

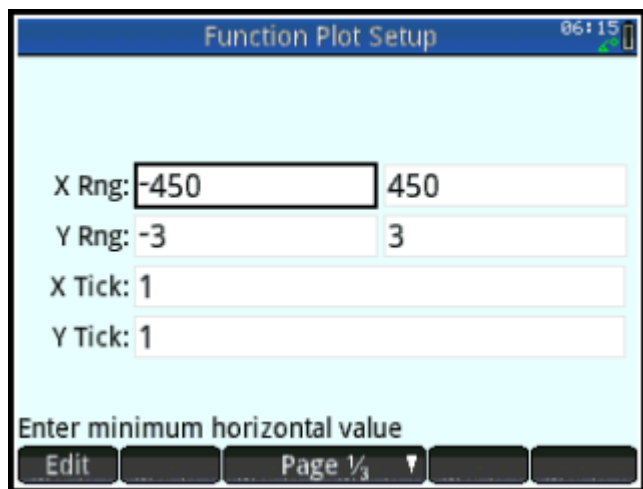
# HP Prime Application Note Physics:

## 03. Composing Wave Forms

According to Fourier's theorem, periodic functions consist of superimposed sine waves. For example, the following formula represents a sawtooth wave:

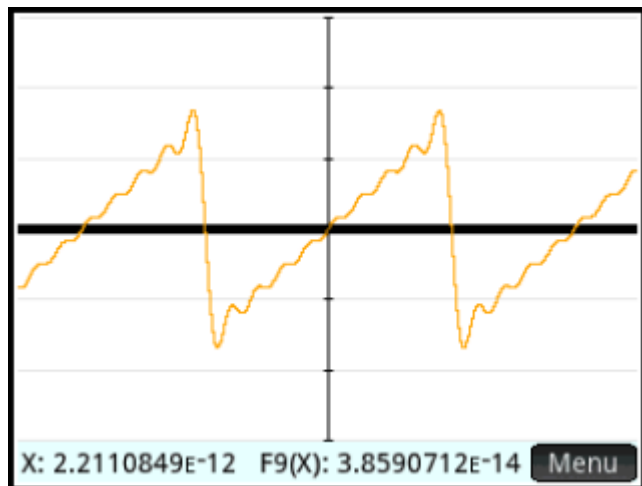
$$y = \sin x - \frac{\sin 2x}{2} + \frac{\sin 3x}{3} - \frac{\sin 4x}{4} + \frac{\sin 5x}{5} - \frac{\sin 6x}{6} + \frac{\sin 7x}{7} - \frac{\sin 8x}{8} + \frac{\sin 9x}{9} + \dots$$

Let us first set the HP Prime to degrees and the x and y ranges as follows:



Enter the entire formula of the sawtooth wave in the Function app:

Draw the wave form with the Plot key:



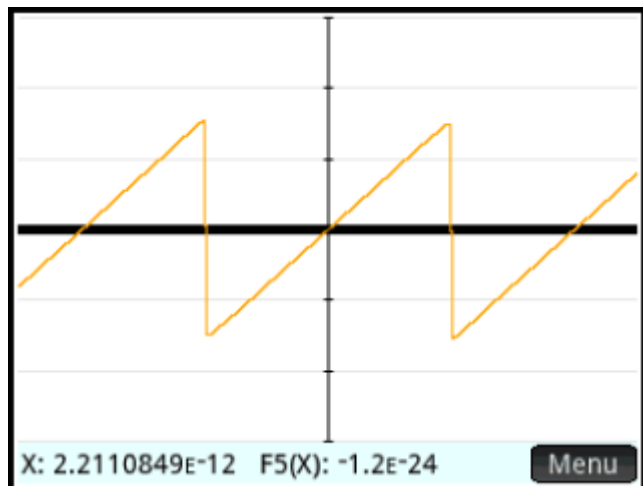
This wave form resembles that of the sound of a violin. For example, watch the video *Bowed violin string in slow motion* at <https://www.youtube.com/watch?v=6JeyiM0YNo4>.

Here, the sum of the sine functions includes only 9 terms. More terms yield a more realistic approximation of the sawtooth wave than the plotted one above but, of course, you need not to key in more terms of the series in your HP Prime. Instead, rewrite the formula using the summation symbol  $\Sigma$  and expand up to 250 terms.

$$-\text{SIN}(X) + \frac{\text{SIN}(2 \cdot X)}{2} - \frac{\text{SIN}(3 \cdot X)}{3} + \frac{\text{SIN}(4 \cdot X)}{4} - \frac{\text{SIN}(5 \cdot X)}{5} + \dots$$

$$\sum_{N=1}^{250} \left( \frac{(-1)^{N+1} * \text{SIN}(N \cdot X)}{N} \right)$$

Now, the plotted wave form of the sawtooth has become quite smooth:

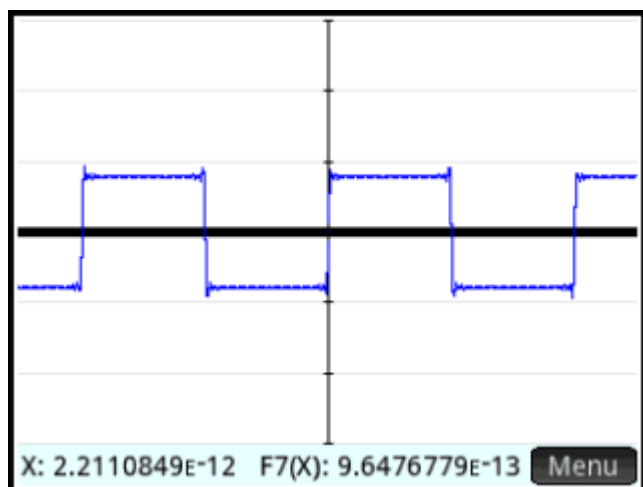


The block or the square is a wave form represented as:

$$y = \sin x + \frac{\sin 3x}{3} + \frac{\sin 5x}{5} + \dots$$

Expand the series up to the 25<sup>th</sup> term and draw it using the Plot key:

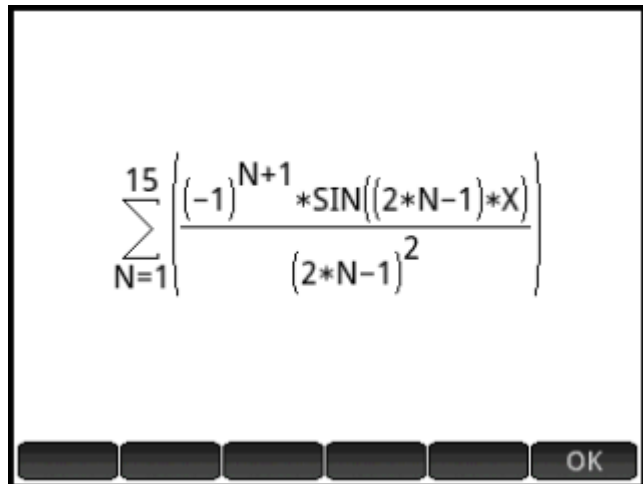
$$\sum_{N=1}^{25} \left( \frac{\text{SIN}((2*N-1)*X)}{2*N-1} \right)$$



Another example is the triangular wave:

$$y = \sin x - \frac{\sin 3x}{3^2} + \frac{\sin 5x}{5^2} + \dots$$

Enter the formula in the HP Prime:



The screenshot shows the HP Prime calculator interface with the following formula entered:

$$\sum_{N=1}^{15} \left\{ \frac{(-1)^{N+1} * \text{SIN}((2*N-1)*X)}{(2*N-1)^2} \right\}$$

At the bottom of the screen, there are several dark buttons, including one labeled "OK".

Draw the wave:

As you see, the triangular wave already looks quite smooth using 15 terms only.

