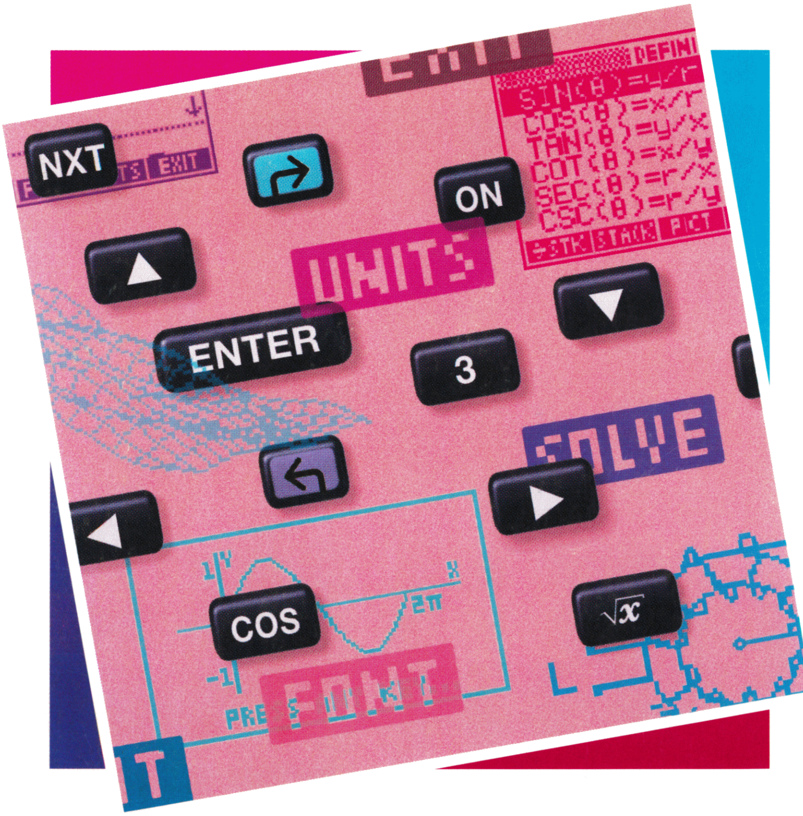
CalcWare™

Application Software for HP 48G Series Calculators



Physics Series

Mechanics & Thermodynamics

PN 12055-1A

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Physics Series

Mechanics & Thermodynamics

Serial Number: 45841019372

CalcWare™
User's Guide

SPARCOM CORPORATION

Physics Series

Mechanics & Thermodynamics

PN 12055-1A

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Credits

CalcWare™ Mechanics & Thermodynamics was made possible by:

- **Product Manager:** Alan Fudge.
- **Project Leader:** Sara Algots.
- **Software Development:** Scott M. Burke, Brian J. Maguire.
- **Physics Content Organization:** Scott M. Burke, Jerry Cooperstein, Karl J. Smith.
- **User's Guide:** Spike Albright.
- **User's Guide Editing:** Scott M. Burke, Alan Fudge, Brian J. Maguire, Bill Welsch.
- **Beta Testers:** Harri Ahola, Patrick Feisthammel, Scott Gustafson, Ned Holbrook, Juha Husgafvel, Brad Leutwyler, Bill Welsch.

Sparcom Corporation
P.O. Box 927
Corvallis, OR 97339
U.S.A.

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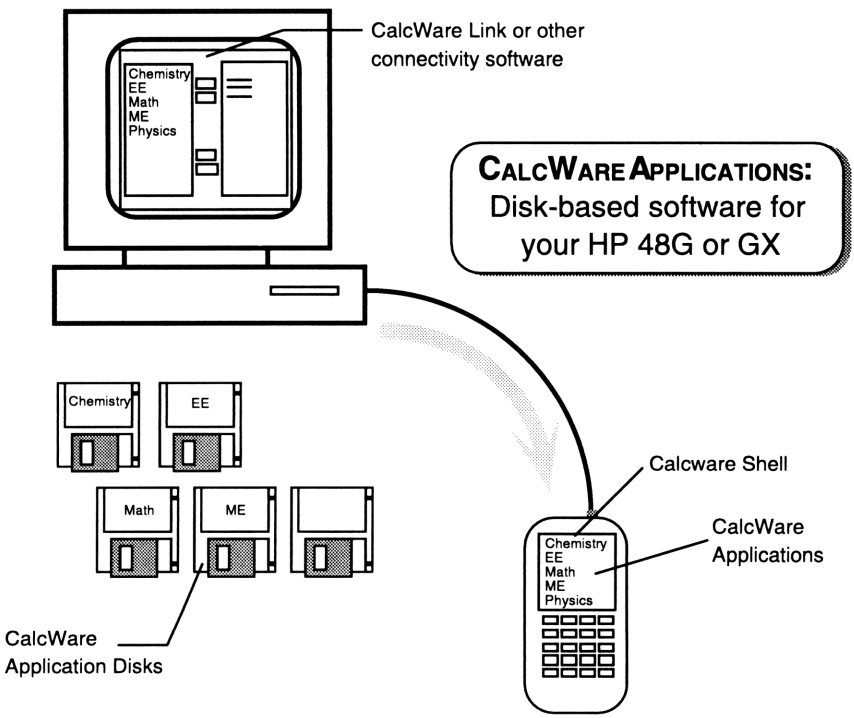
Introduction to CalcWare



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:

	Y =	
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.

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:

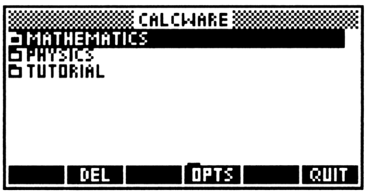
[►] Mathematics
  [►] Tutorial
    [►] Trigonometric Functions

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.

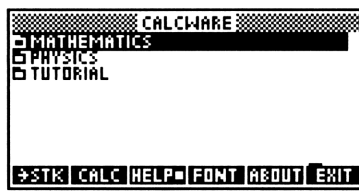
QUIT Exits CalcWare and returns to the HP 48 stack.

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:

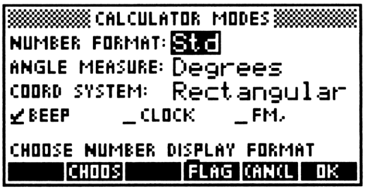
modes

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

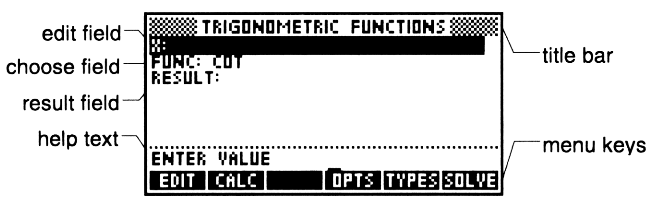
What is the secant of 45°?

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

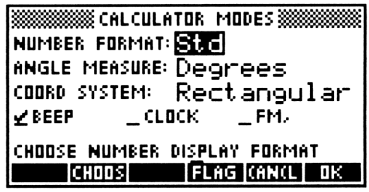


NOTE	When you enter the first CalcWare application screen for this product, you must enter the serial number that appears on the inside front cover of this manual.

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

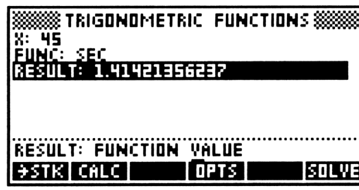
1. Set the modes (*if necessary*):
   a. Press ↱ MODES to go to the Calculator Modes screen.
   b. Set the modes as listed in the Example heading above:

      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.

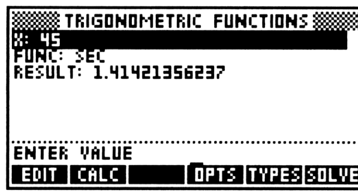
[2] Some analysis routines have too many result fields to display on the input screen; in such cases, a separate output screen is displayed with all the result fields.

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.

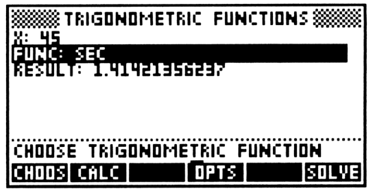
TYPES Displays the allowed object types, such as real number, list, real array, algebraic, etc. (see the table below). Move the highlight bar to the desired input type and press **NEW** to enter a new item of that type, with the appropriate delimiters. Or press **OK** to return to the analysis screen 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.

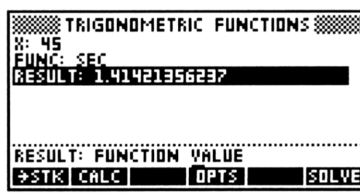
CALC Copies the highlighted item to the HP 48 stack and allows you to view and/or manipulate the item at the stack. Edits made at the stack will not affect the value in a choose field. Press **EXIT** to leave the stack and return to CalcWare.

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

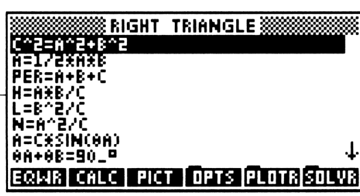
Given that one side of a right triangle measures 5 cm and that the angle opposite that side measures 30 degrees, find the length of the other two sides, the other angle (besides the right angle), the area, and the perimeter of the triangle.

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



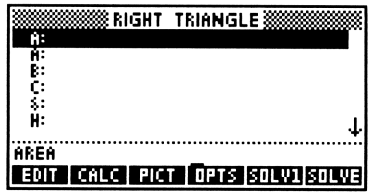
Right Triangle Equations screen

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:

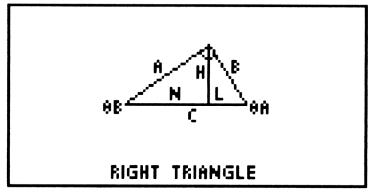
Solve the equation set

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.



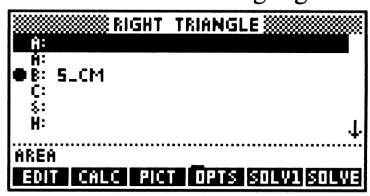
Solver screen

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 **θa**, or **b** and **θb**—it makes no difference. Press any key to return to the Solver screen.



Right triangle picture

4. Enter the values for the known variables **b** and **θb**. 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 **θa** 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.

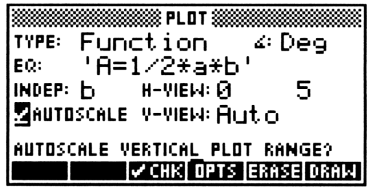
Converted units

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, **θa** = 60°, **A** = 21.65 cm^2, and **per** = 23.66 cm.

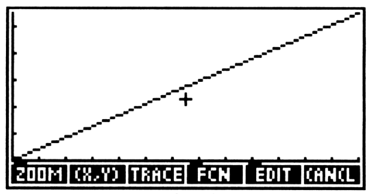
Plot one equation

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.



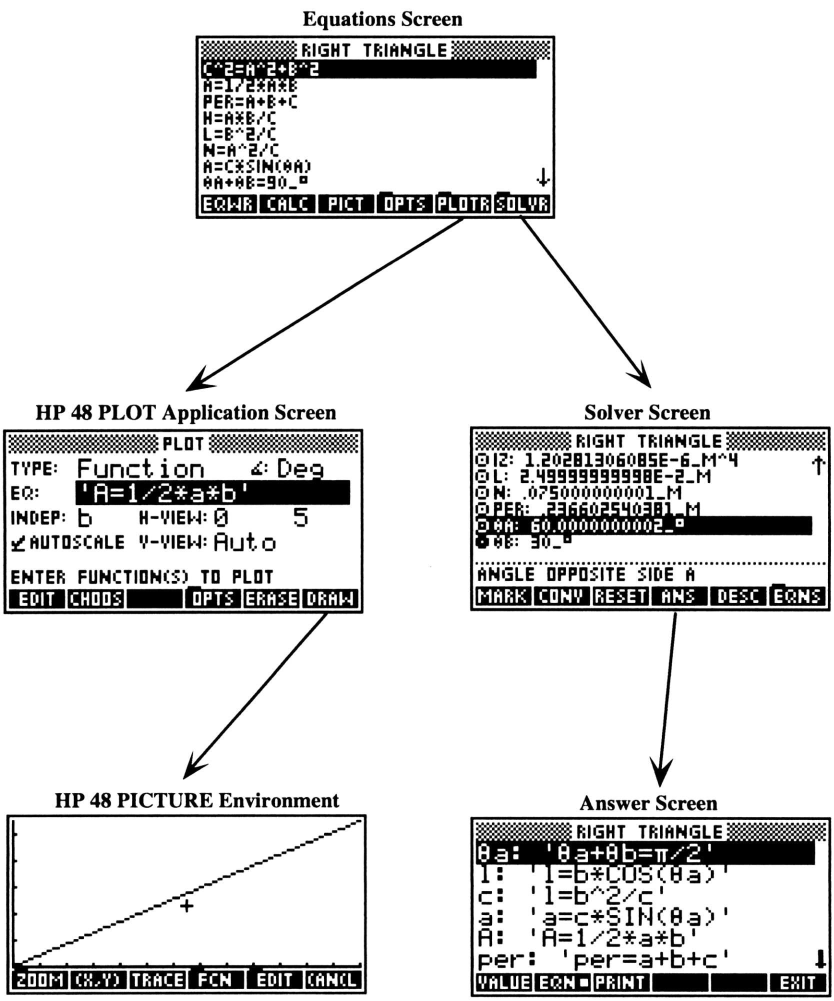
HP 48 PLOT Application screen



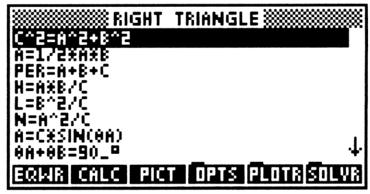
Plot of A=1/2*a*b

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



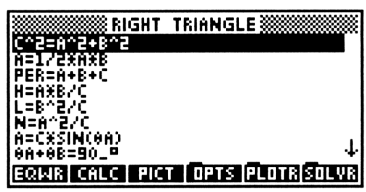
Right Triangle Equations screen

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.

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.

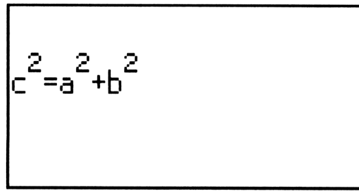
OPTS Displays the Options menu. Refer to "To use the Options menu," page 17.

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

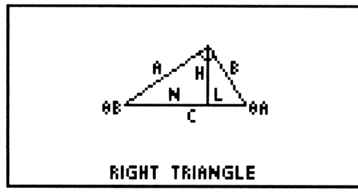
To display an equation in a graphics view using the HP 48 EquationWriter, move the highlight bar to the desired equation and press EQWR. Press CANCEL CANCEL to return to the Equations screen.



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.

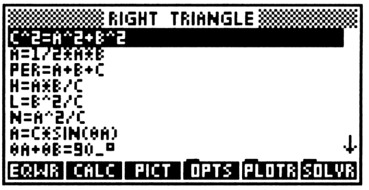
The Solver can handle only real numbers or unit objects as inputs or results; complex numbers can only be used in analysis routines. If an equation has only complex roots, the Solver will probably halt at an extremum and return an incorrect real result. This is commonly indicated by the message, "Extremum,"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

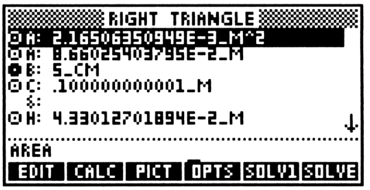
To reset the values of variables, press NXT **RESET**. This will clear the values of all variables at the Solver screen and purge the variables from user memory.

Converting a value

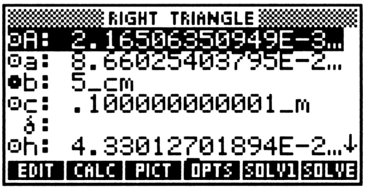
Once a variable value has been entered or solved for, it can easily be converted to different units. To do this, highlight the desired variable and press **CONV**. The value is placed on the edit line and the units available for the highlighted variable are displayed as menu keys (press NXT for more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



Large font, help text off

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.

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.

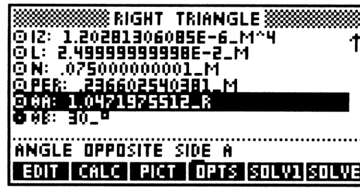
⊙ **Found Variable**
A circle with a dot in the middle (⊙) indicates that a solution was found for the variable by the Solver during the most recent solve operation.

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.

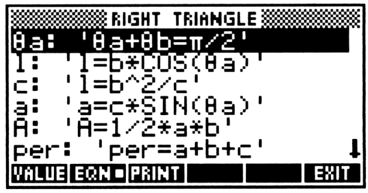
CONV Converts the value of the highlighted variable to a different unit. Refer to "Converting a value," page 33.

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.

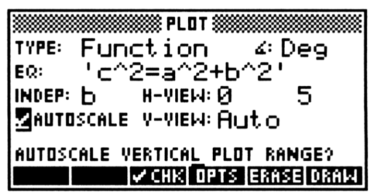
HP 48 PLOT Application Screen

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.



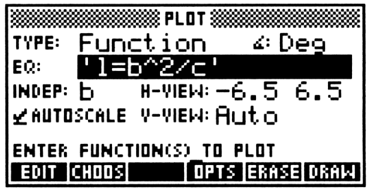
HP 48 PLOT Application screen

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.
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.

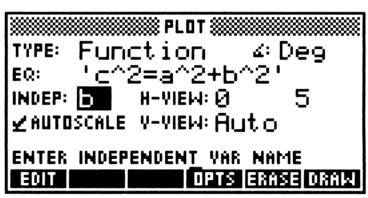
AUTOSCALE: (*Autoscale vertical axis*) Press ✓CHK to autoscale the plot. If autoscale is checked (✓), the values for **V-VIEW** are changed to Auto.

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.

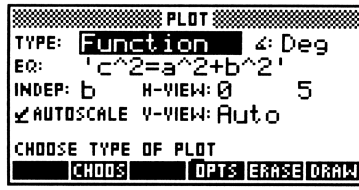
OPTS Displays the Plot Options screen. Refer to "Plot Options screen," page 40.

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.

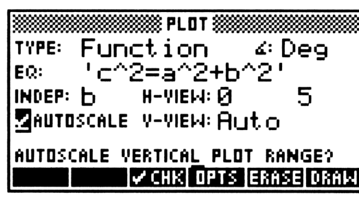
OPTS Displays the Plot Options screen. Refer to "Plot Options screen," page 40.

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.



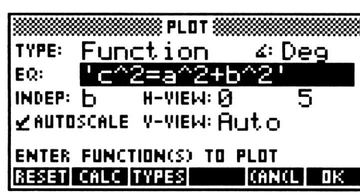
✓CHK Toggles a check mark.

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.

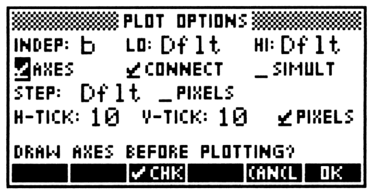
TYPES Displays the allowed object types, such as real number, list, real array, algebraic, etc. (see the table on page 23). Move the highlight bar to the desired input type and press **NEW** to enter a new item of that type, with the appropriate delimiters. Or press **OK** to return to the the PLOT application 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

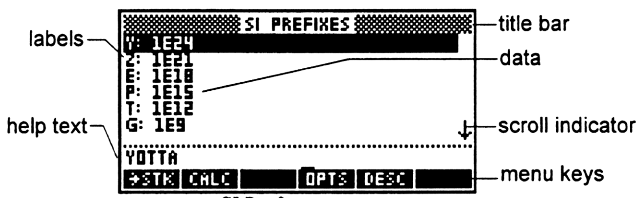
What is the SI prefix for a bigillion?

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

Mechanics & Thermodynamics

Mathematics
- Algebraic Functions
  - Taylor Polynomial
- Coordinate Systems
  - XY ↔ Polar
  - XYZ ↔ Cylindrical
  - XYZ ↔ Spherical
- Hyperbolics
  - Hyperbolic Functions
- Trigonometry
  - Trigonometric Functions
- Vectors
  - Vector Functions
  - Cross Products
  - Curl
  - Del Operator
  - Divergence
  - Dot Products
  - Gradient
  - Laplacian

Physics
- Angular Mechanics
  - Angular Motion
  - Banked Curves
  - Circular Motion
  - Momentum and Precession
  - Momentum, Torque, and Work
  - Parallel Axis Theorem
  - Moments of Inertia
- Fluid Mechanics
  - Bernoulli's Equation
  - Flow Velocity
  - Poiseuille's Law
  - Pressure and Density
  - Pressure Variation
  - Reynolds Number
  - Stokes' Law
- Forces
  - Drag Force
  - Frictional Force
  - Coefficients of Friction (μ)
- Gravitation
  - Escape Velocity
  - Free Falling Object
  - Gravitational Force
  - Orbits (Circular)
  - Orbits (Elliptical)
  - Projectile Motion
  - Terminal Velocity
- Linear Mechanics
  - Center of Mass
  - Collisions (Elastic)
  - Collisions (Elastic, Fixed m2)
  - Collisions (Inelastic)
  - Linear Motion
  - Momentum, Force, and Work
  - Rocket Science
  - Object Centroids
- Thermodynamics
  - Adiabatic Expansion
  - Carnot Cycle
  - Entropy
  - First Law of Thermodynamics
  - Heat Capacity
  - Heat Engines & Refrigerators
  - Heat of Transformation
  - Ideal Gas Law
  - Isothermal Expansion
  - Thermal Conduction
  - Thermal Expansion
  - Coef. of Linear Expansion (α)

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

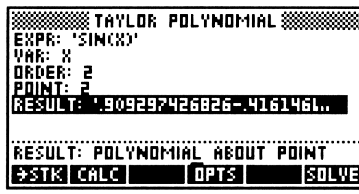
This application computes the *Taylor polynomial* of a function to the specified order about a given point.

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 () 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?

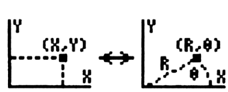
Given: x = 7
y = 13

Results: **r** = 14.76
θ = 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.



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

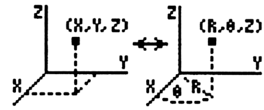
$$r = \sqrt{x^2 + y^2} \qquad \theta = \mathrm{ASIN}\left(\frac{y}{r}\right)$$

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.



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

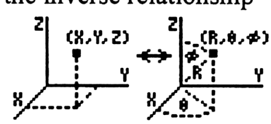
$$r=\sqrt{x^2+y^2} \qquad \theta=\mathrm{ASIN}\left(\frac{y}{r}\right)$$

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



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

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

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:

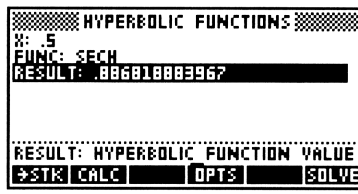
• SINH	• ASINH
• COSH	• ACOSH
• TANH	• ATANH
• COTH	• ACOTH
• SECH	• ASECH
• CSCH	• ACSCH

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 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:

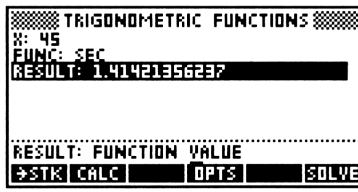
• SIN	• ASIN
• COS	• ACOS
• TAN	• ATAN
• COT	• ACOT
• SEC	• ASEC
• CSC	• ACSC

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.



9 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:

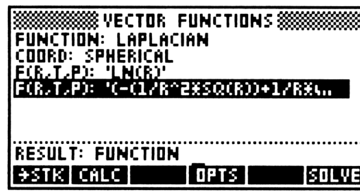
- Gradient
- Curl
- Divergence
- Laplacian

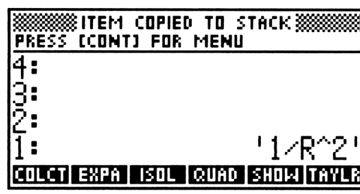
Example

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.

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

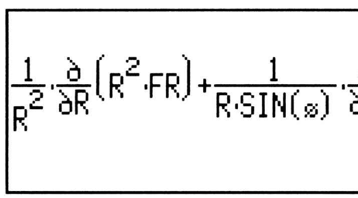
- Cross Product
- Curl
- Del Operator
- Divergence
- Dot Product
- Gradient
- Laplacian

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**, **Fθ**, 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.

10 Angular Mechanics

This chapter covers:

- ❑ Angular Motion
- ❑ Banked Curves
- ❑ Circular Motion
- ❑ Momentum and Precession
- ❑ Momentum, Torque, and Work
- ❑ Parallel Axis Theorem
- ❑ Moments of Inertia

To install Angular 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 Angular Mechanics screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 angular		Angular Mechanics
🖹 angmotn.eqn	→	Angular Motion
🖹 bankcurv.eqn	→	Banked Curves
🖹 circmotn.eqn	→	Circular Motion
🖹 momnprec.eqn	→	Momentum and Precession
🖹 momntorq.eqn	→	Momentum, Torque, and Work
🖹 parlaxis.eqn	→	Parallel Axis Theorem
🖹 momniner.eqn	→	Moments of Inertia

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	total acceleration	m/s^2
ac	centripetal acceleration	m/s^2
at	tangential acceleration	m/s^2
f	frequency	Hz
Fc	centripetal force	N
I	moment of inertia	kg/m^2
Icm	I at center of mass	kg/m^2
Kf	final kinetic energy	J
Ki	initial kinetic energy	J
L	angular momentum	$kg\ m^2/s$
m	mass	kg
N	normal force	N
Pavg	average power	W
pt	tangential momentum	kg m/s
r	radius	m
s	arc length	m
T	period	s
t	time	s
v	velocity	m/s
vt	tangential velocity	m/s
W	work	J
x	x position	m
y	y position	m
α	angular acceleration	r/s^2
θ	angular displacement	r
θb	bank angle	r
θf	final angular displacement	r
θi	initial angular displacement	r
τ	torque	N m
ω	angular velocity	r/s
Ω	precession rate	r/s
ωavg	average angular velocity	r/s
ωf	final angular velocity	r/s
ωi	initial angular velocity	r/s

Example: Banked Curves

Standard
Degrees
Rectangular

A car is going around a curve of radius 700 m, banked at an angle of 7°. How fast can it go before it will escape the road?

Given: **θb** = 7°
r = 700 m

Result: **v** = 29 m/s
= 65 mph

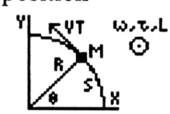
If the mass of the car is known, the normal force can also be calculated.

Angular Motion

Physics Series
Angular Mechanics
➢ ***Angular Motion***

Y =

These equations describe the fundamentals of Newtonian angular motion at constant angular acceleration α. The first equation computes the final angular velocity **ωf** using the initial angular velocity **ωi**, time **t**, and α. The second equation relates **ωf** to the change in angular position **θf–θi**. The next two equations compute the average angular velocity **ωavg**. The last three equations compute the final angular position, **θf**.



$$\omega f=\omega i+\alpha\cdot t \qquad \omega f^{2}=\omega i^{2}+2\cdot\alpha\cdot(\theta f-\theta i) \qquad \omega avg=\frac{1}{2}\cdot(\omega i+\omega f)$$

$$\omega avg=\frac{(\theta f-\theta i)}{t} \qquad \theta f=\theta i+\omega i\cdot t+\frac{1}{2}\cdot\alpha\cdot t^{2} \qquad \theta f=\theta i+\omega f\cdot t-\frac{1}{2}\cdot\alpha\cdot t^{2}$$

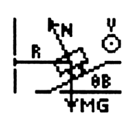
$$\theta f=\theta i+\omega avg\cdot t$$

Banked Curves

Physics Series
Angular Mechanics
➢ ***Banked Curves***

Y =

These equations describe a vehicle moving along a banked curve. They allow calculations of the bank angle θ for specified maximum velocity **v** and curve radius **r**.



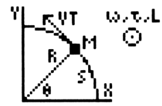
$$N\cdot SIN(\theta b)=\frac{m\cdot v^{2}}{r} \qquad N\cdot COS(\theta b)=m\cdot g \qquad TAN(\theta b)=\frac{v^{2}}{r\cdot g}$$

Circular Motion

Physics Series
Angular Mechanics
➢ ***Circular Motion***

Y =

These equations describe circular motion (angular motion at constant radius). They relate centripetal force, arc length, linear position, angle, tangential velocity, and centripetal and tangential acceleration. The expressions involving the frequency and period may be used only when the angular acceleration vanishes.



$Fc=m\cdot ac$	$ac=\frac{vt^2}{r}$	$ac=\omega^2\cdot r$
$at=\alpha\cdot r$	$a^2=at^2+ac^2$	$vt=\omega\cdot r$
$s=r\cdot\theta$	$x=r\cdot COS(\theta)$	$y=r\cdot SIN(\theta)$
$r^2=x^2+y^2$	$\omega=2\cdot\pi\cdot f$	$T=\frac{1}{f}$

Momentum and Precession

Physics Series
Angular Mechanics
➢ ***Momentum and Precession***

Y =

These equations cover the angular momentum and precession of an object in terms of its moment of inertia and angular velocity.

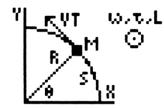
$L=I\cdot\omega$	$I=m\cdot r^2$	$\Omega=\frac{m\cdot g\cdot r}{I\cdot\omega}$
$\omega=2\cdot\pi\cdot f$	$T=\frac{1}{f}$	

Momentum, Torque, and Work

Physics Series
Angular Mechanics
➢ ***Momentum, Torque, and Work***

Y =

These equations relate angular momentum, work, kinetic energy, torque, and particle angular momentum. The first three equations define **τ**, **Ki** and **Kf**, the torque, initial and final kinetic energies of an object with moment of inertia **I** and initial and final angular velocities **ωi** and **ωf**. The fourth equation gives the work done on the object in terms of the change in kinetic energy. The next two equations compute the work done by a constant external torque τ, and also **Pav**, the average power expended in time **t**. The last three equations give the angular momentum of a particle at distance **r** from a fixed axis, in terms of its tangential velocity **vt** and tangential momentum **pt**.



$\tau=I\cdot\alpha$	$Ki=\frac{1}{2}\cdot I\cdot\omega i^{2}$	$Kf=\frac{1}{2}\cdot I\cdot\omega f^{2}$
$W=Kf-Ki$	$W=\tau\cdot(\theta f-\theta i)$	$Pavg=\frac{W}{t}$
$L=pt\cdot r$	$L=m\cdot vt\cdot r$	$pt=m\cdot vt$

Parallel Axis Theorem

Physics Series
Angular Mechanics
➢ ***Parallel Axis Theorem***

Y =

The parallel axis theorem relates the moment of inertia of a body about its centroid (center of mass) **Icm** to the moment of inertia about a point a distance **r** from the center of mass.

$$I=Icm+m\cdot r^{2}$$

Moments of Inertia

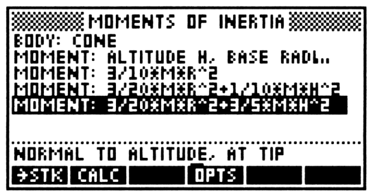
The Moments of Inertia reference table contains moment of inertia information for twelve solids. The information can be viewed or copied to the stack.

Example

Standard
Degrees
Rectangular

Where are the moments of inertia for a cone?

1. Move the highlight bar to **BODY**, press CHOOS, and highlight Cone and press OK.
2. Scroll through the data list by pressing ▲ and ▼. The moments of inertia are identified in the help text.



11 Fluid Mechanics

This chapter covers:

- ❑ Bernoulli's Equation
- ❑ Flow Velocity
- ❑ Poiseuille's Law
- ❑ Pressure and Density
- ❑ Pressure Variation
- ❑ Reynolds Number
- ❑ Stokes' Law

To install Fluid 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 Fluid Mechanics screen.

Computer File Structure		HP 48 CalcWare Structure
c:\		
calcware		
physics		Physics
fluids		Fluid Mechanics
🗎 bernouli.eqn	→	Bernoulli's Equation
🗎 flowvel.eqn	→	Flow Velocity
🗎 poiseuil.eqn	→	Poiseuille's Law
🗎 presdens.eqn	→	Pressure and Density
🗎 presvari.eqn	→	Pressure Variation
🗎 reynolds.eqn	→	Reynolds Number
🗎 stokslaw.eqn	→	Stokes' Law

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
A1	area 1	m^2
A2	area 2	m^2
D	pipe diameter	m
F	force	N
l	length	m
m	mass	kg
Re	Reynolds number	unitless
P	pressure	N/m^2
P1	pressure at 1	N/m^2
P2	pressure at 2	N/m^2
Q	volume flow rate	m^3/s
r0	pipe radius	m
r	radius	m
V	volume	m^3
v	velocity	m/s
v1	velocity 1	m/s
v2	velocity 2	m/s
vt	terminal velocity	m/s
y1	y position 1	m
y2	y position 2	m
η	viscosity	P (poise)
ρ	density	kg/m^3
ρfl	fluid density	kg/m^3

Example: Pressure and Density

Standard
Degrees
Rectangular

Find the mass of 7.4 m^3 of air at a density of 0.001 g/cm^3.

Given: **V** = 7.4 m^3
ρ = .001 g/cm^3
= 1 kg/m^3

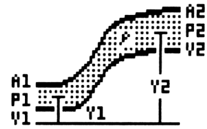
Result: **m** = 7.4 kg

Bernoulli's Equation

Physics Series
Fluid Mechanics
➢ ***Bernoulli's Equation***

Y =

This is Bernoulli's equation, which governs flow of an incompressible fluid of density ρ along a stream line. It allows one to calculate the pressure change **P2–P1** when there is a change of height and/or a change of velocity.



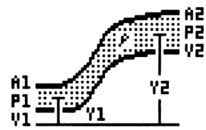
$$P2-P1+\frac{1}{2}\cdot\rho\cdot\left(v2^2-v1^2\right)+\rho\cdot g\cdot(y2-y1)=0$$

Flow Velocity

Physics Series
Fluid Mechanics
➢ ***Flow Velocity***

Y =

These equations cover the fluid flow rate **Q** through a pipe where the fluid enters one end (of cross-sectional area **A1**) at velocity **v1** and leaves at the other end (of cross-sectional area **A2**) at velocity **v2**. It expresses continuity of mass flow.



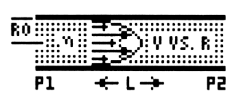
$$A1\cdot v1=A2\cdot v2 \qquad Q=A1\cdot v1 \qquad Q=A2\cdot v2$$

Poiseuille's Law

Physics Series
Fluid Mechanics
➢ ***Poiseuille's Law***

Y =

The first equation expresses Poiseuille's Law, which gives **Q**, the volume rate of laminar flow of an incompressible fluid of viscosity η through a pipe of radius **r0** and length **l**, with a pressure differential of **P1–P2** over the pipe's length. The second equation gives **v**, the fluid velocity within the pipe as a function of **r**, the distance from the central axis, where **r** < **r0**.



$$Q=\frac{\pi}{8}\cdot\left(\frac{r0^4}{\eta}\right)\cdot\left(\frac{(P1-P2)}{l}\right) \qquad v=\frac{(P1-P2)}{4\cdot\eta\cdot l}\cdot\left(r0^2-r^2\right)$$

Pressure and Density

Physics Series
Fluid Mechanics
➤ ***Pressure and Density***

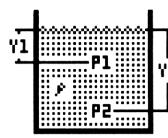
Y = These equations define the density ρ in terms of the mass **m** that occupies a volume **V**, and the pressure **P** as the force **F** on an area **A**.

$$\rho=\frac{m}{V} \qquad P=\frac{F}{A}$$

Pressure Variation

Physics Series
Fluid Mechanics
➤ ***Pressure Variation***

Y = This equation gives the difference in pressure according to height (or depth) in an incompressible fluid of density ρ between vertical positions **y1** and **y2**.



$$P2=P1+\rho\cdot g\cdot(y1-y2)$$

Reynolds Number

Physics Series
Fluid Mechanics
➢ ***Reynolds Number***

Y =

This equation defines **Re**, the Reynolds number, for the flow of an incompressible fluid of density ρ and viscosity η at velocity **v** through a pipe or tube of diameter **D**. When **Re** is greater than 3000 the flow is turbulent; below 2000 the flow is laminar; and in between these values the flow is transitional.

$$Re=\frac{\rho\cdot v\cdot D}{\eta}$$

Stokes' Law

Physics Series
Fluid Mechanics
➢ ***Stokes' Law***

Y =

The first equation is Stokes' Law, which gives the viscous drag force on a sphere of radius **r** moving at velocity **v** through a fluid of viscosity η. The second equation gives the terminal velocity **vt** for a sphere of density ρ falling through a fluid of density ρ**fl**.

$$F=6\cdot\pi\cdot\eta\cdot r\cdot v \qquad vt=\frac{2}{9}\cdot\left(\frac{r^2\cdot g}{\eta}\right)\cdot(\rho-\rho fl)$$

12 Forces

This chapter covers:

- ❑ Drag Force
- ❑ Frictional Force
- ❑ Coefficients of Friction

To install Forces

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 Forces screen.

Computer File Structure		HP 48 CalcWare Structure
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 forces		Forces
🗎 dragforc.eqn	→	Drag Force
🗎 fricforc.eqn	→	Frictional Force
🗎 coefrict.ref	→	Coefficients of Friction

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	area	m^2
Cd	drag coefficient	unitless
F	force	N
fk	kinetic friction force	N
fs	static friction force	N
m	mass	kg
N	normal force	N
v	velocity	m/s
μk	coefficient of kinetic friction	unitless
μs	coefficient of static friction	unitless
ρ	density	kg/m^3

Example: Frictional Force

Standard
Degrees
Rectangular

An object exerts a normal force of 24 N on a surface with which it has a coefficient of static friction of 0.14 and a coefficient of kinetic friction of 0.10. What force is required to dislodge the block from rest, and what force is required to keep it moving at constant velocity?

Given: **N** = 24 N
μs = 0.14
μk = 0.10

Results: **fs** = 3.36 N
fk = 2.4 N

Drag Force

Phyics Series
Forces
➢ ***Drag Force***

Y =

These equations describe the drag force **F** and terminal velocity **v** associated with an object of mass **m** and cross-sectional area **A** moving through a fluid (including air) of density ρ.

$$F=Cd\cdot\left(\frac{\rho\cdot v^{2}}{2}\right)\cdot A \qquad v=\sqrt{\frac{2\cdot m\cdot g}{Cd\cdot\rho\cdot A}}$$

Frictional Force

Physics Series
Forces
➢ ***Frictional Force***

Y =

These equations describe the static and kinetic frictional forces encountered by an object at rest or moving along a surface which acts upon it with normal force **N**.

$$fs=\mu s\cdot N \qquad fk=\mu k\cdot N$$

Coefficients of Friction (μ)

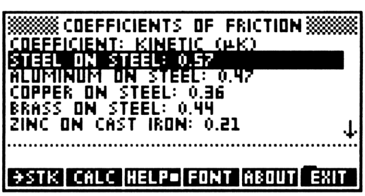
Physics Series
Forces
➢ ***Coefficients of Friction (μ)***

The Coefficients of Friction reference table contains the static and kinetic coefficients of friction for various pairs of substances. The information may be viewed or copied to the stack.

Example

Standard
Degrees
Rectangular

What is the kinetic coefficient of friction for steel on steel?



1. Move the highlight bar to **COEFFICIENT** and press CHOOS. Highlight Kinetic (μk) and press OK.
2. Scroll through the data list by pressing ▲ and ▼ until the answer is found (the second item in the list).

13 Gravitation

This chapter covers:

- ❑ Escape Velocity
- ❑ Free Falling Object
- ❑ Gravitational Force
- ❑ Orbits (Circular)
- ❑ Orbits (Elliptical)
- ❑ Projectile Motion
- ❑ Terminal Velocity

To install Gravitation

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 Gravitation screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗀 c:\		
🗀 calcware		
🗀 physics		Physics
🗀 gravity		Gravitation
🗎 escapvel.eqn	→	Escape Velocity
🗎 freefall.eqn	→	Free Falling Object
🗎 gravforc.eqn	→	Gravitational Force
🗎 orbitcir.eqn	→	Orbits (Circular)
🗎 orbitell.eqn	→	Orbits (Elliptical)
🗎 projmotn.eqn	→	Projectile Motion
🗎 termvel.eqn	→	Terminal Velocity

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	cross sectional area	m^2
a	semi-major axis	m
a1	acceleration of m1	m/s
a2	acceleration of m2	m/s
Cd	drag coefficient	unitless
E	eccentricity	unitless
Etot	total energy	J
F	gravitational force	N
Fc	centripetal force	N
H	maximum height	m
K	kinetic energy	J
Kf	final kinetic energy	J
Ki	initial kinetic energy	J
m	mass	kg
m1	mass 1	kg
m2	mass 2	kg
mc	central mass	kg
Mp	planet mass	kg
ms	orbiting satellite mass	kg
R	maximum range	m
r	separation	m
ra	aphelion	m
Rp	planet radius	m
rp	perihelion	m
T	period	s
t	time	s
U	potential energy	J
Uf	final potential energy	J
Ui	initial potential energy	J
v	velocity	m/s
vf	final velocity	m/s
vi	initial velocity	m/s
vx	x velocity	m/s
vy	y velocity	m/s
xf	final x position	m
xi	initial x position	m
yf	final y position	m
yi	initial y position	m
θ	launch angle	r
ρ	fluid density	kg/m^3

Example: Free Falling Object

Standard
Degrees
Rectangular

Part 1: An object of mass 1.3 kg is thrown upward from the ground with an initial velocity of 20 m/s. How high will it go before it turns around?

Given:	**m** = 1.3 kg	**Result:**	**yf** = 20.4 m
	yi = 0 m		
	vi = 20 m/s		
	vf = 0 m/s		

Part 2: When it falls back down, what will be its kinetic and gravitational potential energies when it has fallen halfway back down to the ground, and how long will this take?

Given:	**m** = 1.3 kg	**Results:**	**Kf** = 130 J
	yi = 20.4 m		**Uf** = 130 J
	yf = 10.2 m		**t** = 1.44 s
	vi = 0 m/s		

In the second part, both **t** = 1.44 s and **t** = –1.44 s solve the problem mathematically, but the positive time is the physical solution. The calculator may arrive at either answer depending on the initial value stored for **t**.

Escape Velocity

Phyics Series
Gravitation
➢ *Escape Velocity*

Y =

This equation gives the escape velocity necessary for an object to escape a planet of mass **Mp** from a distance **Rp** from its center. If the object is at the surface of the planet, **Rp** is the planet radius. The object's mass is assumed to be negligible in comparison to the planet mass.

$$v=\sqrt{\frac{2\cdot G\cdot Mp}{Rp}}$$

Free Falling Object

Y =

These equations describe the motion of a freely falling object of mass **m** in the Earth's gravitational field, using the equations of linear motion with **a** = **–g**. With these equations, the initial and final positions, velocities, and kinetic and potential energies can be calculated as a function of time.

$$vf=vi-g\cdot t \qquad yf=yi+vi\cdot t-\frac{1}{2}\cdot g\cdot t^2 \qquad yf=yi+vf\cdot t+\frac{1}{2}\cdot g\cdot t^2$$

$$vf^2=vi^2-2\cdot g\cdot (yf-yi) \qquad Ki=\frac{1}{2}\cdot m\cdot vi^2 \qquad Kf=\frac{1}{2}\cdot m\cdot vf^2$$

$$Ui=m\cdot g\cdot yi \qquad Uf=m\cdot g\cdot yf$$

$$Etot=Ki+Ui \qquad Etot=Kf+Uf$$

Gravitational Force

Y =

These equations cover the gravitational attraction between two masses, **m1** and **m2**, separated by a distance **r**. Computed are the attractive force, the acceleration of each mass, and the potential energy of interaction.

$$F=\frac{G\cdot m1\cdot m2}{r^2} \qquad a1=\frac{G\cdot m2}{r^2}$$

$$a2=\frac{G\cdot m1}{r^2} \qquad U=\frac{-G\cdot m1\cdot m2}{r}$$

Orbits (Circular)

Y =

These equations cover Kepler's third law of motion, which relates the orbital period to the separation between and masses of two objects. In this simplified case, the central mass **mc** is assumed to be much greater than the orbiting satellite mass **ms** and the orbit is taken to be circular. The second equation gives the velocity of the orbiting mass, the third gives the centripetal force supplied by gravitation, the fourth gives the kinetic energy, and the fifth computes the potential energy associated with the orbit.

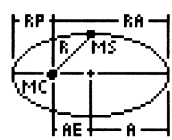
$$T^2=\frac{4\cdot\pi^2}{G\cdot(mc+ms)}\cdot r^3 \qquad v^2=\frac{G\cdot mc}{r} \qquad Fc=\frac{ms\cdot v^2}{r}$$

$$K=\frac{G\cdot ms\cdot mc}{2\cdot r} \qquad U=\frac{-G\cdot ms\cdot mc}{r}$$

Orbits (Elliptical)

Y =

These equations cover Kepler's third law of motion, which relates the orbital period to the separation between and masses of two objects. The equations are *not* simplified for the case where the central mass **mc** is much greater than the orbiting mass **ms**, or for the case where the orbit is circular. The second equation gives the velocity of the orbiting mass and the third gives the kinetic energy at any point along the orbit. The last two equations determine **ra** and **rp**, the aphelion and perihelion distances, as a function of **E** and **a**, the eccentricity and semimajor axis of the orbit.



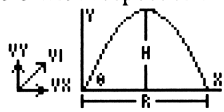
$$T^2=\frac{4\cdot\pi^2}{G\cdot(ms+mc)}\cdot a^3 \qquad v^2=G\cdot(ms+mc)\cdot\left(\frac{2}{r}-\frac{1}{a}\right)$$

$$K=\frac{1}{2}\cdot ms\cdot v^2 \qquad ra=a\cdot(1+E) \qquad rp=a\cdot(1-E)$$

Projectile Motion

Physics Series
Gravitation
➢ ***Projectile Motion***

Y = These equations describe the motion of a projectile launched with initial velocity **vi** from position (**xi**, **yi**), at launch angle θ with respect to the ground. The final position and velocity are expressed, as well as the maximum height and range the projectile may achieve.



$$xf = xi + vi \cdot \cos(\theta) \cdot t \qquad yf = yi + vi \cdot \sin(\theta) \cdot t - \frac{1}{2} \cdot g \cdot t^2$$

$$vx = vi \cdot \cos(\theta) \qquad vy = vi \cdot \sin(\theta)$$

$$vf^2 = vx^2 + vy^2 \qquad R = \frac{vi^2}{g} \cdot \sin(2 \cdot \theta)$$

$$H = yi + \frac{vi^2 \cdot \sin(\theta)^2}{2 \cdot g} \qquad xf = xi + \frac{\left(yf - yi + \frac{1}{2} \cdot g \cdot t^2\right)}{\tan(\theta)}$$

Terminal Velocity

Physics Series
Gravitation
➢ ***Terminal Velocity***

Y = This equation calculates the terminal velocity **v** achieved by an object of mass **m** and cross-sectional area **A** moving through a fluid (including air) of density ρ.

$$v = \sqrt{\frac{2 \cdot m \cdot g}{Cd \cdot \rho \cdot A}}$$

14 Linear Mechanics

This chapter covers:

- ❑ Center of Mass
- ❑ Collisions (Elastic)
- ❑ Collisions (Elastic, Fixed m2)
- ❑ Collisions (Inelastic)
- ❑ Linear Motion
- ❑ Momentum, Force, and Work
- ❑ Rocket Science
- ❑ Object Centroids

To install Linear 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 Linear Mechanics screen.

Computer File Structure		HP 48 CalcWare Structure
c:\		
calcware		
physics		Physics
linear		Linear Mechanics
🖹 centmass.eqn	→	Center of Mass
🖹 collelas.eqn	→	Collisions (Elastic)
🖹 collfixd.eqn	→	Collisions (Elastic, Fixed m2)
🖹 collinel.eqn	→	Collisions (Inelastic)
🖹 linrmotn.eqn	→	Linear Motion
🖹 momforce.eqn	→	Momentum, Force, and Work
🖹 rockets.eqn	→	Rocket Science
🖹 objcentr.ref	→	Object Centroids

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	acceleration	m/s^2
F	force	N
Kf	final kinetic energy	J
Ki	initial kinetic energy	J
m	mass	kg
m1	mass 1	kg
m2	mass 2	kg
m3	mass 3	kg
m4	mass 4	kg
mf	final rocket mass	kg
mi	initial rocket mass	kg
p	momentum	kg m/s
Pavg	average power	W
R	fuel consumption	kg/s
t	time	s
u	exhaust gas velocity	m/s
v	velocity	m/s
v1f	final velocity of m1	m/s
v1i	initial velocity of m1	m/s
v2f	final velocity of m2	m/s
v2i	initial velocity of m2	m/s
vavg	average velocity	m/s
vcm	center of mass velocity	m/s
vf	final velocity	m/s
vi	initial velocity	m/s
W	work	J
x1	x position of m1	m
x2	x position of m2	m
x3	x position of m3	m
x4	x position of m4	m
xcm	center of mass, x position	m
xf	final position	m
xi	initial position	m
y1	y position of m1	m
y2	y position of m2	m
y3	y position of m3	m
y4	y position of m4	m
ycm	center of mass, y position	m

Example: Rocket Science

Standard
Degrees
Rectangular

A rocket's engine expels 10 kg/s of exhaust gas at a velocity of 20 m/s relative to the rocket. If the rocket starts out at rest, what is its velocity when it has lost half of its mass in fuel?

Given: **R** = 10 kg/s
u = 20 m/s
vi = 0 m /s
mi = 1.0 kg
mf = 0.5 kg

Result: **vf** = 13.9 m/s

For the question posed, only the ratio of **mf** to **mi** is needed, and thus **mi** may be set to 1.0 kg and **mf** taken to be half of that value. Also, if **m** is set, the acceleration can be computed. However, note that if the rocket continually loses mass, the accleration will not be constant, so these two equations cannot be solved simultaneously, except in the approximation that the mass lost is much less than the mass of the rocket.

Center of Mass

Phyics Series
Linear Mechanics
➢ ***Center of Mass***

Y =

These equations compute the center of mass coordinates (**xcm**, **ycm**), of a system of up to four distinct objects lying in the xy-plane. If fewer than four objects are desired, leave the remaining masses zero.

$$xcm=\frac{(x1\cdot m1+x2\cdot m2+x3\cdot m3+x4\cdot m4)}{m1+m2+m3+m4}$$

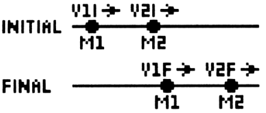
$$ycm=\frac{(y1\cdot m1+y2\cdot m2+y3\cdot m3+y4\cdot m4)}{m1+m2+m3+m4}$$

Collisions (Elastic)

Physics Series
Linear Mechanics
➢ *Colisions (Elastic)*

Y =

These equations describe a one-dimensional elastic collision between an object of mass **m1** moving at initial velocity **v1i** and an object of mass **m2** moving at initial velocity **v2i**. They relate the final and initial velocities and give the center of mass velocity, **vcm**. For the special case of a stationary target, set **v2i** = 0.



$$v1f=\frac{(m1-m2)}{m1+m2}\cdot v1i+\frac{2\cdot m2}{m1+m2}\cdot v2i \qquad v2f=\frac{2\cdot m1}{m1+m2}\cdot v1i+\frac{(m2-m1)}{m1+m2}\cdot v2i$$

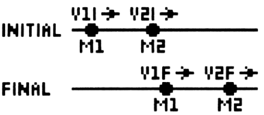
$$vcm=\frac{(m1\cdot v1i+m2\cdot v2i)}{m1+m2} \qquad vcm=\frac{(m1\cdot v1f+m2\cdot v2f)}{m1+m2}$$

Collisions (Elastic, Fixed m2)

Physics Series
Linear Mechanics
➢ *Collisions (Elastic, Fixed m2)*

Y =

These equations describe a one-dimensional elastic collision between an object of mass **m1** moving at initial velocity **v1i** and a fixed target of mass **m2**. They relate the final and initial velocities and give the center of mass velocity, **vcm**. These equations can be derived from the equation set for Collisions (Elastic), for the case **v2i** = 0.



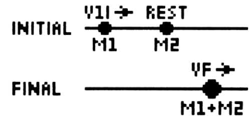
$$v1f=\frac{(m1-m2)}{m1+m2}\cdot v1i \qquad v2f=\frac{2\cdot m1}{m1+m2}\cdot v1i \qquad vcm=\frac{m1}{m1+m2}\cdot v1i$$

Collisions (Inelastic)

Phyics Series
Linear Mechanics
➤ ***Collisions (Inelastic)***

Y =

This equation describes a one-dimensional inelastic collision in which an object of mass **m1** and initial velocity **v1i** collides with a stationary target of mass **m2**. After the collision, the two objects move together at a final velocity **vf**.



$$vf=\frac{v1i\cdot m1}{m1+m2}$$

Linear Motion

Physics Series
Linear Mechanics
➤ ***Linear Motion***

Y =

These equations describe the fundamentals of Newtonian linear motion at constant acceleration **a**. The first equation computes the final velocity **vf** using the initial velocity **vi**, time **t**, and acceleration **a**. The second equation relates **vf** to the change in position **xf–xi**. The next two equations compute the average velocity **vavg**. The last three equations compute the final position **xf.**

$$vf=vi+a\cdot t \qquad vf^2=vi^2+2\cdot a\cdot(xf-xi) \qquad vavg=\frac{1}{2}\cdot(vi+vf)$$

$$vavg=\frac{(xf-xi)}{t} \qquad xf=xi+vi\cdot t+\frac{1}{2}\cdot a\cdot t^2 \qquad xf=xi+vf\cdot t-\frac{1}{2}\cdot a\cdot t^2$$

$$xf=xi+vavg\cdot t$$

Momentum, Force, and Work

Physics Series
Linear Mechanics
➢ ***Momentum, Force, and Work***

Y =

These equations relate momentum, work, kinetic energy, force, and particle momentum. The first two equations define **Ki** and **Kf**, the initial and final kinetic energies of an object with mass **m** and initial and final velocities **vi** and **vf**. The third equation gives the work **W** done on the object in terms of the change in kinetic energy. The next two equations assume a constant external force **F** and compute the work done and the average power expended, **Pavg**. The last three equations give the momentum of a particle moving at velocity **v**.

$$Ki=\frac{1}{2}\cdot m\cdot vi^2 \qquad Kf=\frac{1}{2}\cdot m\cdot vf^2 \qquad W=Kf-Ki$$

$$W=F\cdot(xf-xi) \qquad Pavg=\frac{W}{t} \qquad F=m\cdot a$$

$$p=m\cdot v$$

Rocket Science

Phyics Series
Linear Mechanics
➢ ***Rocket Science***

Y =

These equations describe rockets and other varying mass objects, relating the rocket acceleration **a** to the exhaust gas velocity **u** and fuel rate consumption **R**. The final velocity **vf** can be computed knowing the inital and final rocket masses, **mi** and **mf**.

$$R\cdot u=m\cdot a \qquad vf=vi+u\cdot LN\left(\frac{mi}{mf}\right)$$

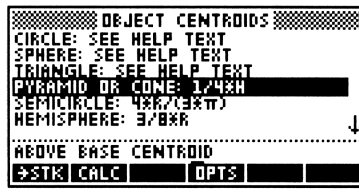
Object Centroids

The Object Centroids reference table contains information on the position of the centroid (center of mass) of various figures and solids. The information may be viewed or copied to the stack.

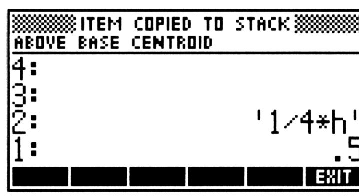
Example

Standard
Degrees
Rectangular

Where is the centroid of a cone of height 2 m?



1. Scroll through the object list by pressing [▲] and [▼] until Pyramid or Cone is found (the fourth item on the list).
2. The answer is shown to be 1/4*h, and the help text identifies this distance to be above the center of the cone's base centroid.



3. To compute the numerical value of the distance above the base centroid at which the cone's centroid is located, copy the equation to the stack by pressing **CALC**. Then, guided by the equation, press [1] [ENTER] [4] [÷] [2] [*]. The cone's centroid is shown to be 0.5 m above the base centroid of the cone.
4. Press **EXIT** to return to CalcWare.

15 Thermodynamics

This chapter covers:

- ❑ Adiabatic Expansion
- ❑ Carnot Cycle
- ❑ Entropy
- ❑ First Law of Thermodynamics
- ❑ Heat Capacity
- ❑ Heat Engines & Refrigerators
- ❑ Heat of Transformation
- ❑ Ideal Gas Law
- ❑ Isothermal Expansion
- ❑ Thermal Conduction
- ❑ Thermal Expansion
- ❑ Coef. of Linear Expansion (α)

To install Thermodynamics

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 Thermodynamics screen.

Computer File Structure		**HP 48 CalcWare Structure**
🗁 c:\		
🗁 calcware		
🗁 physics		Physics
🗁 thermo		Thermodynamics
🗎 adiabatc.eqn	→	Adiabatic Expansion
🗎 carncycl.eqn	→	Carnot Cycle
🗎 entropy.eqn	→	Entropy
🗎 firstlaw.eqn	→	First Law of Thermodynamics
🗎 heatcapc.eqn	→	Heat Capacity
🗎 heatengn.eqn	→	Heat Engines & Refrigerators
🗎 heattran.eqn	→	Heat of Transformation
🗎 idealgas.eqn	→	Ideal Gas Law
🗎 isotherm.eqn	→	Isothermal Expansion
🗎 thermcon.eqn	→	Thermal Conduction
🗎 thermexp.eqn	→	Thermal Expansion
🗎 coeflinr.ref	→	Coef. of Linear Expansion (α)

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
C	heat capacity	J/K
Cp	molecular specific heat at constant pressure	J/(K mol)
Cv	molecular specific heat at constant volume	J/(K mol)
E	thermal efficiency of engine	unitless
Eint	internal energy	J
H	heat conduction rate	W
K	performance coefficient of refrigeration	unitless
k	thermal conductivity	J/(K m s)
Kavg	average translational energy	J
L	slab thickness	m
Lf	heat of fusion	J/kg
Lv	heat of vaporization	J/kg
m	mass of object	kg
MWT	molecular weight	kg/mol
n	number of moles	mol
P	pressure	N/m^2
Pf	final pressure	N/m^2
Pi	initial pressure	N/m^2
Q	heat added to system	J
Qc	heat discharged by engine	J
Qf	heat needed to melt	J
Qh	heat taken in by engine	J
Qv	heat needed to vaporize	J
Rt	thermal resistance	$K\ m^2 s/J$
s	specific heat	J/(K kg)
S	entropy	J/K
T	temperature	K
Tc	temperature of cold reservoir	K
Tf	final temperature	K
Th	temperature of hot reservoir	K
Ti	initial temperature	K
V	volume	m^3
Vf	final volume	m^3
Vi	initial volume	m^3
vrms	root mean square speed	m/s

W	work done by system	J
w	number of system states	unitless
α	coeffient of linear expanansion	1/K
β	coeffient of volume expanansion	1/K
ΔEint	change in internal energy	J
ΔL	change in length	m
ΔQ	heat conducted through slab	J
ΔS	change in entropy	J/K
Δt	time elapsed	s
ΔV	change in system volume	m^3
γ	ratio of molecular specific heats	unitless

Example: Heat of Transformation

Standard
Degrees
Rectangular

How much water can be vaporized at its boiling point by 2000 KJ of heat? If the same quantity of water is frozen to ice at its freezing point, how much heat is liberated? The heats of fusion and vaporization for water are:
Lf = 333 KJ/kg, Lv = 2260 KJ/kg.

Given:
Qv = 2000 KJ
Lv = 2260 KJ/kg
Lf = 333 KJ/kg

Results:
m = 0.885 kg
Qf = 294690 J
Qf = 295 KJ

Adiabatic Expansion

Phyics Series
Thermodynamics
Adiabatic Expansion

Y = This equation gives the work done by an ideal gas in adiabatic (isolated) expansion from **Vi** to **Vf**.

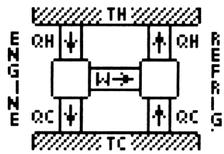
$$Pi \cdot Vi^{\gamma} = Pf \cdot Vf^{\gamma} \qquad \gamma = \frac{Cp}{Cv} \qquad \gamma = 1 + \frac{R}{Cv}$$

Carnot Cycle

Physics Series
Thermodynamics
➢ ***Carnot Cycle***

Y =

These equations describe the operation of ideal (reversible) heat engines and refrigerators following the Carnot Cycle. No real system can have a greater efficiency or coefficient of performance. The efficiency of the heat engine is denoted by **E**, and the performance coefficient of the refrigerator by **K**. The engine and refrigerator are each connected to a cold reservoir of temperature **Tc** and a hot reservoir of temperature **Th**.



$$E=\frac{(Th-Tc)}{Th} \qquad K=\frac{Tc}{Th-Tc}$$

Entropy

Physics Series
Thermodynamics
➢ ***Entropy***

Y =

These equations describe changes in the entropy of a system, **ΔS**. In the first equation, an amount of heat **Q** is added at temperature **T**. In the second equation, the volume of **n** moles of gas changes from **Vi** to **Vf**. This equation should only be used for free expansion, in which there is no external work done or heat transfer. The last equation defines the entropy as being proportional to the natural logarithm of the number of ways a system can be internally rearranged without changing its external macroscopic properties.

$$\Delta S=\frac{Q}{T} \qquad \Delta S=n\cdot R\cdot LN\left(\frac{Vf}{Vi}\right) \qquad S=k\cdot LN(w)$$

First Law of Thermodynamics

Phyics Series
Thermodynamics
➢ ***First Law of Thermodynamics***

Y = These equations give a system's change of internal energy **ΔEint** as the difference between **W**, the work done by the system when its volume changes from **Vi** to **Vf** at pressure **P**, and **Q**, the heat added to the system.

ΔEint=Q−W	W=P·ΔV	ΔV=Vf−Vi

Heat Capacity

Physics Series
Thermodynamics
➢ ***Heat Capacity***

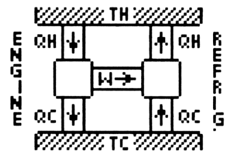
Y = These equations give **Q**, the heat added to an object of mass **m**, as when its temperature changes. The involve the heat capacity **C** and specific heat **s**.

Q=C·(Tf−Ti)	Q=s·m·(Tf−Ti)	C=s·m

Heat Engines & Refrigerators

Y =

These equations give **E**, the efficiency of a heat engine, and **K**, the performance coefficient of a refrigerator, either of which does an amount of work given by **W**. In the case of the heat engine, **Qc** is the heat discharged and **Qh** is the energy taken in by the engine. In the case of the refrigerator, **Qc** is the heat extracted by and **Qh** is the heat discharged by the refrigerator.



$$E=\frac{W}{Qh} \qquad E=\frac{(Qh-Qc)}{Qh}$$

$$K=\frac{Qc}{W} \qquad K=\frac{Qc}{Qh-Qc}$$

Heat of Transformation

Y =

These equations give the heat needed to vaporize a liquid or melt a solid. The heat released by the reverse processes of condensation and freezing is the negative of this quantity.

$$Qv=Lv\cdot m \qquad Qf=Lf\cdot m$$

Ideal Gas Law

Y = These equations cover the properties of an ideal gas, relating pressure, volume, temperature, internal energy, average molecular velocity and kinetic energy, and molar specific heats at constant volume and pressure. The last equation gives the molar specific heat for processes done at constant volume. A similar equation $Cp = \dfrac{Q}{n(Tf - Ti)}$ applies when heat is added at constant pressure.

$$P \cdot V = n \cdot R \cdot T \qquad P = \frac{n \cdot MWT \cdot vrms^2}{3 \cdot V} \qquad vrms = \sqrt{\frac{3 \cdot R \cdot T}{MWT}}$$

$$Kavg = \frac{3}{2} \cdot k \cdot T \qquad Eint = n \cdot Cv \cdot T \qquad Cp = Cv + R$$

$$Cv = \frac{Q}{n \cdot (Tf - Ti)}$$

Isothermal Expansion

Y = This equation gives the work done by an ideal gas in isothermal (constant temperature) expansion from **Vi** to **Vf**.

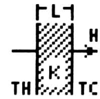
$$W = n \cdot R \cdot T \cdot LN\left(\frac{Vf}{Vi}\right)$$

Thermal Conduction

Physics Series
Thermodynamics
➢ ***Thermal Conduction***

Y =

These equations relate **H**, the heat conducted per unit time across a slab of thickness **L** and area **A**, with a temperature difference **Th–Tc** between its faces, to the material's thermal conductivity **k**, and thermal resistance **Rt**.



$$H=\frac{\Delta Q}{\Delta t} \qquad H=\frac{k\cdot A\cdot(Th-Tc)}{L} \qquad H=\frac{A\cdot(Th-Tc)}{Rt}$$

$$Rt=\frac{L}{k}$$

Thermal Expansion

Physics Series
Thermodynamics
➢ ***Thermal Expansion***

Y =

These equations relate the change in size and volume of a solid or a liquid to a change in its temperature. If only **ΔT** is known (and not **Tf** and **Ti**), then enter dummy values for **Tf** and **Ti** such that $Tf - Ti = \Delta T$. For a solid, the coefficients of volume and linear expansion are related by $\beta = 3\alpha$.

$$\Delta L=L\cdot\alpha\cdot(Tf-Ti) \qquad \Delta V=V\cdot\beta\cdot(Tf-Ti)$$

Coef. of Linear Expansion (α)

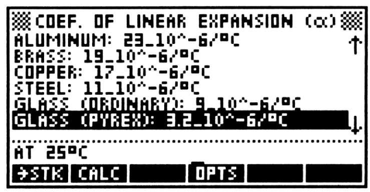
Physics Series
Thermodynamics
Coef. of Linear Expansion (α)

The Coefficients of Linear Expansion (α) reference table contains the coefficients of linear expansion for various common substances. The information may be viewed or copied to the stack

Example

Standard
Degrees
Rectangular

What is the coefficient of linear expansion for pyrex glass?



1. Scroll through the data list by pressing ▲ and ▼.
2. The coefficient of linear expansion for pyrex glass is 3.2×10^{-6} per °C at 25°C (room temperature).

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 π/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 π/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] 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 get 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 [C/] [C/] 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 12055-1A

Mechanics & Thermodynamics

Mechanics & Thermodynamics 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
Physics Lab
1st Year Engineering
Science

Saves Time

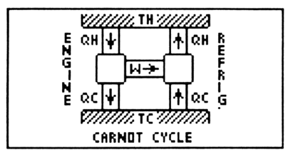
No need to program the HP 48G or HP 48GX. Just load the software and you are ready to go. Explore basic concepts and master the subject material at your own pace.

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.



(Mechanics & Thermodynamics Screen Capture)

Angular Mechanics *Fluid Mechanics* *Thermodynamics* *Friction*
Linear Mechanics *Gravitation* *Drag Force* *Vectors*

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

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