# hp calculators

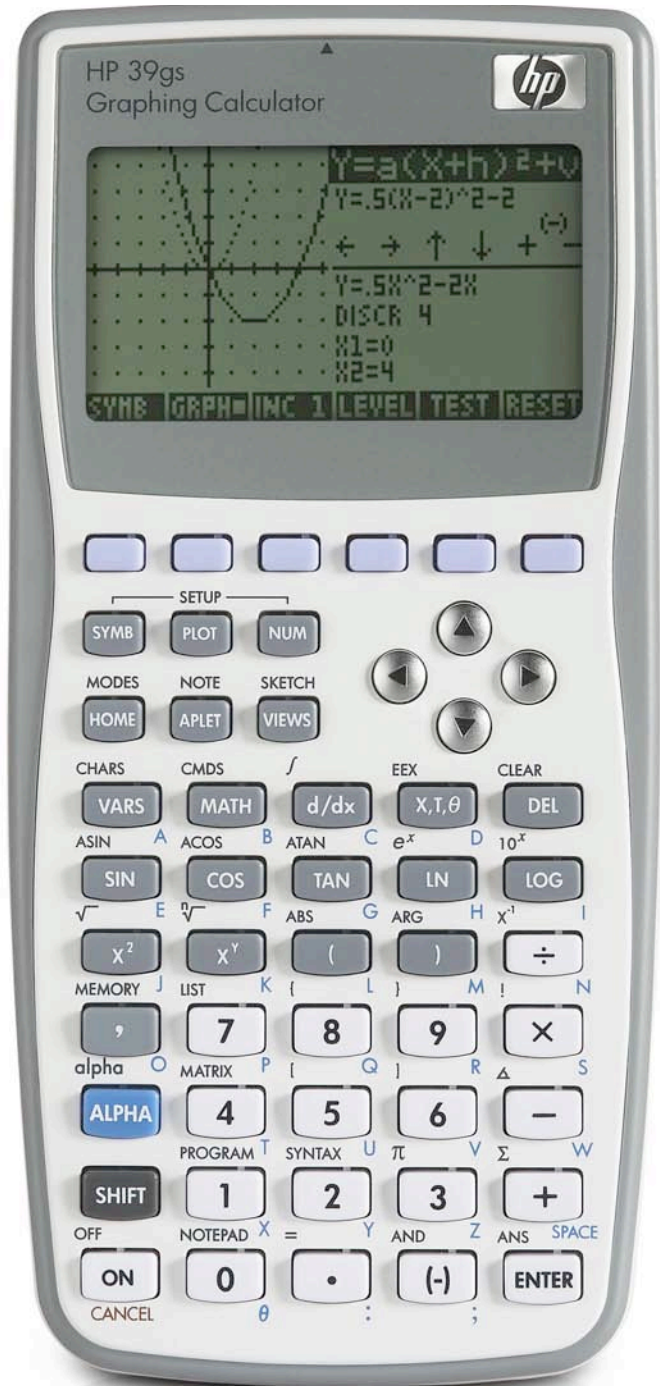**HP 39gs**  Examples of graphing

A few simple functions

A flower in the Polar aplet

Motion in the Parametric aplet

The role of thetaStep and TStep

Choosing a 'nice' scale

Split views

**A few simple functions**

**Example 1**

> The profit for a company for its first ten years is given by the function $P(t) = \dfrac{5000}{(1+5t)} + 50t^2$. Graph the profit function for this period.

In the APLET view, choose the Function aplet and press START (screen key 6). Enter the equation into the SYMB view. If desired, highlight it and press SHOW to verify that it has been entered correctly.
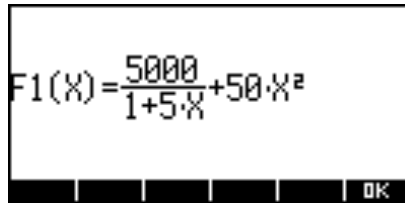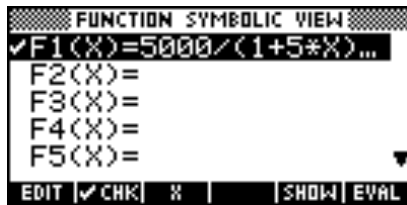
Press SHIFT PLOT to set axes. Enter the domain into the XRng setting. Press VIEWS and Autoscale.
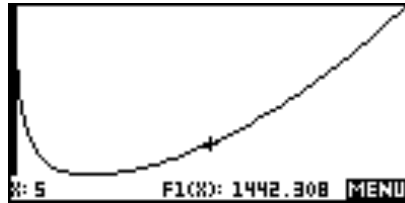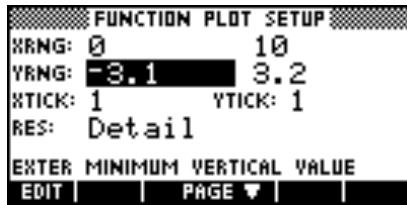
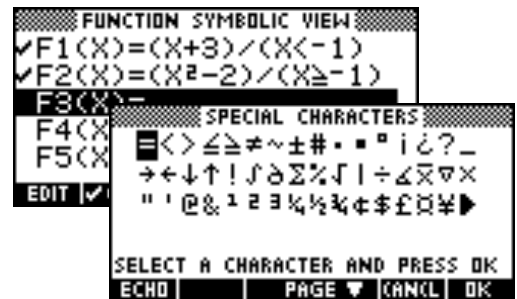Adjust the settings for the y axis by changing the minimum to –1000 and the step to 500.
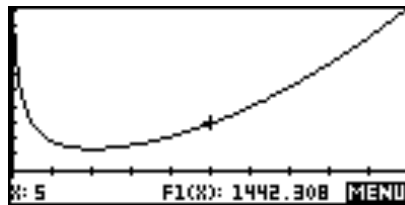
**Example 2**

> Graph the function $y = \begin{cases} x+3 & ; \ x < -1 \\ x^2 - 2 & ; \ x \geq -1 \end{cases}$

Enter the piecewise defined function as two separate functions:

       F1(X)=(5-X)/(X<-1)

and     F2(X)=(X²-2)/(X≥ -1).

The < and ≥ symbols, along with many others, can be found in the CHARS view shown right.

The two expressions for the domains are evaluated as either true (1) for values inside the domain or false (0) outside. Dividing by this domain expression means that the function becomes undefined outside the domain because it is divided by zero. This has the effect that it is not graphed.
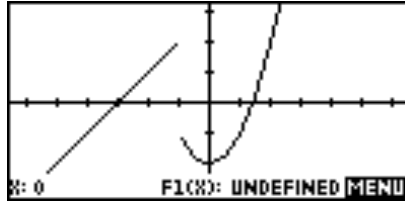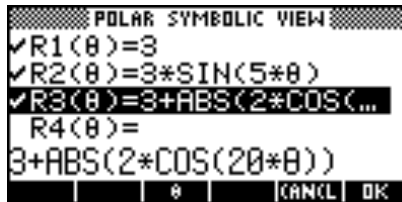


**A flower in the Polar aplet**

Graphing a flower using polar functions is quick and easy. There are many possible ways to do it, one of which is shown below. Exploring this and other ways can be a lot of fun.

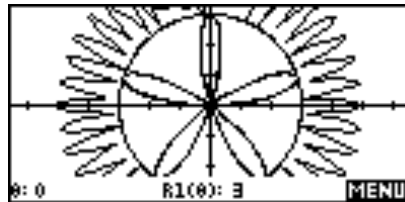Start by entering the functions below into the Polar aplet:

$$r(\theta) = 3$$

$$r(\theta) = 3\sin(5\theta)$$

$$r(\theta) = 3 + \left|2\cos(20\theta)\right|$$



Before plotting the graph, change into the PLOT SETUP view and alter the value of Step.  The default value is Pi/24 or 0.130899…. Change this value to 0.025. The resulting graph can now be seen in the PLOT view.
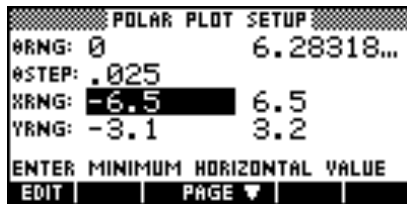


**Motion in the Parametric aplet**

> Illustrate graphically the first 8 seconds of the path of a particle P with displacement $x$ metres given by $x(t) = t^3 - 11t^2 + 31t - 21$, where $t$ is in seconds.

Start by entering the functions below into the Parametric aplet:
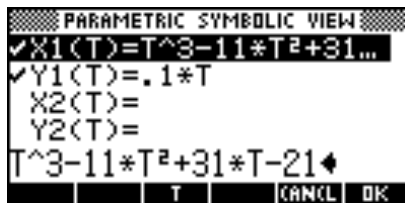
Change into the PLOT SETUP view and alter the values as shown and then PLOT.

```
▒▒▒▒ PARAMETRIC PLOT SETUP ▒▒▒▒
TRNG: 0          8
TSTEP: .075
XRNG: -30        40
YRNG: -.5        1

ENTER STEP SIZE
EDIT |     | PAGE ▼ |    |
```

```
T: 0 (-21,0)              MENU
```
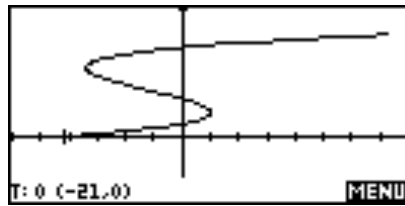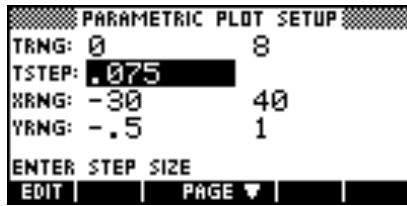
**Notes:**
- Watch the graph carefully! You will see it slow down, halt, and then accelerate again exactly as the particle P does. The overall speed is controlled by the value of TStep.
- The only purpose of the equation Y1(T)=0.1T is to spread the graph vertically so that the particle is not simply moving along the x axis. The values of YRng are chosen with the TRng of 0 to 8 in mind.
- This equation could be entered into the Function aplet if the purpose were analytical instead of simply to illustrate the motion.

**The role of  Step and TStep**

In Function the graph is produced by "joining the dots" using the F(X) equation supplied. The Polar and Parametric aplets are slightly different. In these aplets the (x,y) points derive from r(theta) and x(t),y(t) respectively. Separation between successive dots is controlled by thetaStep and TStep.

The choice of TStep (or thetaStep) is a tradeoff between speed and accuracy. The more complex the graph, the smaller the value of TStep that is needed. Some graphs, such as the one below require a smaller value than the default to be sufficiently accurate.

| $\begin{cases} x(t) = 2\sin(t) + 2\sin(9t) \\ y(t) = 2\cos(t) + 2\cos(9t) \end{cases}$ | **Time to plot (seconds)** | **Result** |
|---|---|---|
| **TStep** = 0.01 | 110 |  |
| **TStep** = 0.05 | 30 |  |
| **TStep** = 0.1 *(default)* | 13 |  |
| **TStep** = 0.2 | 8 |  |
| **TStep** = 0.5 | 4 |  |

The default value for thetaStep in the Polar aplet is  Pi/24, since this gives 'nice' values for trigonometric equations.

### Choosing a 'nice' scale

When you press PLOT there is a good chance that the default scale will not be suitable. For example the graph of
$f(x) = x^4 - 27x^2 - 14x + 135$ shown below. There are a number of approaches which will help you in finding a good scale
to display it. The best, of course, is to use your brain!
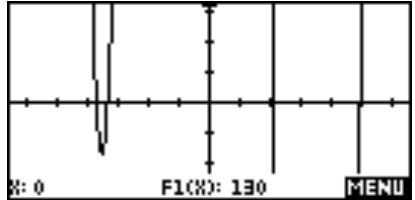


In the case above it is clear all four roots are shown so the x axis is well chosen. Press MENU and ZOOM. From the menu, press 2
to jump to the first entry in the menu starting with Y and then choose Y-Zoom Out. Repeat this twice.
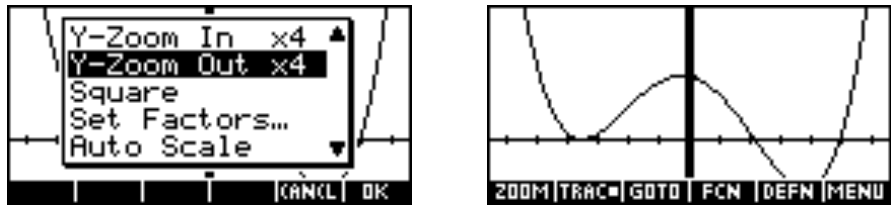


The y axis is thick because the ticks are too close. Clean up the y axis in the PLOT SETUP view by using the values shown below.
The result is a clear graph.
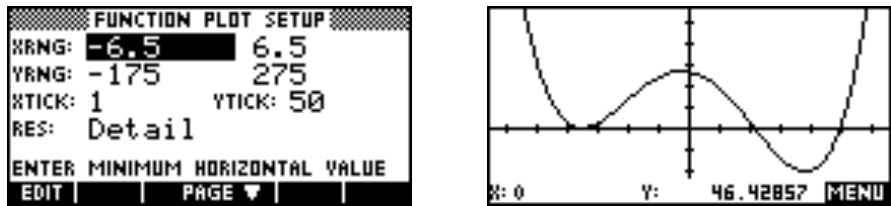


Another option is to use Autoscale from the VIEWS menu. This finds the 'best' y scale for the first function which has a ✔ in the
SYMB view, using whatever the current x scale is in PLOT SETUP.
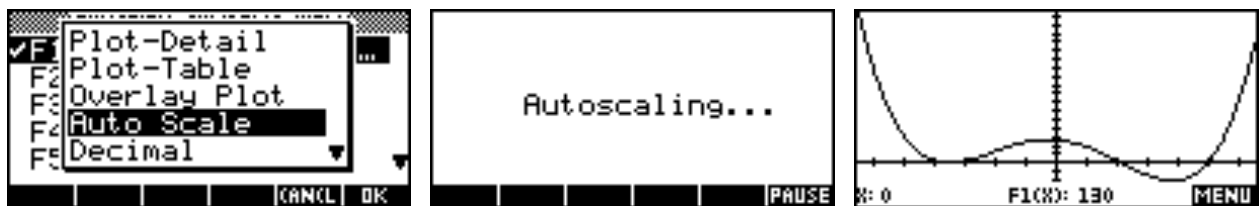


There are two problems with Autoscale. The first is that if there are multiple functions then the scale found may not suit the others.
The second is that in order to show y values for the entire x axis some interesting features of the graph may be lost.

An example of this is the function shown below. An Autoscale on this gave the graph shown right but a better choice would give the screen under it.
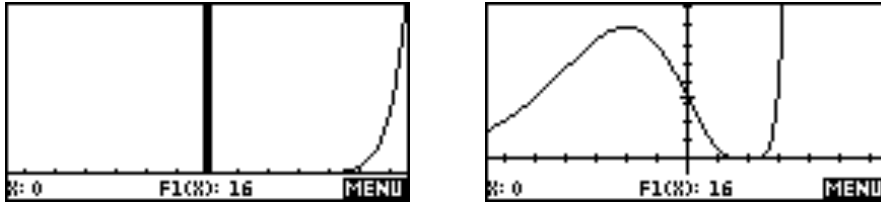


Another method that generally works well is to use the NUM view to explore the range of the function. Set the NumStep to be 0.5 and then simply scroll through the domain to find approximate minimums and maximums.



Another aspect of choosing a 'nice' scale arises if you wish to trace the graph – to move the cursor along it. When tracing along a graph the values displayed at the bottom of the screen (see right) are determined by the dots on the LCD screen. The default scale of –6.5 to 6.5 is chosen so that dots are 0.1 apart. Choosing a scale such as –10 to 10, while not affecting the graph in any other way, will give less useful values when tracing. You may wish to try this.
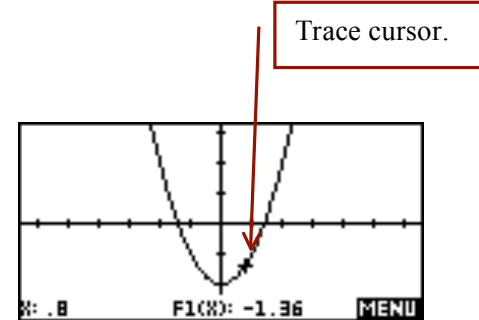
Normally this is largely irrelevant since the GOTO button (screen key 3) allows you to jump to any value on or off the screen and the FCN functions will find roots and extrema independently of the current scale.

Trace cursor.



If you particularly want to trace a graph using 'nice' values then simply choose a multiple of the basic default.  For example, you could choose instead to double it and use -13 to 13 or to halve it and use –3.25 to 3.25. If you don't want to have the y axis centered then just add a constant. For example, -6.5 to 6.5 could become –3 to 10 by adding 3.5 to both values. The choice of y axis scale is not relevant.

One easy way to obtain 'nice' scales is to use the ZOOM  button on the PLOT view (screen key 1) as discussed earlier. It will always give multiples of the current scale, zooming either in or out. The default multiple is a factor of 4 but this can be changed.

**Split views**

There are two split views available through the VIEWS menu.

The first one, called Plot-Detail, allows easy zooming between two views of the same graph. The second, Plot-Table, combines a tabular view with a graph.



Note:  When using a Plot-Table view the default axes of –6.5 to 6.5 are no longer the best choice and should be changed to –6.4 to 6.4. This choice gives the step size of 0.2 shown in the table above. Any multiple of a power of 2 is suitable. Other choices will result



in tables which don't contain 'nice' values in the X column.
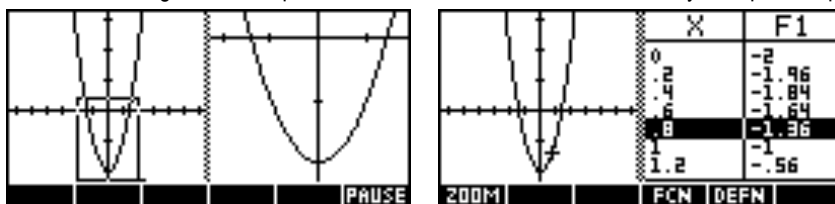
The Plot-Detail view is best shown in the Function aplet.