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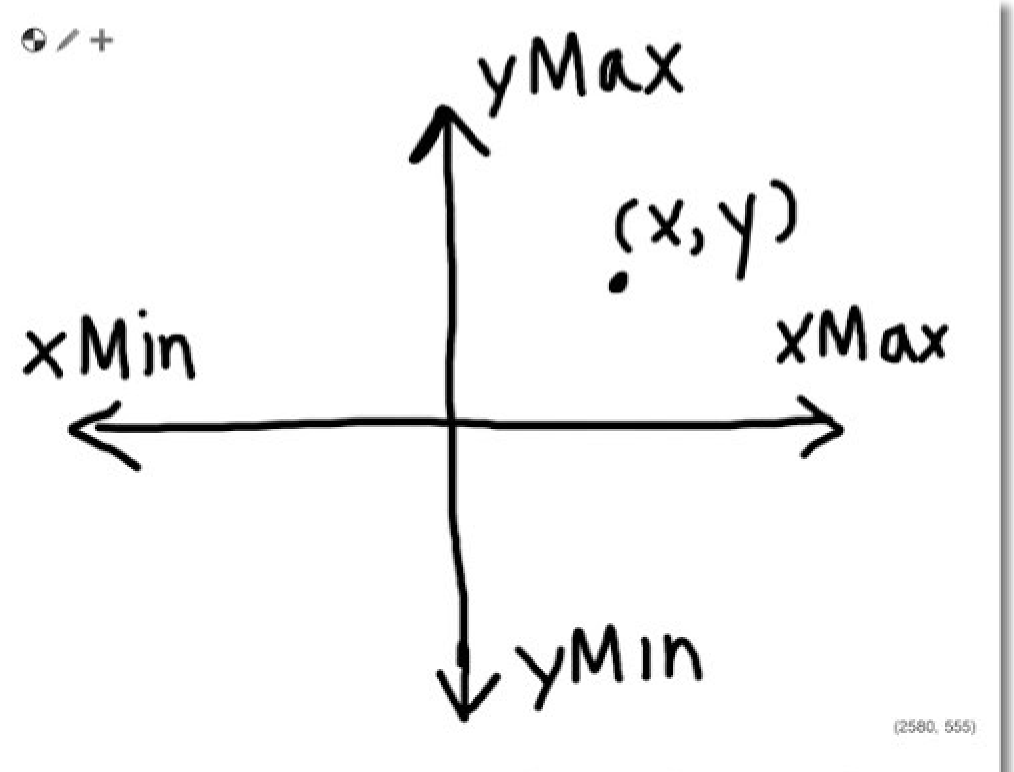
## Cartesian Coordinates to Pixel (Screen) Coordinates

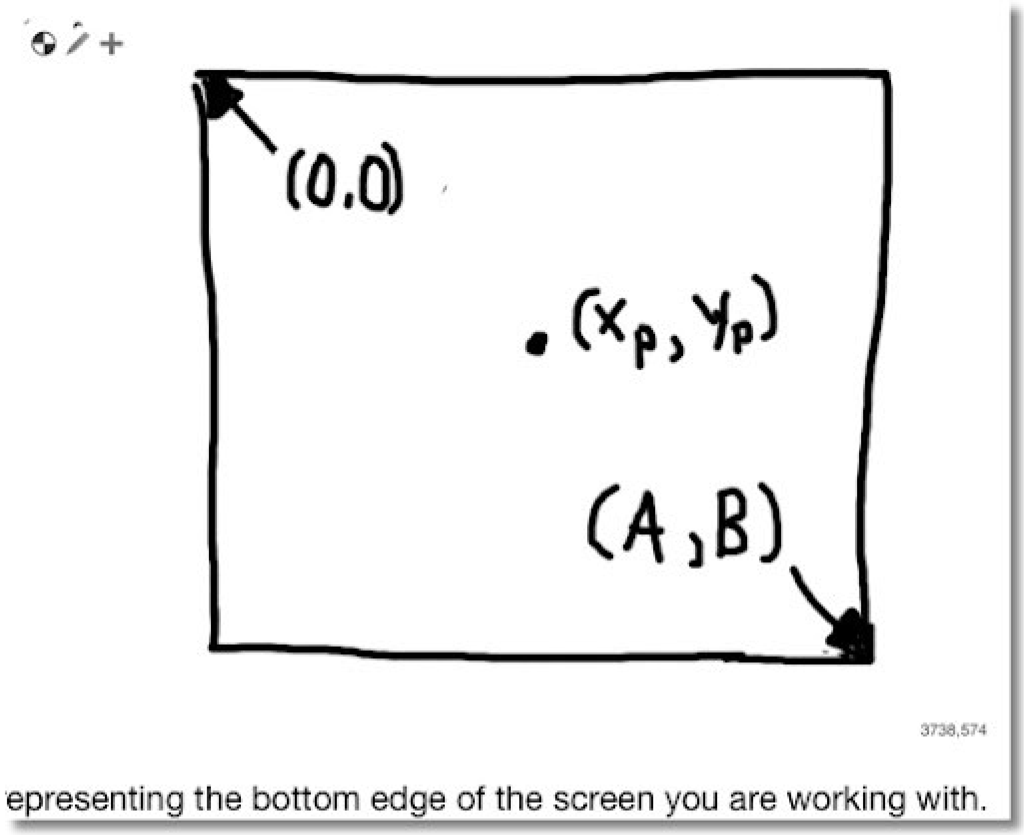
### Converting Cartesian Coordinates to Screen Coordinates

When working with computer or calculator graphics, sometimes we have to work with screen coordinates. The screen coordinate system has the following:

1. The upper corner pixel (point) is (0,0).
2. The lower corner pixel is (A, B).
3. The x axis increases in the right direction.
4. The y axis increases in the down direction, the opposite direction of the Cartesian plane.




Cartesian Coordinate System.




In order to to convert a point (x, y) in the Cartesian coordinates to point (xp, yp) in Screen coordinates, first observe the following:

1. Picture the plane you are working with as a screen. If you are working with a calculator or computer, this is fairly easy.
2. Let Xmin be the least-valued x of the screen (left edge) and Xmax be the most-valued x (right edge). Similarly, let Ymin be the least-valued y of the screen (bottom) and Ymax be the most-valued y of the screen (top).

You can check with the window settings on a graphing calculator to verify Xmax, Xmin, Ymax, and Ymin.

For the Hewlett Packard 28 series, 48 series and 50g, the variables XRNG and YRNG list the screen's dimensions, {Xmin, Xmax} for XRNG and {Ymin, Ymax} for YRNG.

To transform Cartesian coordinates to screen coordinates, we can use transformation matrices for scaling and translation. The general form

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \begin{bmatrix} x + x_s \\ y + y_s \end{bmatrix}$$

show the transformation from coordinates (x, y) to (x', y') where:

s_x = scale of the new x axis. If s_x < 0, the x point is reflected with respective to the x axis.

$s\_y$ = scale of the new y axis. If $s\_y < 0$, the y point is reflected with respected to the y axis. In going from Cartesian coordinates to screen coordinates, $s\_y < 0$.

$x\_s$ = Is the translation (shift to the new center) in the x-direction. If $x\_s > 0$, the new center is to the right of the original center. Similarly, if $x\_s < 0$, the new center is to the left of the original center.

$y\_s$ = Is the translation (shift to the new center) in the y-direction. If $y\_s > 0$, the new center is to the above the original center. Similarly, if $y\_s < 0$, the new center is to the below the original center.

For the transformation from Cartesian coordinates to screen coordinates:

$s\_x = A / (Xmax - Xmin)$

$s\_y = -B / (Ymax - Ymin)$

Since the new center will be at (Xmin, Ymax):

$x\_s = -Xmin$

$y\_s = -Ymax$

Therefore by matrix multiplication, with $x' = xp$ and $y' = yp$:

$xp = (x - Xmin) * A / (Xmax - Xmin)$

$yp = (y - Ymax) * -B / (Ymax - Ymin)$

On the HP 48 series and 50g, the translation from Cartesian to screen coordinates can be accomplished with the C→PX function.

Example:

Using the following window with settings Xmin = -5, Xmax = 5, Ymin = -4, and Ymax = 4, transform the Cartesian coordinate (1, 0) to screen coordinates. The screen has pixel size 130 × 79.

In this case, A = 130 and B = 79.

Then:

$xp = 130 / (5 - (-5)) * (1 - (-5)) = 78$
$yp = -79 / (4 - (-4)) * (0 - 4) = 39.5$

The screen coordinate of (1, 0) is {78, 39.5}.