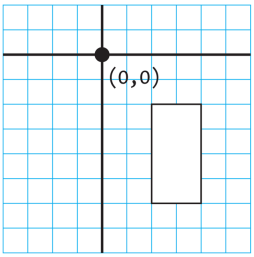
6/Translate, Rotate, Scale

Another technique for positioning and moving things on screen is to change the screen coordinate system. For example, you can move a shape 50 pixels to the right, or you can move the location of coordinate (0,0) 50 pixels to the right—the visual result is the same.

```
translate(40, 20);
rect(20, 20, 20, 40);
```




```
translate(60, 70);
rect(20, 20, 20, 40);
```

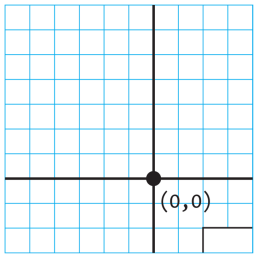


Figure 6-1. *Translating the coordinates*

By modifying the default coordinate system, we can create different *transformations* including *translation*, *rotation*, and *scaling*.

Translate

Working with transformations can be tricky, but the `translate()` function is the most straightforward, so we'll start with that. As

Figure 6-1 shows, this function can shift the coordinate system left, right, up, and down.

Example 6-1: Translating Location

In this example, notice that the rectangle is drawn at coordinate (0,0), but it is moved around on the screen, because it is affected by `translate()`:

```
void setup() {
  size(120, 120);
}

void draw() {
  translate(mouseX, mouseY);
  rect(0, 0, 30, 30);
}
```

The `translate()` function sets the (0,0) coordinate of the screen to the mouse location (`mouseX` and `mouseY`). Each time the `draw()` block repeats, the `rect()` is drawn at the new origin, derived from the current mouse location.

Example 6-2: Multiple Translations

After a transformation is made, it is applied to all drawing functions that follow. Notice what happens when a second `translate` function is added to control a second rectangle:

```
void setup() {
  size(120, 120);
}

void draw() {
  translate(mouseX, mouseY);
  rect(0, 0, 30, 30);
  translate(35, 10);
  rect(0, 0, 15, 15);
}
```

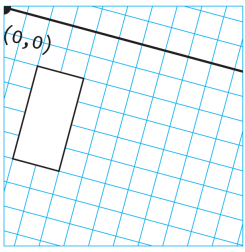
The values for the `translate()` functions are added together. The smaller rectangle was translated the amount of `mouseX` + 35 and `mouseY` + 10. The *x* and *y* coordinates for both rectangles are (0,0), but the `translate()` functions move them to other positions on screen.

However, even though the transformations accumulate within the `draw()` block, they are reset each time `draw()` starts again at the top.

Rotate

The `rotate()` function rotates the coordinate system. It has one parameter, which is the angle (in radians) to rotate. It always rotates relative to (0,0), known as rotating around the origin. Figure 3-2 in Example 3-7 on page 18 shows the radians angle values. Figure 6-2 shows the difference between rotating with positive and negative numbers.

```
rotate(PI/12.0)
rect(20, 20, 20, 40);
```




```
rotate(-PI/3);
rect(20, 20, 20, 40);
```

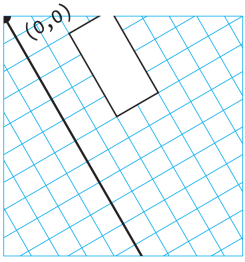
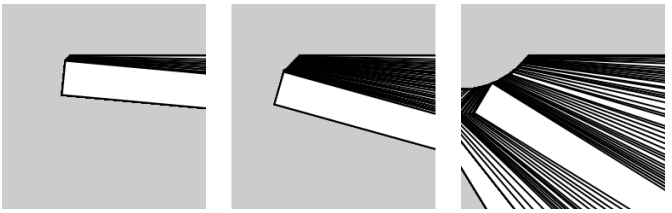


Figure 6-2. *Rotating the coordinates*

Example 6-3: Corner Rotation

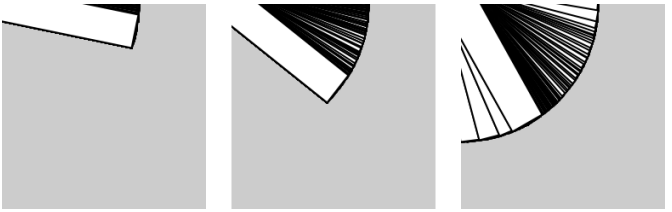
To rotate a shape, first define the rotation angle with `rotate()`, then draw the shape. In this sketch, the amount to rotate (`mouseX / 100.0`) will be between 0 and 1.2 to define the rotation angle because `mouseX` will be between 0 and 120, the width of the Display Window specified with the `size()` function. Note that you should divide by 100.0 not 100, because of how numbers work in Processing (see "Making Variables" on page 36).



```
void setup() {
  size(120, 120);
}

void draw() {
  rotate(mouseX / 100.0);
  rect(40, 30, 160, 20);
}
```

Example 6-4: Center Rotation

To rotate a shape around its own center, it must be drawn with coordinate (0,0) in the middle. In this example, because the shape is 160 wide and 20 high as defined in `rect()`, it is drawn at the coordinate (–80, –10) to place (0,0) at the center of the shape:



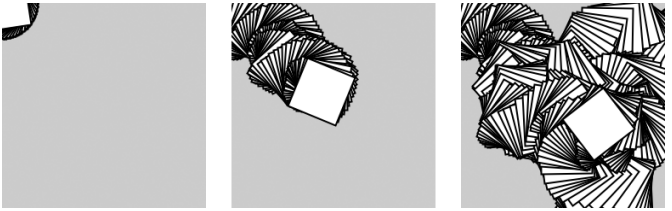
```
void setup() {
  size(120, 120);
```

```
}

void draw() {
  rotate(mouseX / 100.0);
  rect(-80, -10, 160, 20);
}
```

The previous pair of examples showed how to rotate around coordinate (0,0), but what about other possibilities? You can use the `translate()` and `rotate()` functions for more control. When they are combined, the order in which they appear affects the result. If the coordinate system is first moved and then rotated, that is different than first rotating the coordinate system, then moving it.

Example 6-5: Translation, then Rotation

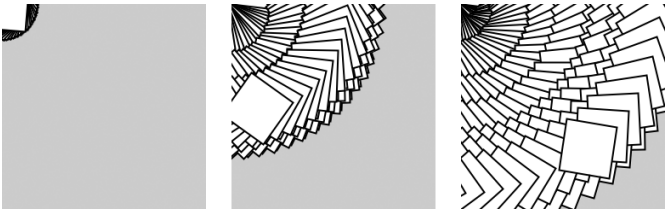
To spin a shape around its center point at a place on screen away from the origin, first use `translate()` to move to the location where you'd like the shape, then call `rotate()`, and then draw the shape with its center at coordinate (0,0):



```
float angle = 0;

void setup() {
  size(120, 120);
}

void draw() {
  translate(mouseX, mouseY);
  rotate(angle);
  rect(-15, -15, 30, 30);
  angle += 0.1;
}
```

Example 6-6: Rotation, Then Translation

The following example is identical to Example 6-5 on page 79, except that `translate()` and `rotate()` are reversed. The shape now rotates around the upper-left corner of the Display Window, with the distance from the corner set by `translate()`:



```
float angle = 0.0;

void setup() {
  size(120, 120);
}

void draw() {
  rotate(angle);
  translate(mouseX, mouseY);
  rect(-15, -15, 30, 30);
  angle += 0.1;
}
```

Another option is to use the `rectMode()`, `ellipseMode()`, `imageMode()`, and `shapeMode()` functions, which make it easier to draw shapes from their center. You can read about these functions in the *Processing Reference*.

Example 6-7: An Articulating Arm

In this example, we've put together a series of `translate()` and `rotate()` functions to create a linked arm that bends back and forth. Each `translate()` further moves the position of the lines, and each `rotate()` adds to the previous rotation to bend more:

```
float angle = 0.0;
float angleDirection = 1;
float speed = 0.005;

void setup() {
  size(120, 120);
}

void draw() {
  background(204);
  translate(20, 25);  // Move to start position
  rotate(angle);
  strokeWeight(12);
  line(0, 0, 40, 0);
  translate(40, 0);   // Move to next joint
  rotate(angle * 2.0);
  strokeWeight(6);
  line(0, 0, 30, 0);
  translate(30, 0);   // Move to next joint
  rotate(angle * 2.5);
  strokeWeight(3);
  line(0, 0, 20, 0);

  angle += speed * angleDirection;
  if ((angle > QUARTER_PI) || (angle < 0)) {
    angleDirection = -angleDirection;
  }
}
```

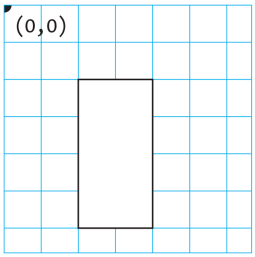
The `angle` variable grows from 0 to `QUARTER_PI` (one quarter of the value of pi), then decreases until it is less than zero, then the cycle repeats. The value of the `angleDirection` variable is always 1 or –1 to make the value of `angle` correspondingly increase or decrease.

Scale

The `scale()` function stretches the coordinates on the screen. Because the coordinates expand or contract as the scale changes, everything drawn to the Display Window increases or decreases in dimension. Use `scale(1.5)` to make everything 150% of their original size, or `scale(3)` to make them three times larger. Using `scale(1)` would have no effect, because everything would remain 100% of the original. To make things half their size, use `scale(0.5)`.

```
scale(1.5);
rect(20, 20, 20, 40);
```

```
scale(3);
rect(20, 20, 20, 40);
```



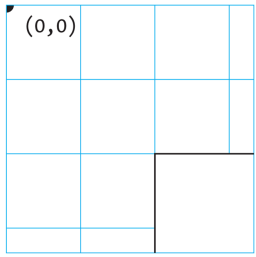
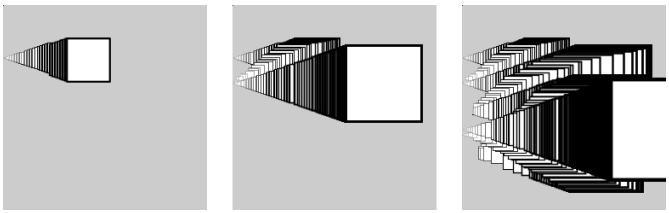


Figure 6-3. *Scaling the coordinates*

Example 6-8: Scaling

Like `rotate()`, the `scale()` function transforms from the origin. Therefore, as with `rotate()`, to scale a shape from its center, translate to its location, scale, and then draw with the center at coordinate (0,0):



```
void setup() {
  size(120, 120);
}
```

```
void draw() {
  translate(mouseX, mouseY);
  scale(mouseX / 60.0);
  rect(-15, -15, 30, 30);
}
```

Example 6-9: Keeping Strokes Consistent

From the thick lines in Example 6-8 on page 82, you can see how the `scale()` function affects the stroke weight. To maintain a consistent stroke weight as a shape scales, divide the desired stroke weight by the scalar value:

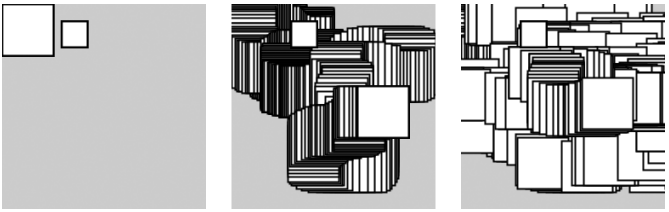
```
void setup() {
  size(120, 120);
}

void draw() {
  translate(mouseX, mouseY);
  float scalar = mouseX / 60.0;
  scale(scalar);
  strokeWeight(1.0 / scalar);
  rect(-15, -15, 30, 30);
}
```

Push and Pop

To isolate the effects of a transformation so they don't affect later commands, use the `pushMatrix()` and `popMatrix()` functions. When `pushMatrix()` is run, it saves a copy of the current coordinate system and then restores that system after `popMatrix()`. This is useful when transformations are needed for one shape, but not wanted for another.

Example 6-10: Isolating Transformations

In this example, the smaller rectangle always draws in the same position because the `translate(mouseX, mouseY)` is cancelled by the `popMatrix()`:



```
void setup() {
  size(120, 120);
}

void draw() {
  pushMatrix();
  translate(mouseX, mouseY);
  rect(0, 0, 30, 30);
  popMatrix();
  translate(35, 10);
  rect(0, 0, 15, 15);
}
```

The `pushMatrix()` and `popMatrix()` functions are always used in pairs. For every `pushMatrix()`, you need to have a matching `popMatrix()`.