcom Corporation against defects in materials and workmanship for ninety (90) days from the date of original purchase. If you sell your disk or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original ninety-day period. During the warranty period, we will repair or, at our option, replace at no charge a disk that proves to be defective, provided you return the disk, shipping prepaid, to Sparcom Corporation. (Replacement may be made with a newer disk of equal or better functionality.)

This warranty gives you specific legal rights, and you may also have other rights that vary from state to state, province to province, or country to country.

What is not covered

This warranty does not apply if the disk has been damaged by accident or misuse or as the result of service or modification by other than an authorized Sparcom Corporation service center.

No other express warranty is given. The repair or replacement of the disk is your exclusive remedy. ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE NINETY-DAY DURATION OF THIS WRITTEN WARRANTY. Some states, provinces, or countries do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. IN NO EVENT SHALL SPARCOM CORPORATION BE LIABLE FOR CONSEQUENTIAL DAMAGES. Some state, provinces, or countries do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

Products are sold on the basis of specifications applicable at the time of manufacture. Sparcom Corporation shall have no obligation to modify or update products, once sold.

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CalcWare™

Application Software for HP 48G Series Calculators

Physics Series PN 12057-1A

Optics, Waves & Relativity

Optics, Waves & Relativity is diskette-based software for students in physics and engineering who use the HP 48G or HP 48GX calculator.

Can be used in the following classes:
1st Year Physics
2nd Year Physics
Physics Lab
1st Year Engineering
Science

Saves Time

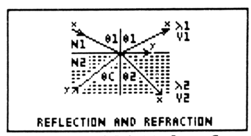
No need to program the HP 48G or HP 48GX. Just load the software and you are ready to go. Explore basic concepts and master the subject material at your own pace.

Easy-To-Use Software

Sparcom's software is menu-driven and includes help text.

Covers Major Subjects of Physics

Quickly customize your calculator with standard physics routines to match the needs of the class you are taking.



(Optics, Waves & Relativity Screen Capture)

Optics *Oscillations* *Quantum Mechanics* *Waves* *Doppler Effect*
Electromagnetic Waves *Uncertainty Principle* *Astronomy* *Refraction*

Contents: User's Guide, Software

The following items are needed to run CalcWare application software:

- **HP 48G or HP 48GX Calculator**
- **Serial Interface Cable**
- **Connectivity Software: CalcWare Link for PC or Macintosh, HP Serial Interface Kit or other transfer software such as Kermit**
- **Personal Computer that can run connectivity software: IBM PC Compatible or Macintosh that reads PC-formatted diskettes**

Sparcom Corporation
897 NW Grant Avenue • Corvallis, Oregon 97330 USA
503-757-8416

7 41867 12057 8

Technical information contained herein is subject to update and may be changed without prior notice.