

# Using an HP48G Series Calculator to Determine Focus Distance, f-Number, Diffraction Limit f-Number, Shutter Speed and Base (for Stereography)

Michael K. Davis  
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Screenshots taken from the iPad version of the *m48* iOS application, developed by Mark Gonser.

**Skip to Page 12 for Field Use instructions.**

***m48* is a fully functional, exact replica, ROM emulation of the Hewlett Packard HP48GX, an RPN-based, programmable, graphing, scientific calculator. The *m48* app can be downloaded from Apple's App Store to an iPhone or iPad for only 99 cents!**



<https://itunes.apple.com/us/app/m48/id332100614>

**Thank you, Markus Gonser, for making this iOS app available to HP calculator fans!**

This app is superior to possessing an actual HP48G series calculator, because an iPhone is much smaller than the original calculator; it is back-lit, by nature of running on an iOS device (no flashlight is needed when working in low light levels); the text of the emulated LCD display can be enlarged for better legibility; and, best of all, it performs calculations several times faster than the real calculator!

HP's [User's Guide](#) and [Quick Start Guide](#) for the actual HP48GX can be downloaded from [this page](#).

These are very intimidating manuals for the uninitiated and, honestly, it took me about four hours of reading, mostly to weed out everything that is of no use to the purpose I had in mind, before I could even *start* programming the equations I wanted to use for DoF and Stereo Base calculations.

**That's why I wrote this document – not only as a favor to other photographers, but also as a reference that I can use, whenever I get a new iOS device and have to reprogram a freshly installed *m48* app!**

Using this document, I can load the equations, listed below, into the *m48* app in about 30 minutes. Yes, it's a pain in the neck, but here's the beautiful thing about HP's programmable calculators: Once you've stored an equation, you can solve for any variable, at will. You don't have to store multiple arrangements of the same equation. Having just performed a calculation to solve for the f-Number that would provide sufficient DoF for your specified Near and Far distances, Focal Length, and Maximum Permissible CoC Diameter, you can, for example, easily overwrite the calculated f-Number with a different value of your choosing, then solve for any one of the other variables – solving for a new Near distance, for example, if you wanted to stop down or open up from the originally calculated f-Number and adjust your camera position, accordingly. This flexibility provides a spectacular advantage over having to program and select from multiple derivations of the same equation.

It is even more advantageous, in my opinion, when working with a Stereo Base equation. I can use it to solve for how far apart my two lenses should be (Base) for a given combination of FL, Viewer FL, Near and Far distances and my desired on-film-deviation (expressed as a percentage of Maximum Acceptable OFD), just as

easily as I can solve for how close the Near can be for a change in Base, or what deviation (%MAOFD) will be recorded for a different Near with the same Base. This flexibility is empowering, to say the least.

Even for stereographers who prefer a “Constant Base” approach, instead of pursuing “Constant Deviation,” as I do...

Hint: I normally pursue about 75% of MAOFD, to accommodate users of adjustable-focus viewers who can focus the virtual image as closely as 10 inches – so that they do not suffer divergence of the eyes when fusing Far homologs, as they would if I were to routinely record OFDs equal to 100% of MAOFD.

... the Base equation can ensure that your fixed-base camera’s placement and the subject spaces you compose do not lead to either insufficient deviation (“flat” stereographs) or excessive deviation (where unwanted window violations and/or divergence of the eyes can be forced.)

The original HP48GX, equipped with a slow, 4MHz Yorke processor and only 128KB of RAM and 512KB of ROM, can still be purchased, in used condition, for about \$110 typically, which is what I paid for it when it was new! They were discontinued in 2003, but they appear to be holding their value extremely well, despite the (perhaps, little known) availability of Mark Gonser’s *m48* emulation for iOS.



Photo source and additional information: <http://mycalcdb.free.fr/main.php?l=0&id=852>

I still carry my original HP48GX, in its case, as a backup to my iOS device (currently, a 32GB iPod Touch 6). It adds surprisingly little weight to my camera backpack and runs on three AAA batteries, which last “forever.”



# Instructions for Programming the HP48G+ or HP48GX

**Equations** (in the syntax to be entered when programming):

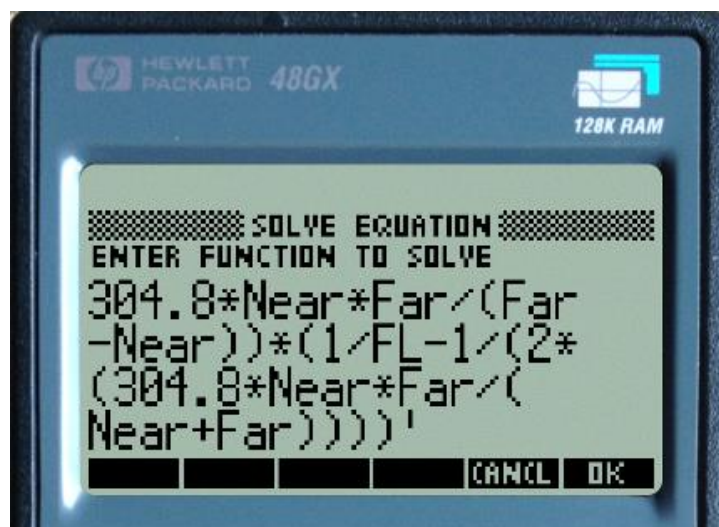
**Object:** 'Base=(FL/30\*(VFL/FL)\*(%MAOFD/100)\*(304.8\*Near\*Far/(Far-Near))\*(1/FL-1/(2\*(304.8\*Near\*Far/(Near+Far))))'

**Name:** B

After programming an equation, you can select **Choos** and then **Edit** to confirm or modify the equation:



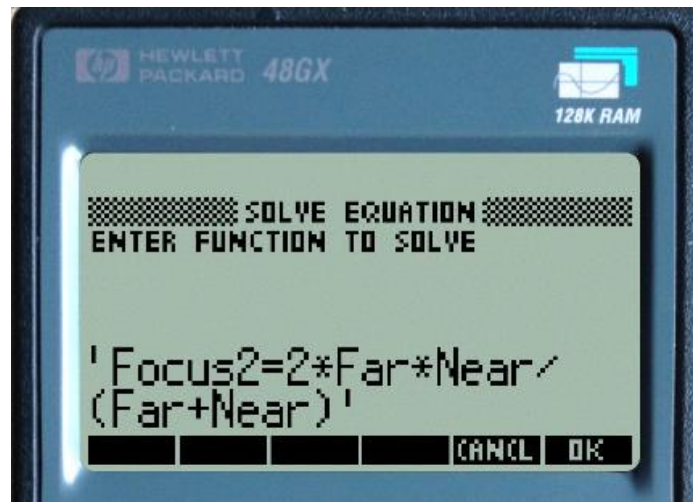
Note that the last two lines of this long equation cannot be seen until scrolled down, as shown here:



**Object:** 'Focus2=(2\*Far\*Near)/(Far+Near)'

**Name:** F2

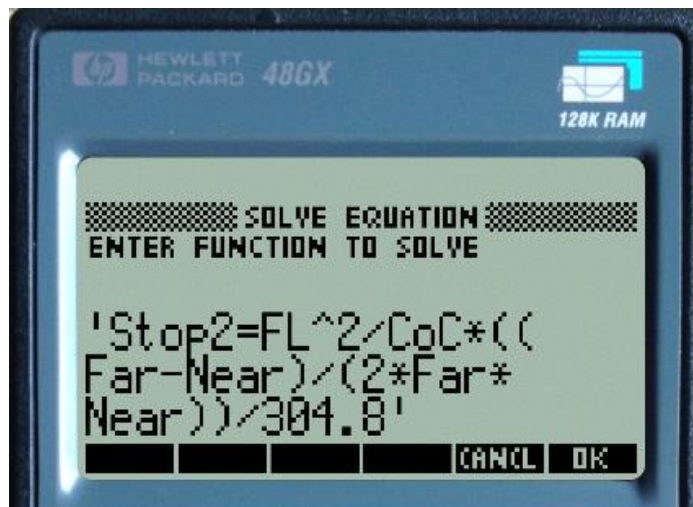
Feel free to specify "Focus=" instead of "Focus2=" in the Object and "F" instead of "F2" for the Name.



**Object:** 'Stop2= (FL^2/CoC)\*((Far-Near)/(2\*Far\*Near))/304.8'

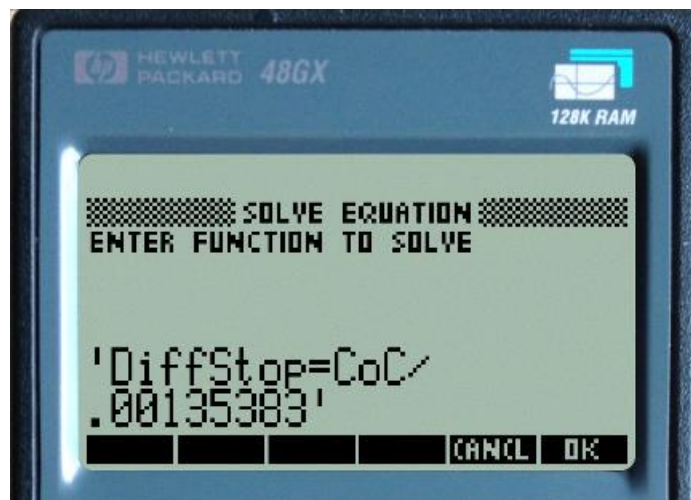
**Name:** S2

Feel free to specify "Stop" instead of "Stop2" in the Object and "S" instead of "S2" for the Name.



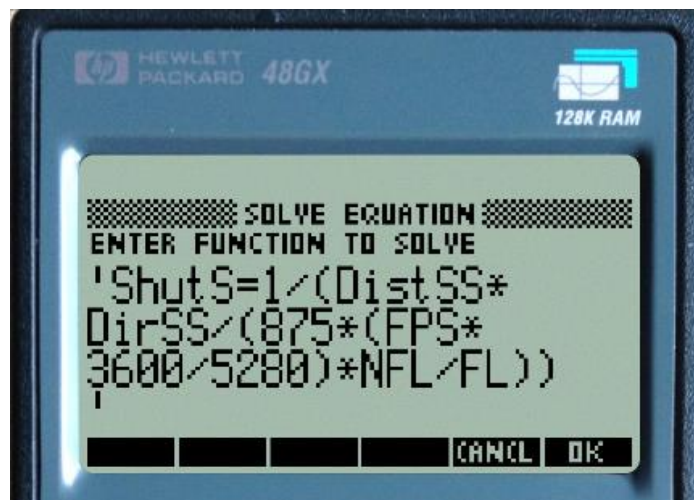
Object: 'DiffStop=CoC/0.00135383'

Name: D



Object: 'ShutS=1/(DistSS\*DirSS/(875\*(FPS\*3600/5280)\*NFL/FL))'

Name: SS



# Variables:

<b>Focus2:</b>	Distance at which to Focus (feet)
<b>Stop2:</b>	F-stop that provides nominal Depth of Field
<b>DiffStop:</b>	Diffraction-Limiting F-Stop, beyond which the user should not stop down.
<b>ShutS:</b>	Minimum Shutter Speed (the denominator of the shutter speed, in 1/n sec.)
<b>FL:</b>	Lens Focal Length (mm)
<b>Near:</b>	Distance to Nearest Subject (feet)
<b>Far:</b>	Distance to Farthest Subject (feet) - Specify a value of 99999 for Infinity.
<b>CoC:</b>	Maximum Permissible CoC Diameter on-film or on-sensor, before enlargement (mm)
<b>DistSS:</b>	Shutter Speed - Distance from the camera position to the moving object (feet)
<b>DirSS:</b>	Shutter Speed - Direction of Movement relative to camera's point of view:  1 = left/right or up/down 2 = diagonal 4 = towards or away
<b>FPS:</b>	Speed of moving subject, in Feet Per Second
<b>NFL:</b>	Normal Focal Length for this format/crop diagonal (mm)

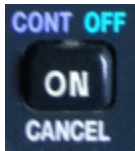
## Variables used only for the stereo Base equation:

<b>Base:</b>	Stereo Base Separation (mm)
<b>VFL:</b>	Viewer Focal Length (mm)
<b>PMAOFD:</b>	Desired <b>O</b> n-Film (or on-sensor) <b>D</b> eviation, expressed as a Percentage of <b>M</b> aximum <b>A</b> ceptable <b>O</b> n-Film <b>D</b> eviation Desired (where MAOFD = VFL/30). For example, specify "75" for an OFD that is 75% of MAOFD.

# Example of Defining a New Equation in the HP48GX:

## Power ON the Calculator:

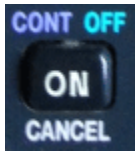
ON



(This will power on the calculator to display the state prior to power OFF.)

## Initialize the Calculator (to clear the current state):

CANCEL



(Same as the “ON” key)

DEL



## Begin Creation of a New Object in Memory:

MEMORY



(Press all keys serially, not simultaneously.)


NEW



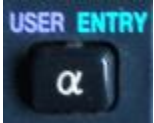


(Use the “D” key, below the word “NEW” at the bottom of the LCD.)



**Define the Object:** Example shown here: 'DiffStop=CoC/0.00135383'

'  (Apostrophe)

D   (This enters an **upper-case** "D")

i    (Use of the left-function key enters a lower-case "i")

Continue by entering these characters:


f (lower-case)  
f (lower-case)  
S (**upper-case**)  
t (lower-case)  
o (lower-case)  
p (lower-case)

=  

C (**upper-case**)  
o (lower-case)  
C (**upper-case**)

/ 

**0.00135383** (Just use the numeric keys)

'  (Apostrophe)

This sequence completes entry of the Object: 'DiffStop=CoC/0.00135383'

## Exit Edit mode, give the Object a Name and save it:

**OK** (Use the “F” key to select **OK**, to exit Edit mode for the Object.)

Cursor down to the **Name** field and enter a “D”

**D** (upper-case)

**OK** (Use the “F” key to select **OK**, to exit Edit mode for the Name.)

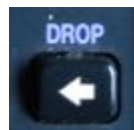
**OK** (Use the “F” key to select **OK**, storing the new equation.)

The Equation has now been saved and is ready for use: D: ‘DiffStop=CoC/0.00135383’

## Hints for Using the HP48GX:



These are the cursor position arrows. You will use them a lot!



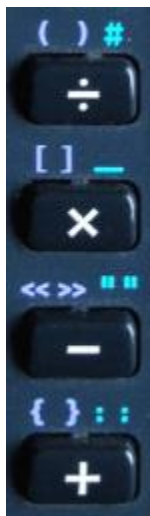
This is the BACKSPACE key. If you make a mistake during entry, you can backspace over it and enter the correct character, then carry on.



This sequence enters *both* a “(” and a “)” – leaving the cursor in between them.

When you are ready to make use of the “)” press the right-arrow key to position the cursor *after* the “)”.

Any unresolved “)”s will stack to the right, automatically.



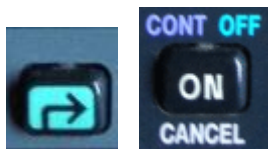
These are the arithmetic operators, which look like this in the equations:  $/$   $*$   $-$   $+$

(Somebody might actually appreciate this hint, when it comes time to enter  $/$  or  $*$ .)



For formulas requiring **(whatever)<sup>x</sup>**, use this **y<sup>x</sup>** key ahead of entering the power value, **x**.

Note: For **(whatever)<sup>2</sup>** you could instead enter **SQ(whatever)** – to Square (whatever).



This sequence turns OFF the calculator – everything currently displayed will be there when you turn it ON, later.

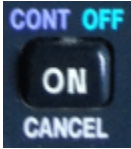
**Now you can have *lots* of fun entering, naming and saving the longer equations of your choice!**

**Mooo-ha-haaaa! 😊**

Return to Page 4, above, to see the other equations provided by this document. Enter them using the same skills. You can do it! 😊

# Instructions for Use in the Field

## To Initialize the Calculator (to clear the current state)

CANCEL  (Same as the “ON” key)

DEL 

## To Calculate Focus Distance (feet) - The distance at which to focus for sufficient DoF

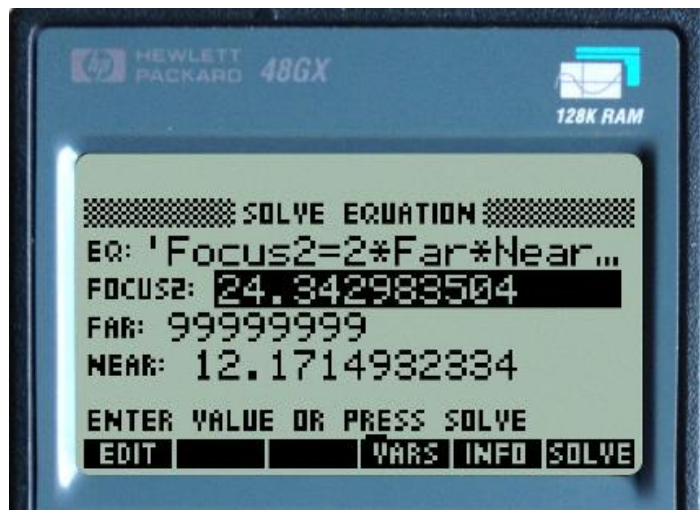
SOLVE   “Solve equation” will be highlighted.

OK Use the “F” key to select “OK”

CHOOS Use “B” key to select “CHOOS”

F2: ‘Focus2... Use up or down arrows to highlight the F2: ‘Focus2... equation.

OK Use the “F” key to select the equation



Enter or overwrite the **FAR** and **NEAR** distances in feet, then select the **FOCUS2** field (before solving).

SOLVE Use the “F” key to select “SOLVE”

CANCEL Same as the “ON” key. **Focus2** will be displayed in the stack. (This step is optional.)

## To Calculate F-Stop - The smallest f-Number that will provide sufficient DoF



**SOLVE**

"Solve equation" will be highlighted.

**OK**

Use the "F" key to select "OK"

**CHOOS**

Use "B" key to select "CHOOS"

**S2: 'Stop2...**

Use up or down arrows to highlight the **S2: 'Stop2...** equation.

**OK**

Use the "F" key to select the equation.



Enter or overwrite values for **FL** and **COC** in mm, and for **FAR** and **NEAR** distances in feet, then select the **STOP2** field (before solving).

The ability to specify *your choice* of maximum permissible CoC diameter is a feature not found in all DoF calculators and, certainly not with the DoF scales engraved on lens barrels. I believe most people who have been disappointed with the results had using DoF calculations are unaware that they can improve the resolutions of objects that reside at the Near and Far limits of the subject space, at least in terms of defocus, by specifying a smaller diameter for CoCs.

To calculate Circle of Confusion diameters that take into account your anticipated enlargement factors and desired print resolutions, which themselves should accommodate your anticipated minimum viewing distances, you can use [my Excel spreadsheet](#), which is based on the equation found in Wikipedia's [Circle of Confusion](#) article. Also see [my essay on this topic](#).

Remember you can solve for any variable after making changes to others, first.

**SOLVE**

Use the "F" key to select "SOLVE"

**CANCEL**

Same as the "ON" key. **Stop2** will be displayed in the stack. (This step is optional.)



**To Calculate Diffraction Stop** - The largest f-Number that can be used without causing diffraction's Airy disk diameters to exceed your specified maximum permissible CoC diameter (which would make the entire print as soft as your Near and Far limits of DoF)

**SOLVE**   "Solve equation" will be highlighted.

**OK** Use the "F" key to select "OK"

**CHOOS** Use "B" key to select "CHOOS"

**D: 'DiffStop...** Use up or down arrows to highlight the **D: 'DiffStop...** equation.

**OK** Use the "F" key to select the equation.



Enter or overwrite the value for **COC** in mm, then select the **DIFFSTOP** field (before solving).



The **CoC** diameter used here should be the same as that which was used to calculate the F-Stop.

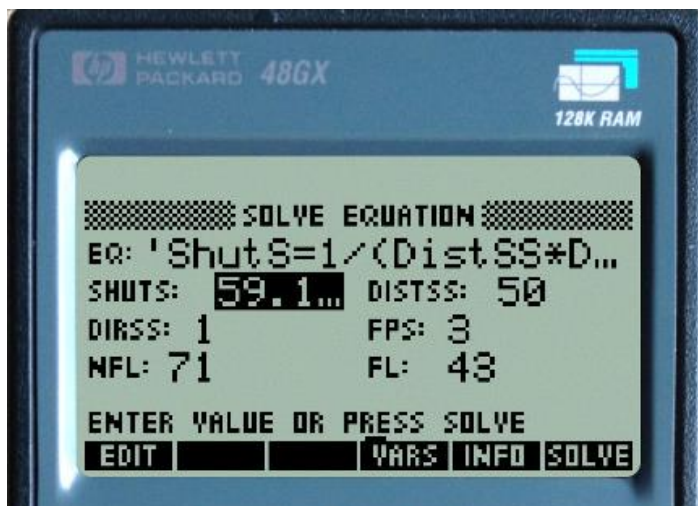
Again, the **DiffStop** calculated here is the largest f-Number (smallest aperture) that can be used without concern for diffraction's Airy disk diameters exceeding the size of largest CoCs. Stopping down further than this, in the quest for greater DoF, will only lower the resolution of the entire print below that which is achieved at the extreme limits of your DoF. (Not good!)

**SOLVE** Use the "F" key to select "SOLVE"

**CANCEL** Same as the "ON" key. **DiffStop** will be displayed in the stack. (This step is optional.)

**To Calculate Shutter Speed (1/n)** - The minimum shutter speed (1/n) for a specified distance to the moving subject and its direction of travel relative to the camera's point of view

- SOLVE**   "Solve equation" will be highlighted.
- OK** Use the "F" key to select "OK"
- CHOOS** Use "B" key to select "CHOOS"
- SS: 'ShutS...** Use up or down arrows to highlight the **SS: 'ShutS...** equation.
- OK** Use the "F" key to select the equation.



Enter or overwrite the values for **DISTSS**, **DIRSS**, **FPS**, **NFL** and **FL** in mm, then select the **SHUTS** field (before solving).

Note: I only use this equation when I find myself doubting how slowly I can shoot.

- DistSS:** Shutter Speed Distance – to moving object (feet)
- DirSS:** Shutter Speed Direction of Movement (as follows):
- 1 = left/right or up/down
  - 2 = diagonal
  - 4 = towards or away
- FPS:** Feet Per Second (estimated speed of moving subject)
- NFL:** Normal Focal Length for this format/cropping diagonal (mm)
- FL:** Lens Focal Length (mm)

- SOLVE** Use the "F" key to select "SOLVE"
- CANCEL** Same as the "ON" key. **DiffStop** will be displayed in the stack. (This step is optional.)

**To Calculate Base (mm)** - The distance, known as Stereo Base, at which two lenses must be separated to secure a desired deviation on film (or at a digital sensor)



**SOLVE**

“Solve equation” will be highlighted.

**OK**

Use the “F” key to select “OK”

**CHOOS**

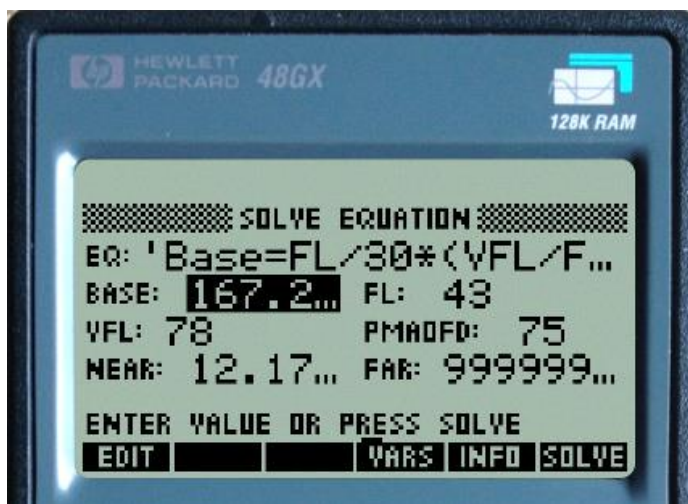
Use “B” key to select “CHOOS”

**B: ‘Base =...**

Use up or down arrows to find the **B: ‘Base =...** equation

**OK**

Use “F” key to select the equation



Enter or overwrite your choice of variables other than BASE. **NEAR** and **FAR** should be entered in feet, **VFL** and **FL** (Viewer Focal Length and Camera FL) in mm, **PMAOFD** (% of MAOFD desired) as an integer less than or equal to 100.

It’s OK to specify a PMAOFD value greater than 100, as long as you are certain the nearest object(s) can protrude into negative parallax without intersecting the edges of your stereo window. Generally, you would not want to specify a PMAOFD value less than 40, as the subject space would appear somewhat flat in the viewer.

When the subject space is so shallow that the Far:Near ratio is less than 2, an exaggeration of the depth can occur if you shoot with the normally calculated Base. *To avoid this, enter a value for **FAR** that is exactly twice the value of **NEAR**. (Do not enter the actual, lesser FAR distance.)*

Remember you can solve for any variable after making changes to others, first.

Select the **BASE** field (before solving).

**SOLVE**

Use the “F” key to select “SOLVE”

**CANCEL**

Same as the “ON” key. **Base** will be displayed in the stack. (This step is optional.)