PAT 204/504 (Fall 2025)

Creative Coding

Lecture 4: Loops & Recursion

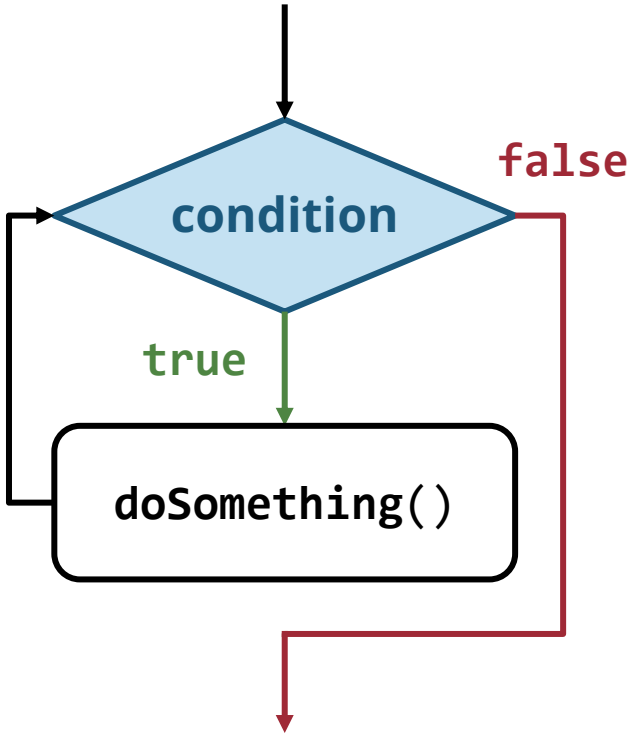
Instructor: Hao-Wen Dong

UNIVERSITY OF MICHIGAN

Loops

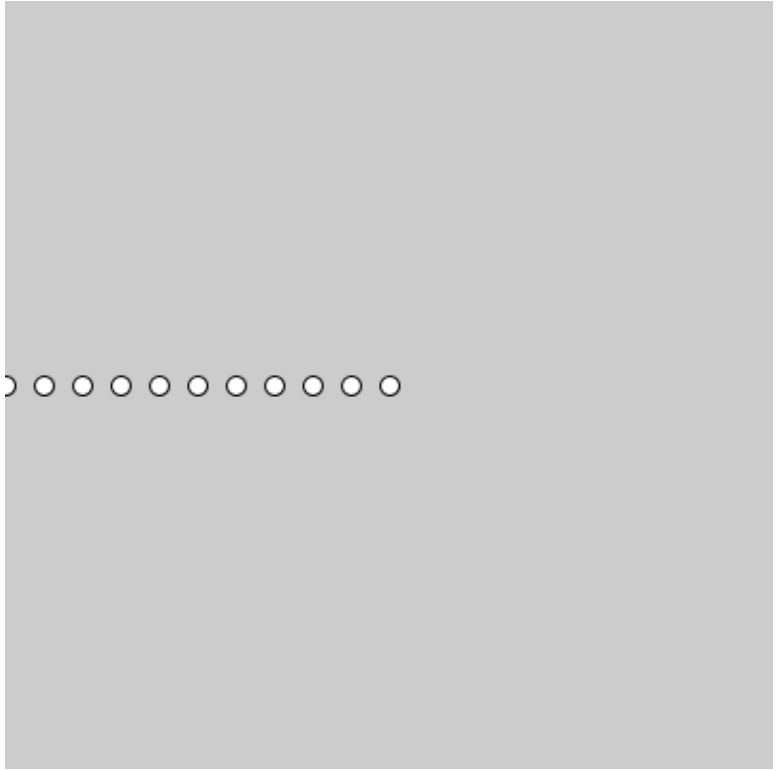
while Loop

```
while (condition) {
  doSomething();
}
```



Example: Circles

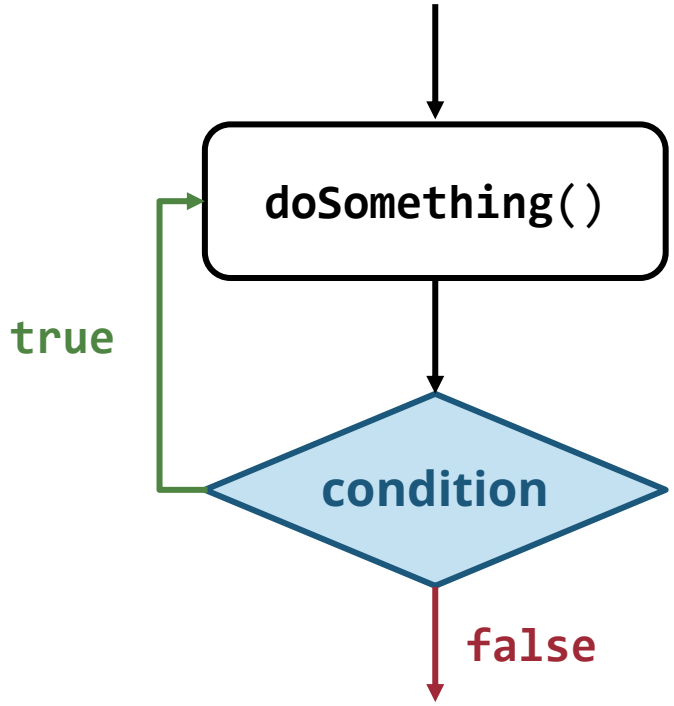
```
// Initialize x
float x = 0;

// Draw the circles
while (x <= 200) {
  circle(x, 200, 10);
  x += 20;
}
```



do-while Loop

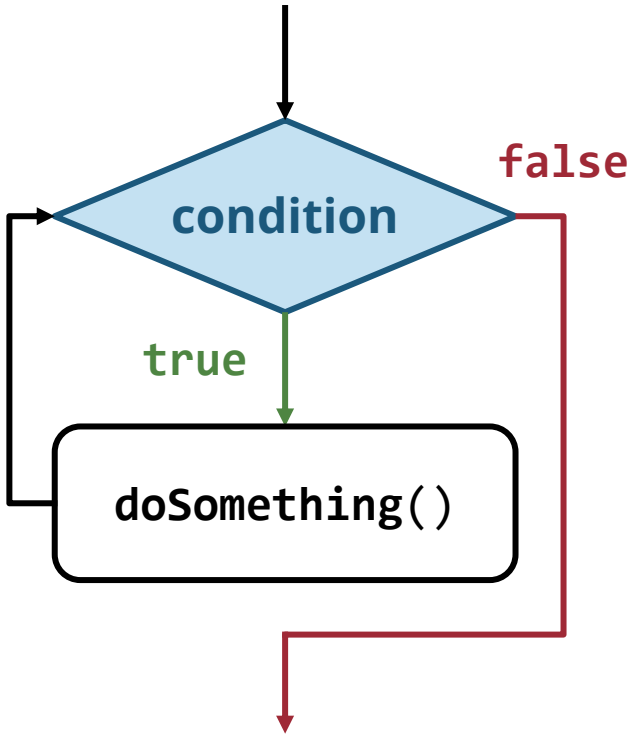
```
do {
  doSomething();
}
while (condition);
```

Don't forget the trailing semicolon

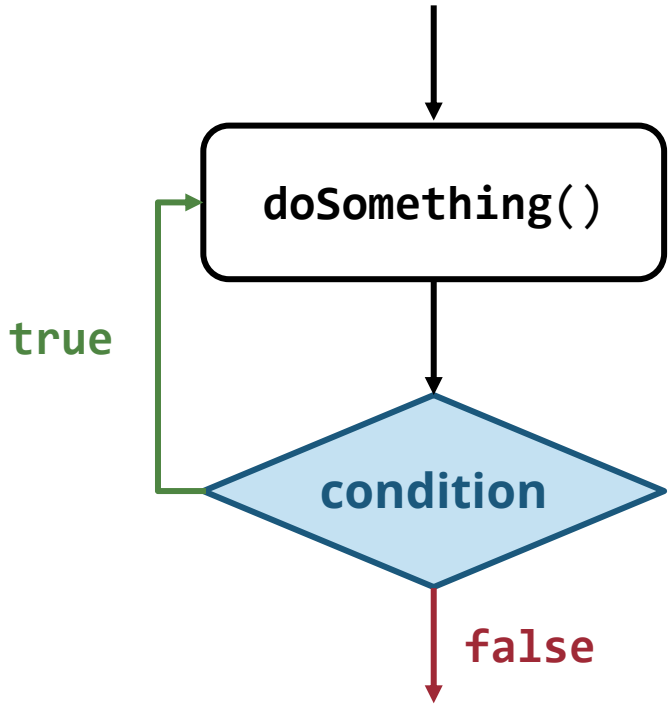


while vs do-while Loops

```
while (condition) {
   doSomething();
}
```




```
do {
   doSomething();
}
while (condition);
```



while vs do-while Loops

```
// Initialize x
float x = 0;

// Draw the circles
while (x <= 200) {
  circle(x, 200, 10);
  x += 20;
}
```



```
// Initialize x
float x = 0;

// Draw the circles
do {
  circle(x, 200, 10);
  x += 20;
}
while (x <= 200);
```

Be careful! `while` and `do-while` loops are not always equivalent!

break: Exiting a Loop in the Middle

```
while (condition) {
  doSomething();

  if (condition2) {
    break;
  }
}
```

Common Control Commands

- **`break`** Exit the current `while`, `for` or `switch` block
- **`return`** Exit the current function like `draw()`
- **`exit()`** Stop the whole program
- **`noLoop()`** Disable looping the `draw()` function

break vs return vs exit()

```
void setup() {
  size(400, 400);
}

void draw() {
  while (condition) {
    doSomething();

    if (condition2) {
      break;
    }
  }
  doSomethingElse();
}
```

```
void setup() {
  size(400, 400);
}

void draw() {
  while (condition) {
    doSomething();

    if (condition2) {
      return;
    }
  }
  doSomethingElse();
}
```

```
void setup() {
  size(400, 400);
}

void draw() {
  while (condition) {
    doSomething();

    if (condition2) {
      exit();
    }
  }
  doSomethingElse();
}
```

return vs noLoop() in draw()

- With **return**, **draw()** exits right away but still loops
- With **noLoop()**, **draw()** runs until the end but stops looping afterwards

Suppose isGameOver=true

```
void draw() {
  if (isGameOVer) {
    doSomething();
    return;
  }
  doSomethingElse();
}
```

```
void draw() {
  if (isGameOVer) {
    doSomething();
    noLoop();
  }
  doSomething();
}
```

while(true) Loop

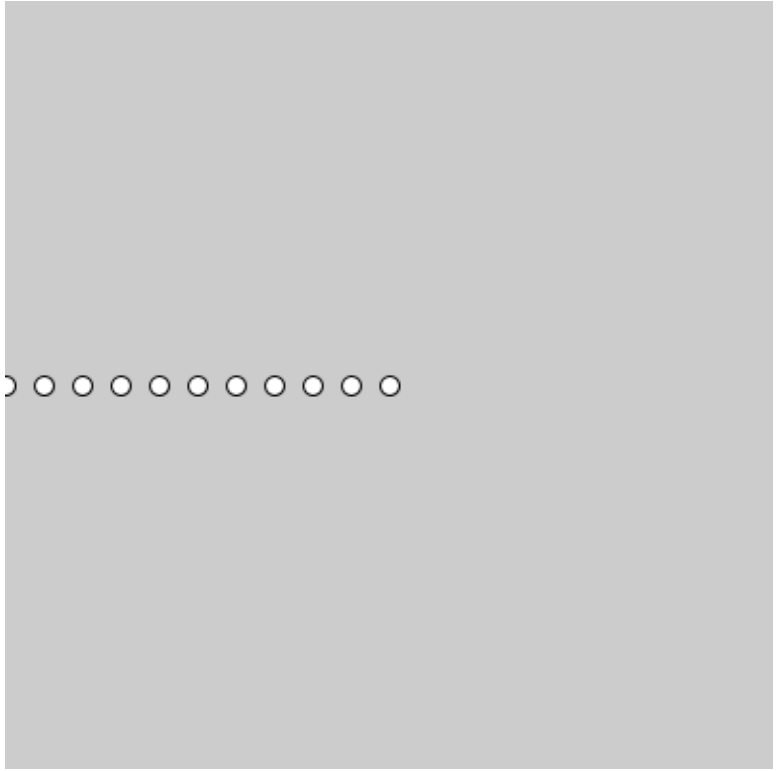
```
while (true) {
  doSomething();

  if (condition) {
    break;
  }
}
```

equivalent ⟷

```
do {
  doSomething();
}
while (condition);
```

Example: Circles

```
// Initialize x
float x = 0;

// Draw the circles
while (x <= 200) {
  circle(x, 200, 10);
  x = x + 20;
}
```

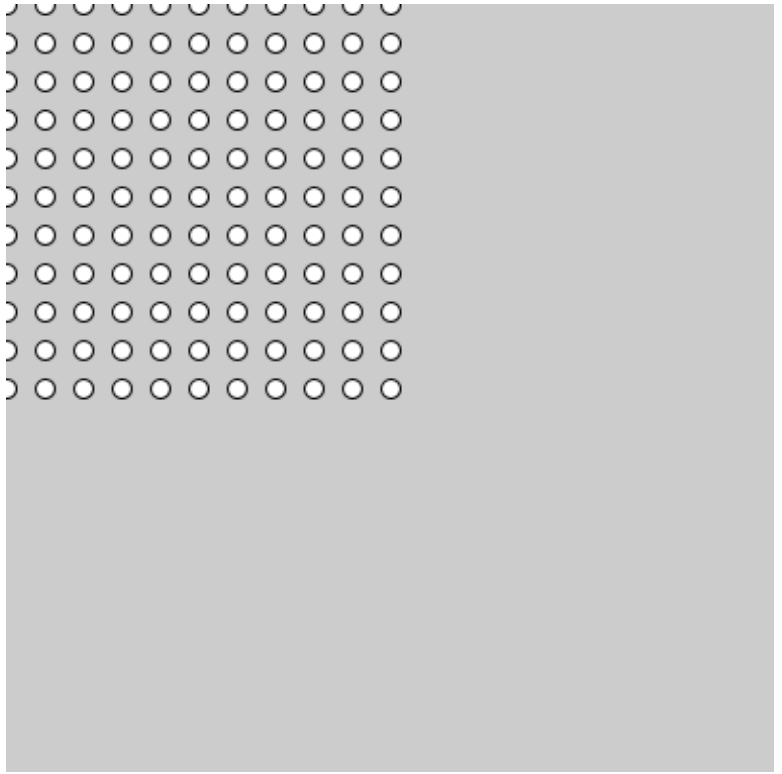


🧐 **Exercise**: Grid of Circles

- Draw a grid of circles using `while` loops
- You'll need two `while` loops
  - One inside the other, i.e., ***nested* loops**

```
float x = 0, y = 0;
while (x <= 200) {
  y = 0;
  while (y <= 200) {
    circle(x, y, 10);
    y += 20;
  }
  x += 20;
}
```

Don't forget to reset y to 0



for Loop

```
// Initialize x
float x = 0;

// Draw the circles
while (x <= 200) {
  circle(x, 200, 10);
  x = x + 20;
}
```

Initialization

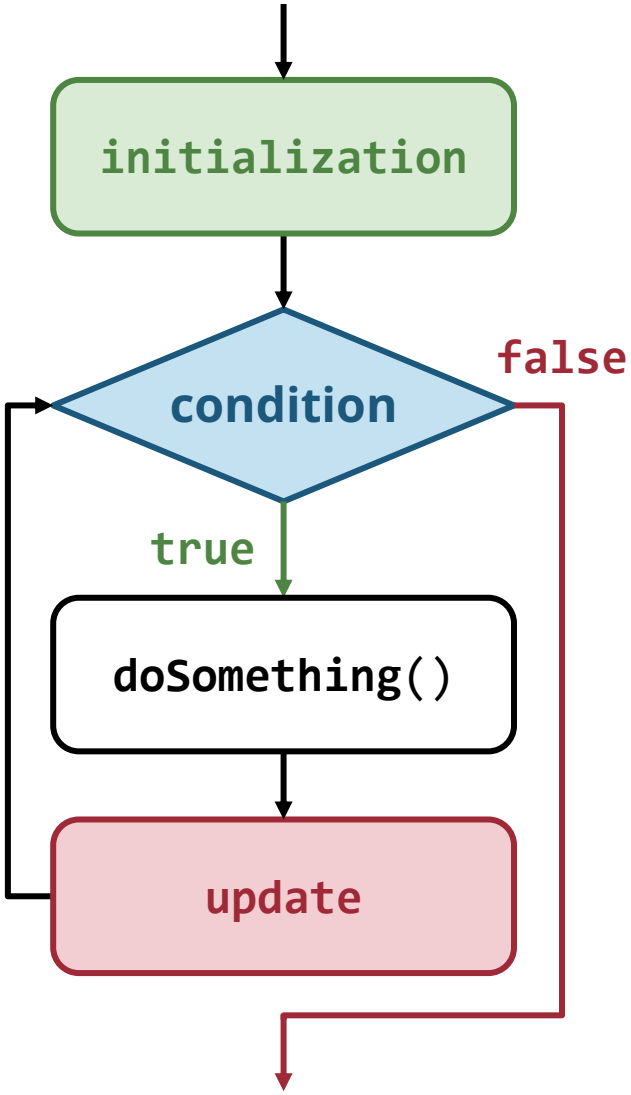
Condition

Update

```
for (float x = 0; x <= 200; x = x + 20) {
  circle(x, 200, 10);
}
```

for Loop

```
for (initialization; condition; update) {
  doSomething();
}
```



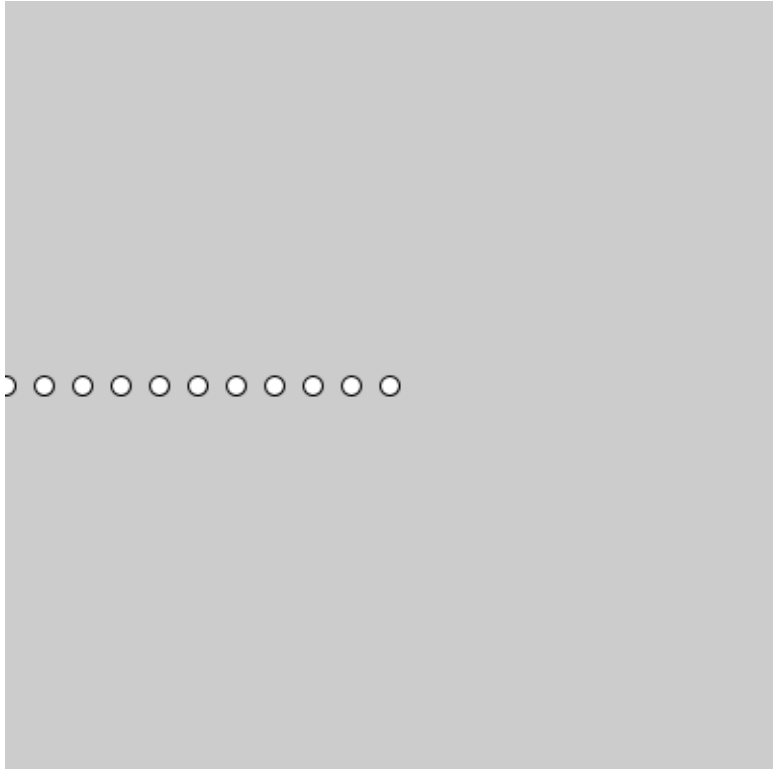
Example: Circles

```
for (float x = 0; x <= 200; x = x + 20) {
  circle(x, 200, 10);
}
```

x-position: 0 20 40 60 80 100 120 140 160 180 200

```
for (int i = 0; i <= 10; i = i + 1) {
  circle(i * 20, 200, 10);
}
```

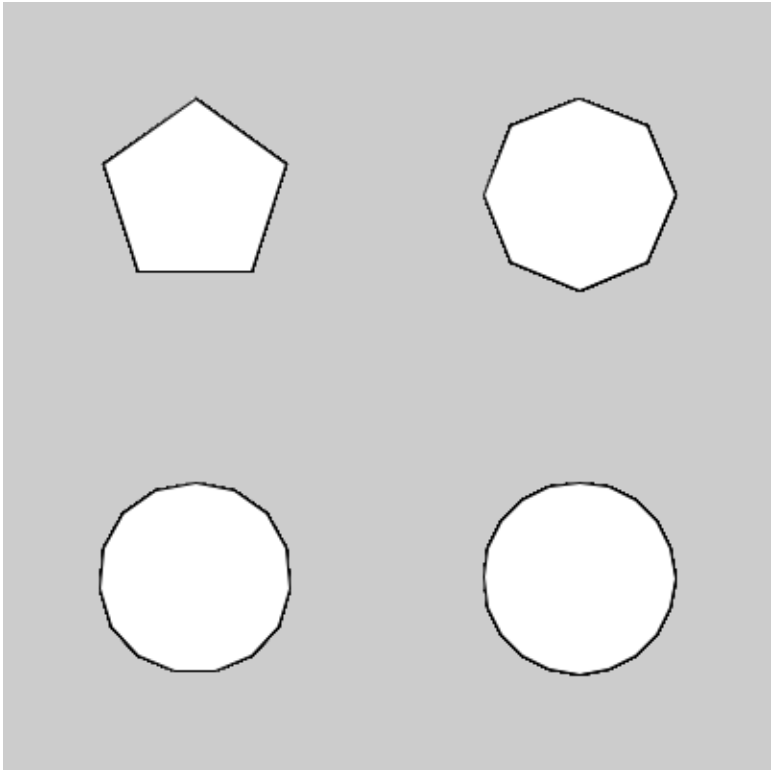
circle index: 0 1 2 3 4 5 6 7 8 9 10



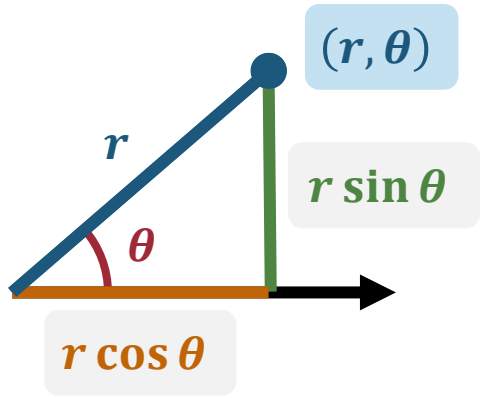
🧐 **Exercise**: Regular Polygons

- Write a function for drawing regular polygons

```
void polygon(float x, float y, float radius, int n) {
  beginShape();
  for (???) {
    ???
  }
  endShape(CLOSE);
}
```

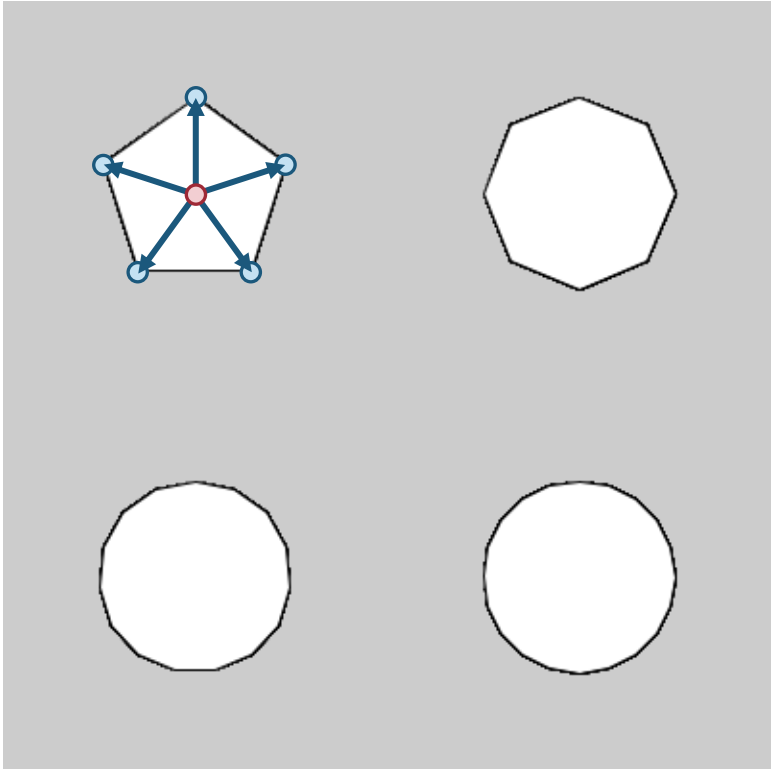


- **Hints**: Use **polar coordinate**!



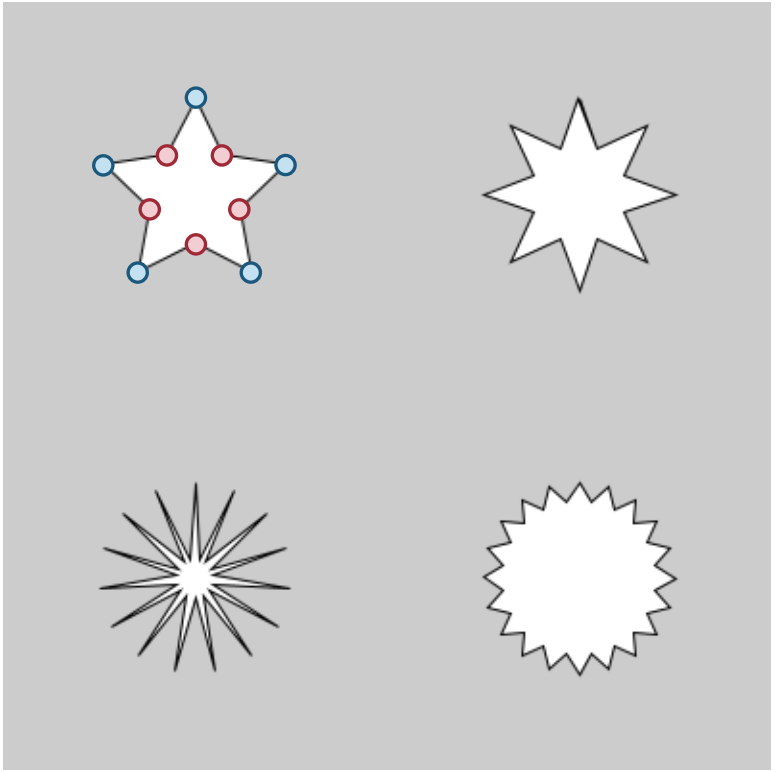
🧐 **Exercise**: Regular Polygons

```
void polygon(float x, float y, float radius, int n) {
  float vertexX, vertexY;
  beginShape();
  for (float a = 0; a < TWO_PI; a += TWO_PI / n) {
    vertexX = x + radius * cos(a - HALF_PI);
    vertexY = y + radius * sin(a - HALF_PI);
    vertex(vertexX, vertexY);
  }
  endShape(CLOSE);
}
```



Example: Stars

```
void star(float x, float y, float r1, float r2, int n) {
  float vertexX, vertexY;
  float angle = TWO_PI / n ;
  beginShape();
  for (float a = 0; a < TWO_PI; a += angle) {
    vertexX = x + radius1 * cos(a - HALF_PI);
    vertexY = y + radius1 * sin(a - HALF_PI);
    vertex(vertexX, vertexY);
    vertexX = x + radius2 * cos(a + angle / 2 - HALF_PI);
    vertexY = y + radius2 * sin(a + angle / 2 - HALF_PI);
    vertex(vertexX, vertexY);
  }
  endShape(CLOSE);
}
```



Handy Operators: +=, -=, *=, /=, ++, --

```
x = x + 1
```

```
x += 1
```

```
x++
```

```
x = x - 1
```

```
x -= 1
```

```
x--
```

```
x = x * 2
```

```
x *= 2
```

```
x = x / 2
```

```
x /= 2
```

```
for (int i = 0; i <= 10; i = i + 1) {
  circle(i * 20, 200, 10);
}
```

```
for (int i = 0; i <= 10; i += 1) {
  circle(i * 20, 200, 10);
}
```

```
for (int i = 0; i <= 10; i++) {
  circle(i * 20, 200, 10);
}
```

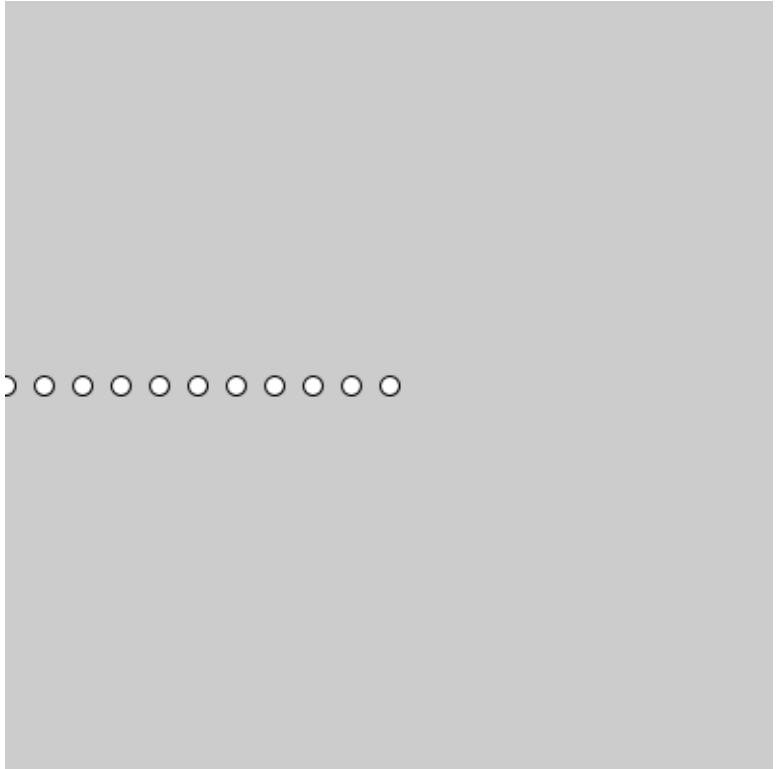
Reverse Looping

```
for (int i = 0; i <= 10; i++) {
  circle(i * 20, 200, 10);
}
```

0 1 2 3 4 5 6 7 8 9 10

```
for (int i = 10; i >= 0; i--) {
  circle(i * 20, 200, 10);
}
```

10 9 8 7 6 5 4 3 2 1 0



Modulo Operator: %

- The modulo operator returns the remainder
  - `a / b` Quotient
  - `a % b` Remainder
- For integer division,

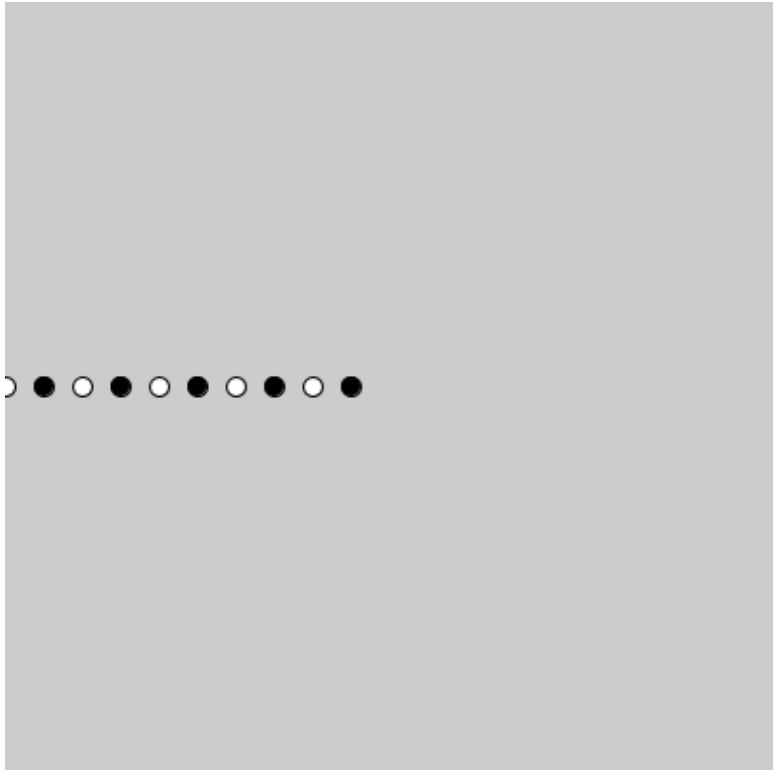
```
a = b * (a / b) + (a % b)
```

Modulo Operator: %

```
for (int i = 0; i <= 10; i++) {
  if (i % 2 == 0) {
    fill(255);
  } else {
    fill(0);
  }

  circle(i * 20, 200, 10);
}
```

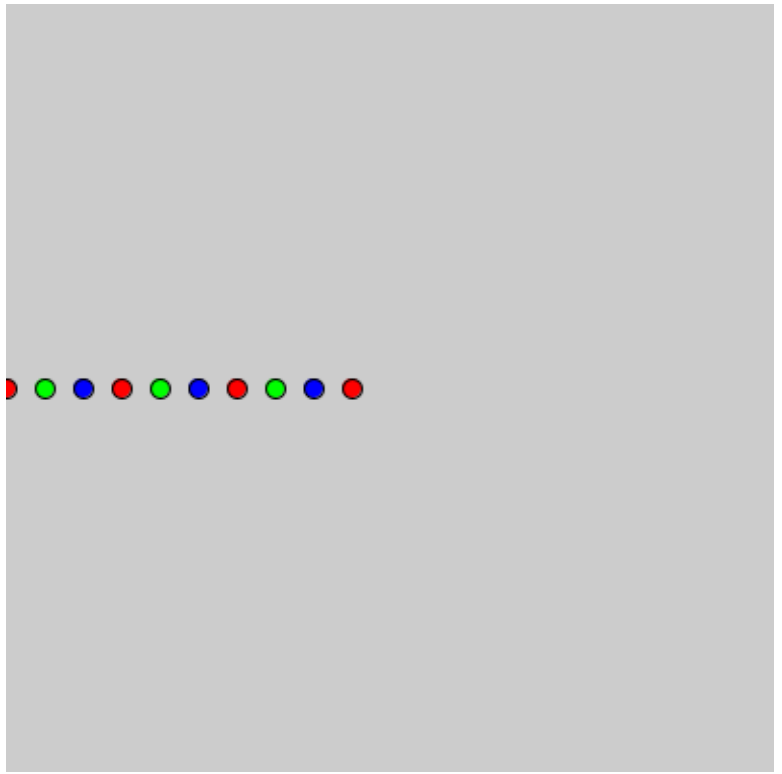
Even numbers

Odd numbers



Modulo Operator: %

```
for (int i = 0; i <= 10; i++) {
  if (i % 3 == 0) {
    fill(255, 0, 0);
  } else if (i % 3 == 1) {
    fill(0, 255, 0);
  } else {
    fill(0, 0, 255);
  }

  circle(i * 20, 200, 10);
}
```



Infinite loops: `while(true)` and `for(;;)`

```
while (true) {
  doSomething();

  if (condition) {
    break;
  }
}
```

equivalent

```
for (;;) {
  doSomething();

  if (condition) {
    break;
  }
}
```

When is an Infinite Loop Useful?

- `while(true)` and `for(;;)` are particularly useful if
  - we need **multiple complex conditions**
  - the **condition needs some computation**

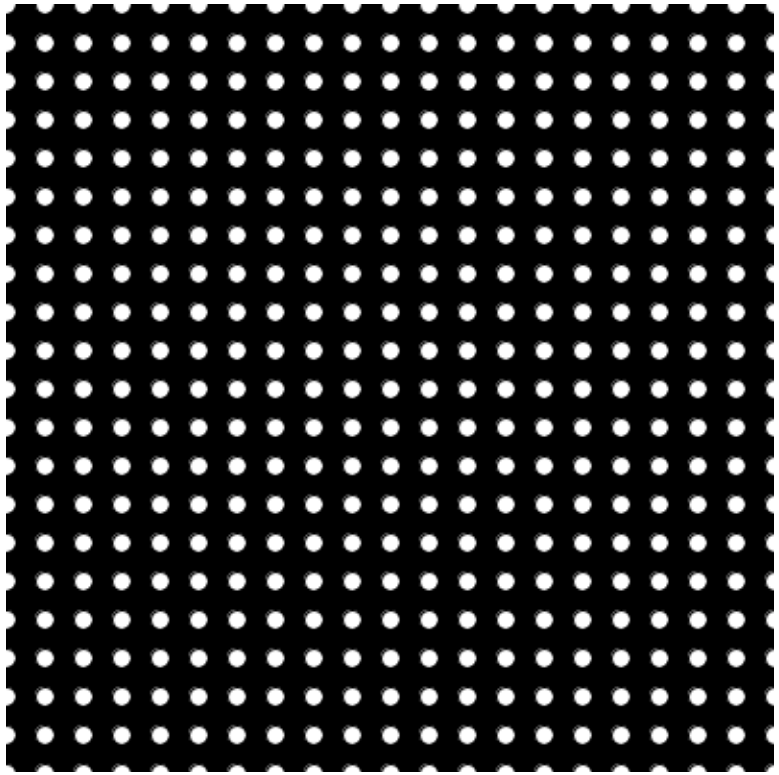
```
while (true) {
  doSomething();

  if (condition1) break;

  doSomethingElse();

  if (condition2) break;

  doYetSomethingElse();
}
```

Nested `for` Loops

🧐 **Exercise**: Grid of Circles

- Draw a grid of circles using `for` loops
- You'll need two **nested `for` loops**

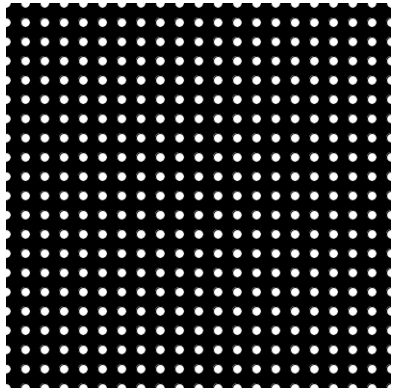
```
for (int i = 0; i <= 20; i++) {
  for (int j = 0; j <= 20; j++) {
    circle(i * 20, j * 20, 10);
  }
}
```

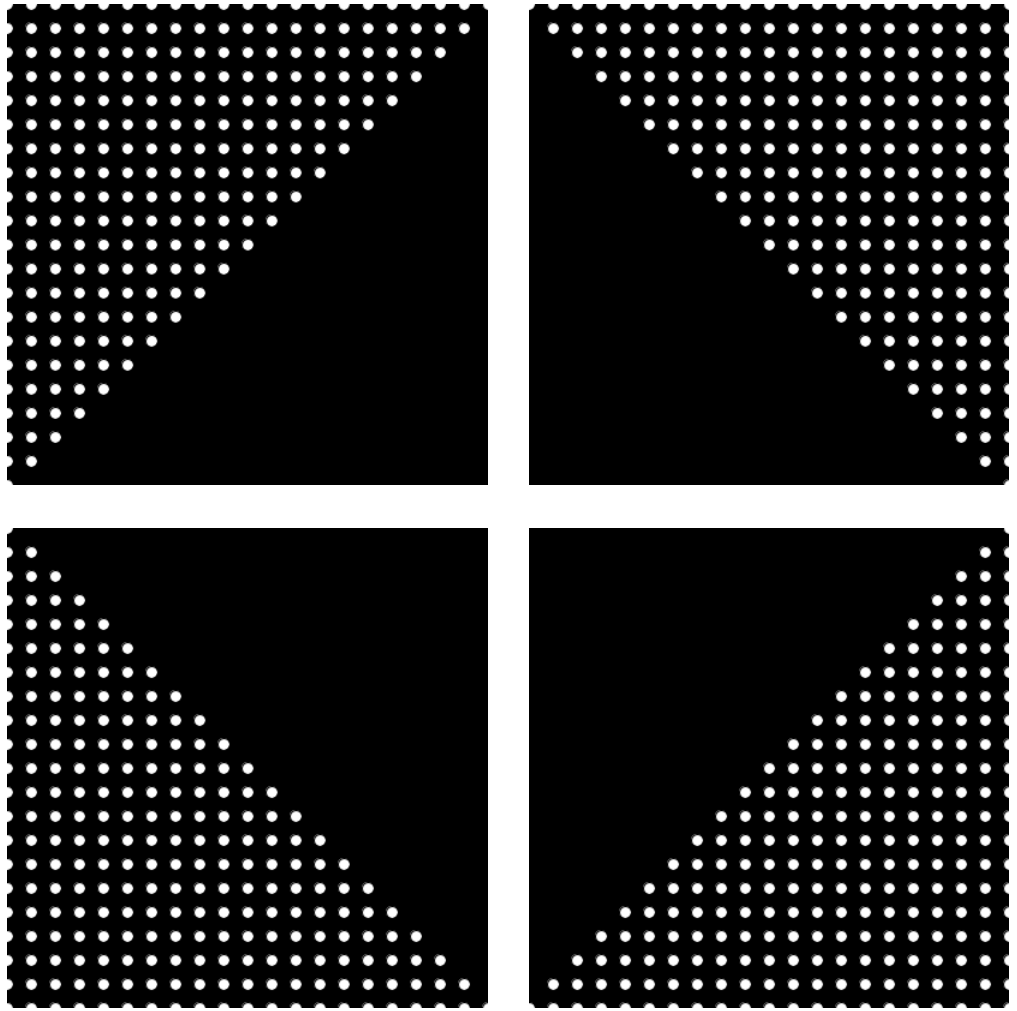


Example: Half Grid of Circles

- Draw a half grid of circles using a **nested `for` loop**

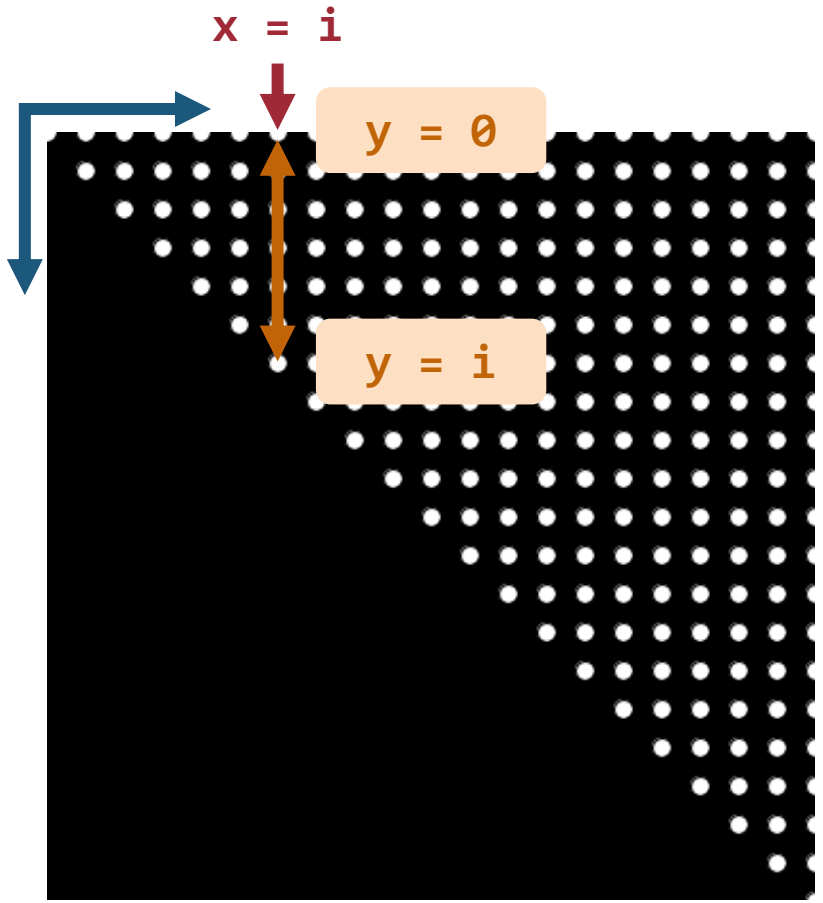
```
for (int i = 0; i <= 20; i++) {
  for (int j = 0; j <= 20; j++) {
    circle(i * 20, j * 20, 10);
  }
}
```





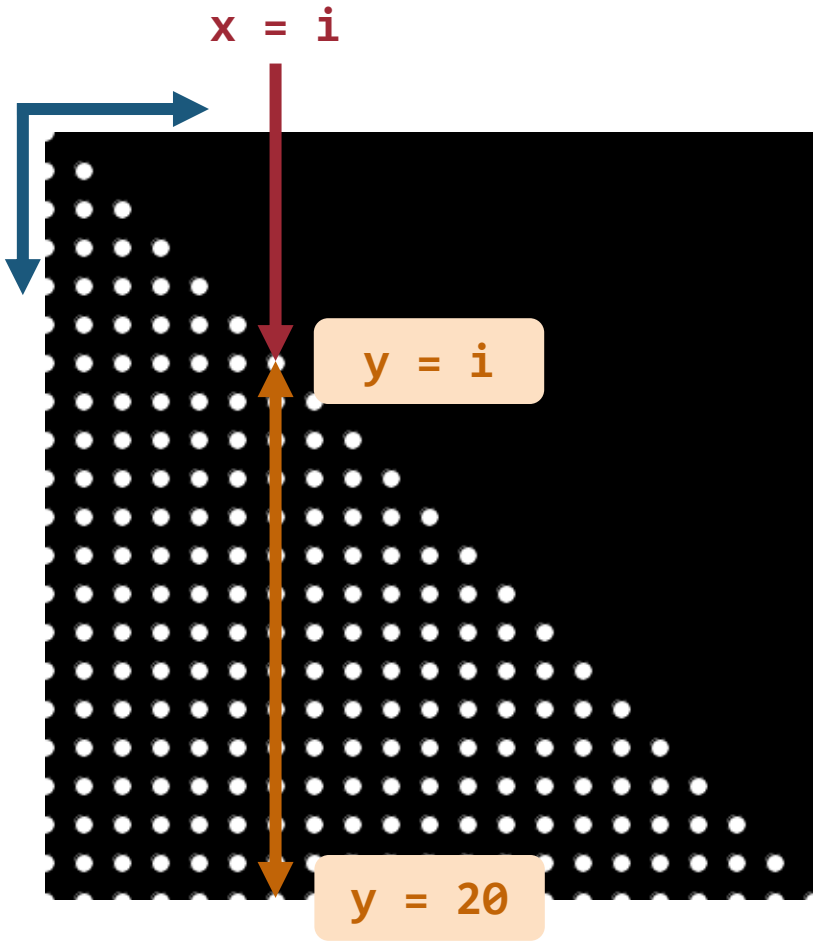
Example: Half Grid of Circles

```
for (int i = 0; i <= 20; i++) {
  for (int j = 0; j <= i; j++) {
    circle(i * 20, j * 20, 10);
  }
}
```



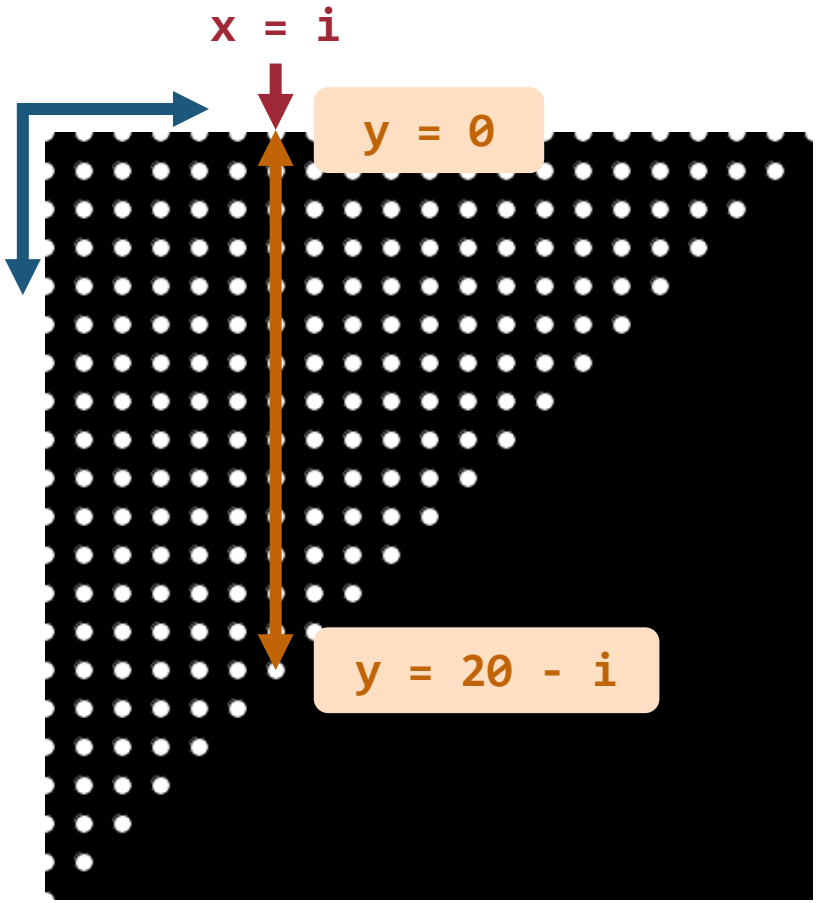
Example: Half Grid of Circles

```
for (int i = 0; i <= 20; i++) {
  for (int j = i; j <= 20; j++) {
    circle(i * 20, j * 20, 10);
  }
}
```



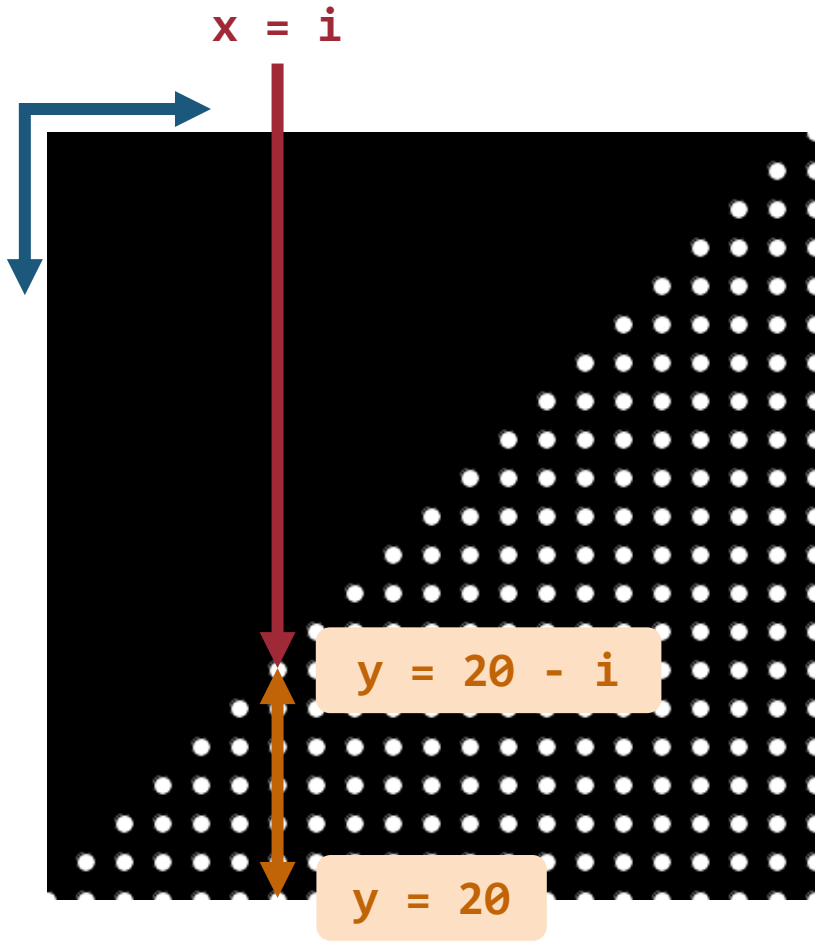
Example: Half Grid of Circles

```
for (int i = 0; i <= 20; i++) {
  for (int j = 0; j <= 20 - i; j++) {
    circle(i * 20, j * 20, 10);
  }
}
```



Example: Half Grid of Circles

```
for (int i = 0; i <= 20; i++) {
  for (int j = 20 - i; j <= 20; j++) {
    circle(i * 20, j * 20, 10);
  }
}
```



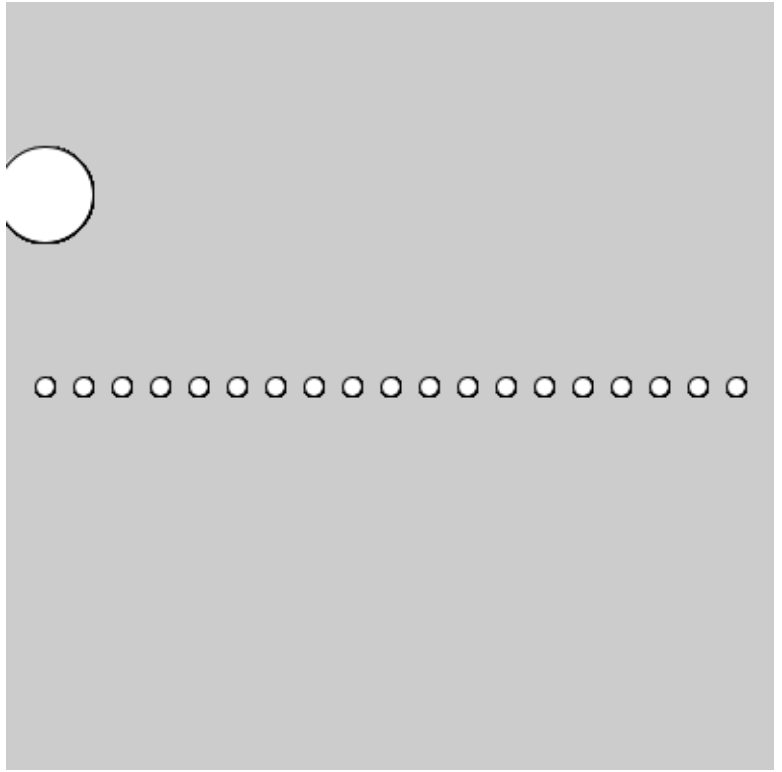
Variable Scope

```
int i = 1;

void setup() {
  size(400, 400);
}

void draw() {
  for (int i = 1; i < 20; i++) {
    circle(i * 20, 200, 10);
  }

  circle(i * 20, 100, 50);
}
```

Local variables will be deleted when we exit the block

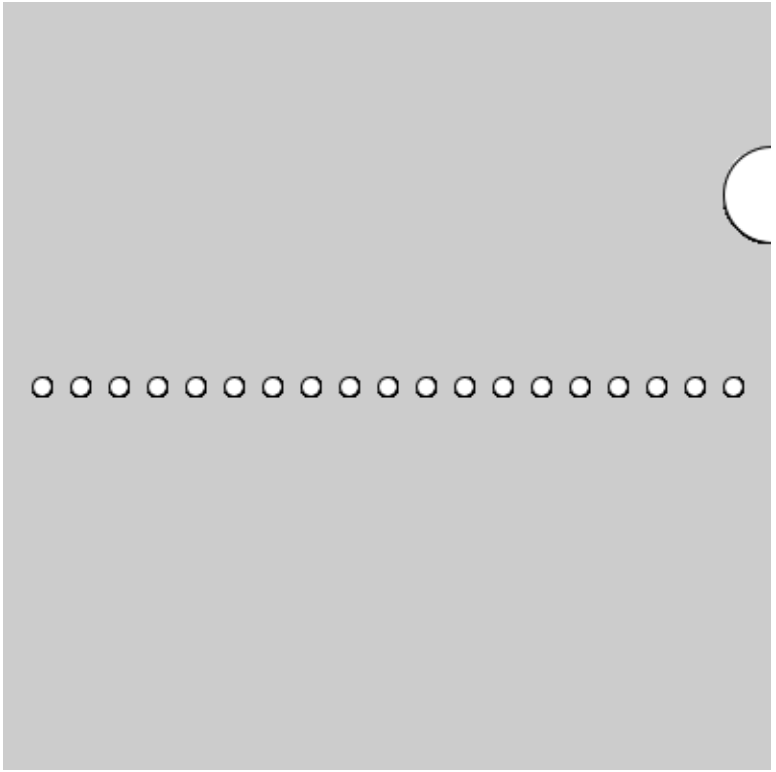
~~New local variable i~~

~~After the for loop, i is 20~~



Variable Scope

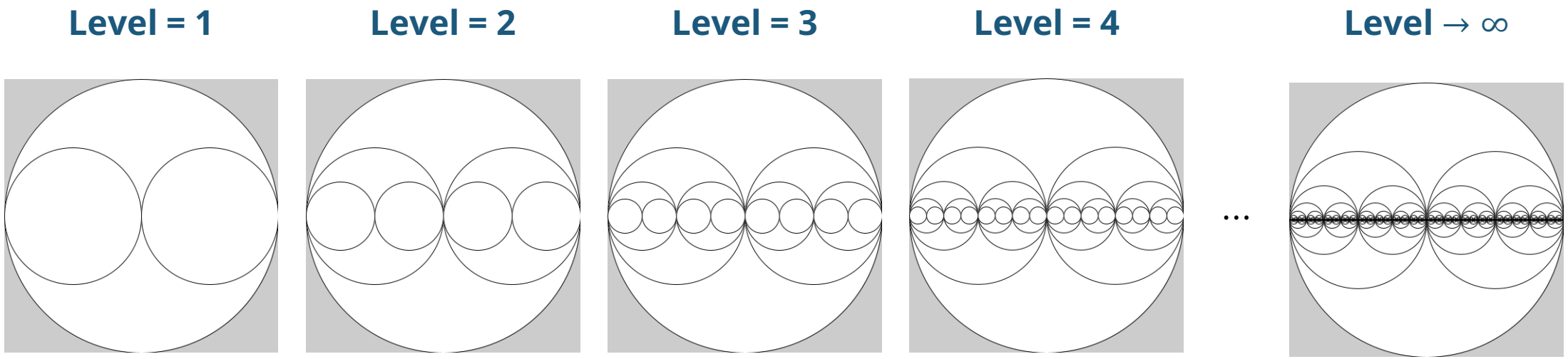
```
int i = 1;

void setup() {
  size(400, 400);
}

void draw() {
  for (i = 1; i < 20; i++) {
    circle(i * 20, 200, 10);
  }

  circle(i * 20, 100, 50);
}
```



Recursion

Recursion

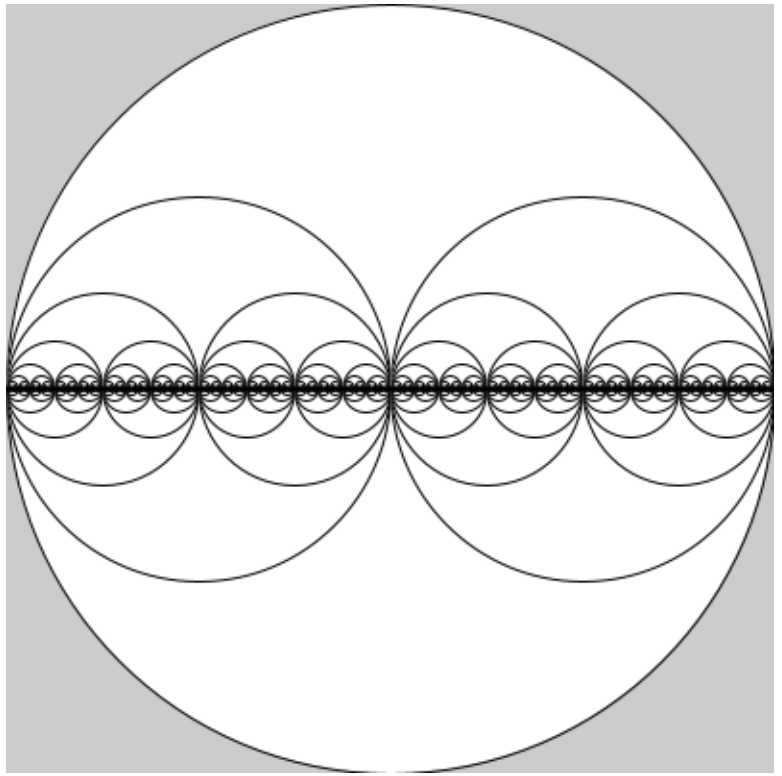
- Recursively calling a function



Example: Recursive Circles

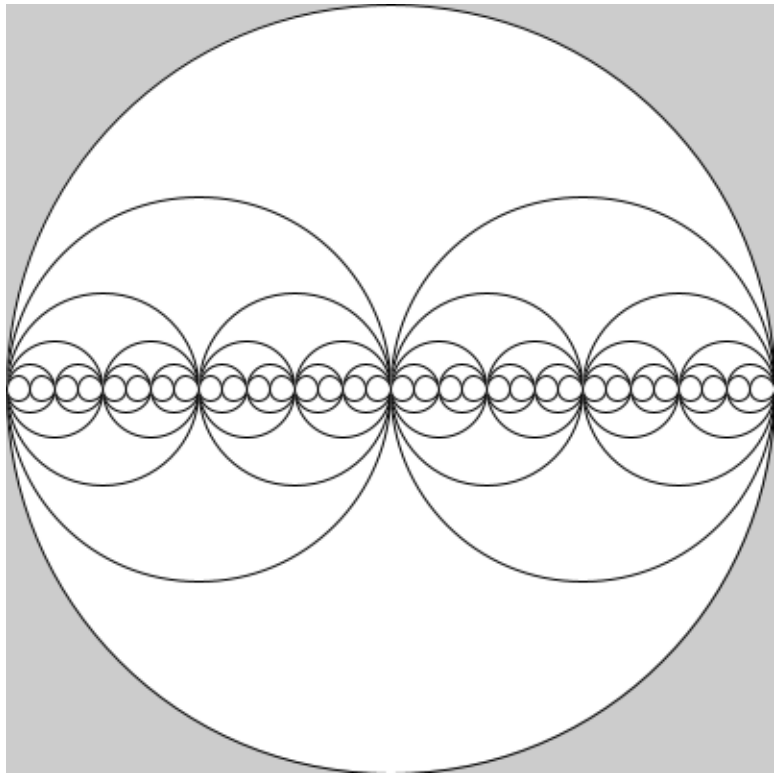
```
void drawCircles(float x, float y, float w) {
  if (w < 1) return;
  circle(x - w / 4, y, w / 2);
  drawCircles(x - w / 4, y, w / 2);

  circle(x + w / 4, y, w / 2);
  drawCircles(x + w / 4, y, w / 2);
}

void draw() {
  circle(200, 200, 400);
  drawCircles(200, 200, w);
}
```

Stop condition



Example: Recursive Circles to a Certain Level

```
void drawCircles(float x, float y, float w, int l) {
  if (l < 1) return;
  if (w < 1) return;
  circle(x - w / 4, y, w / 2);
  drawCircles(x - w / 4, y, w / 2, l - 1);

  circle(x + w / 4, y, w / 2);
  drawCircles(x + w / 4, y, w / 2, l - 1);
}

void draw() {
  circle(200, 200, 400);
  drawCircles(200, 200, w, 6);
}
```



Loops vs Recursion

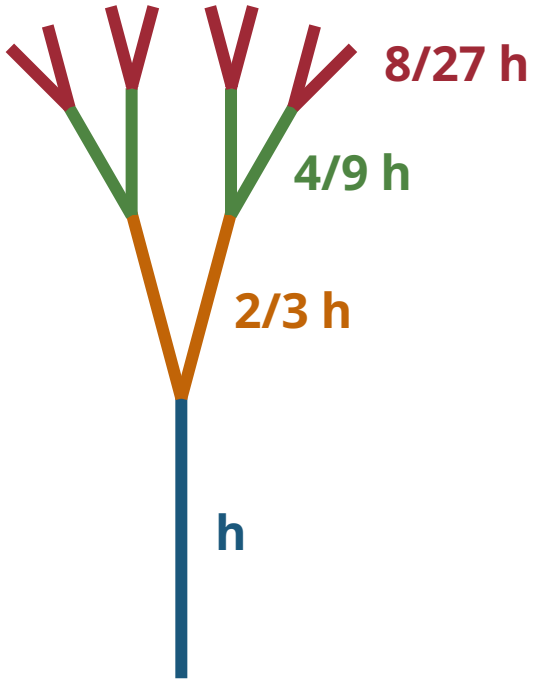
- **Any recursive function can be written using a loop**, and vice versa!
- Loops are usually faster and use less memory
- Recursive functions sometimes are easier to write

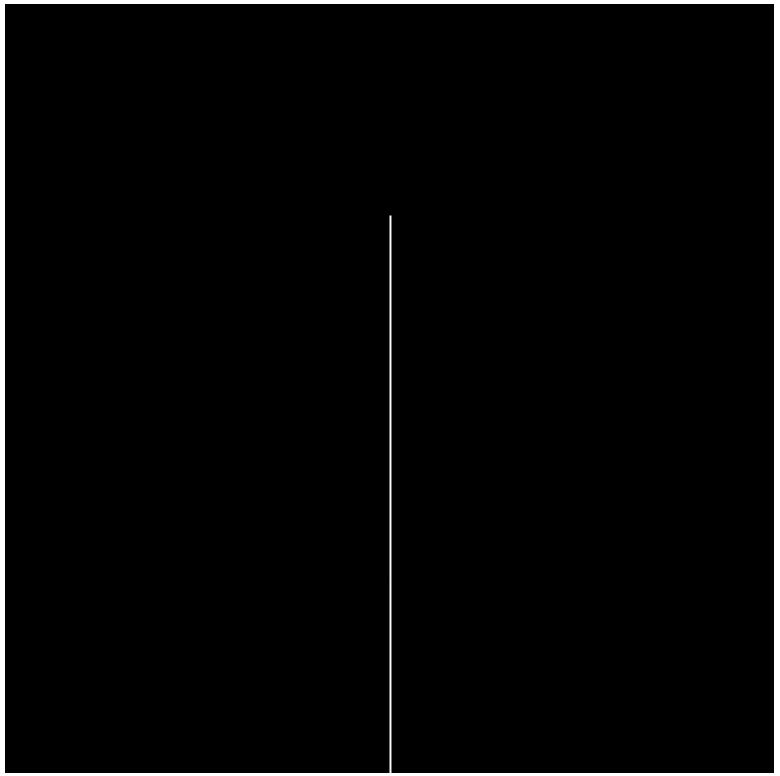
- **When to use which?**

	# of inner routines	Endpoint
`while` loop	unknown	unknown
`for` loop	known	known
Recursion	known	unknown

Example: Recursive Tree

- Symmetric branches of 2/3 length of its root
  - One branch is rotated counterclockwise for a fixed angle
  - The other branch is rotated clockwise for a fixed angle

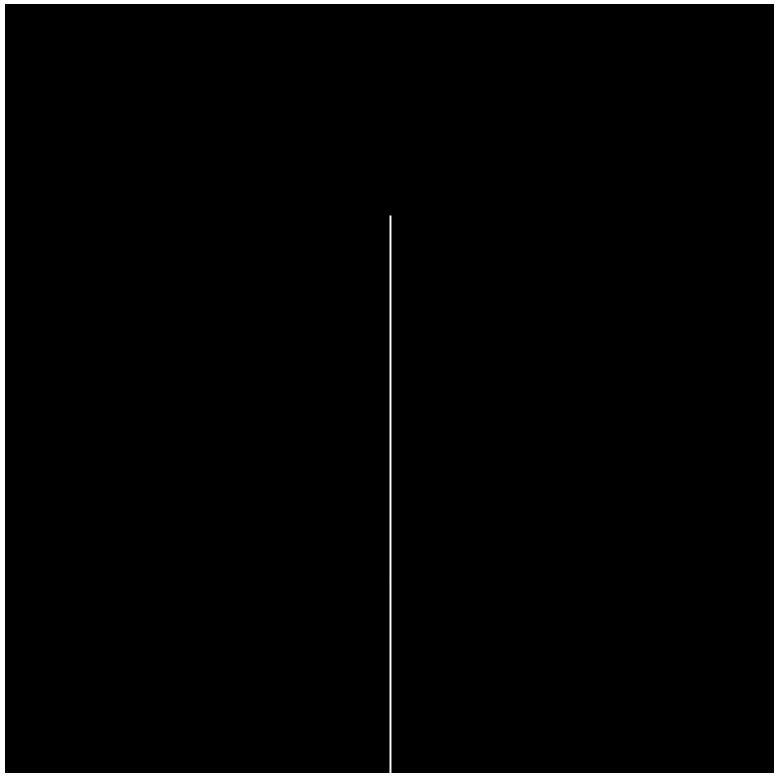




Example: Recursive Tree

```
void branch(float h) {
  if (h < 2) break;

  // Right branch
  pushMatrix();
  rotate(theta);
  line(0, 0, 0, -h * scale);
  translate(0, -h * scale);
  branch(h * scale);
  popMatrix();

  // Left branch
  pushMatrix();
  rotate(-theta);
  line(0, 0, 0, -h * scale);
  translate(0, -h * scale);
  branch(h * scale);
  popMatrix();
}
```

Stop condition



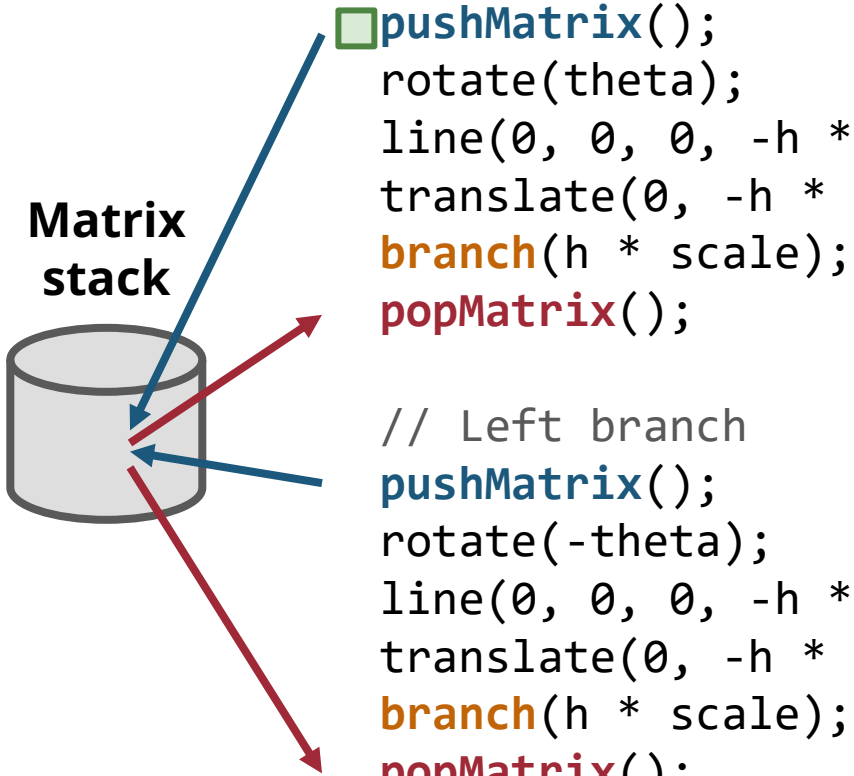
Matrix Transforms

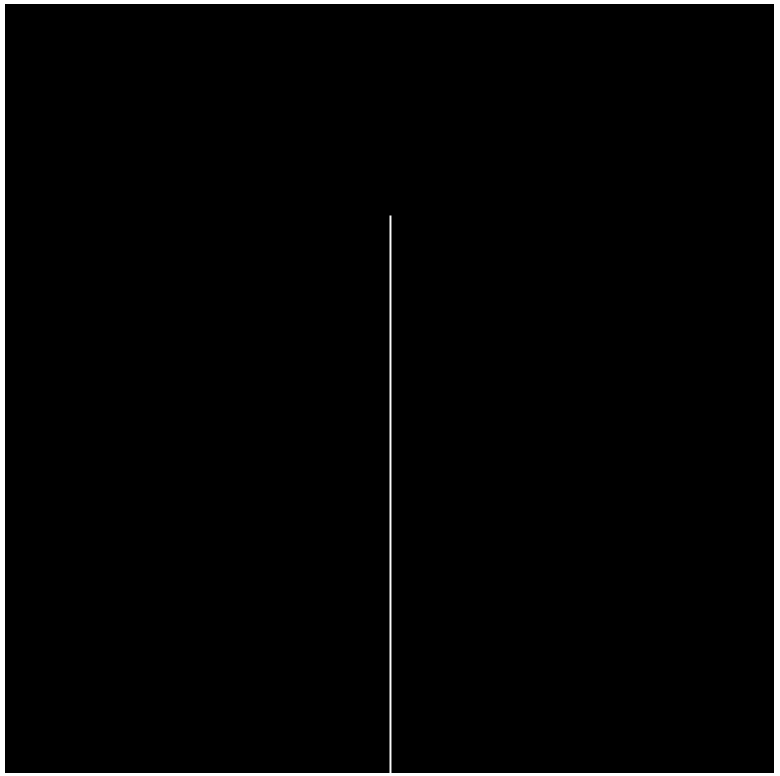
- `pushMatrix()` Push the current transformation matrix to the stack
- `popMatrix()` Pop the latest transformation matrix off the stack
- `resetMatrix()` Reset to identity matrix

- `translate(x, y)`
- `rotate(angle)`
- `scale(s)`
- `scale(x, y)`

Example: Recursive Tree

```
void branch(float h) {
  if (h < 2) break;

  // Right branch
  pushMatrix();
  rotate(theta);
  line(0, 0, 0, -h * scale);
  translate(0, -h * scale);
  branch(h * scale);
  popMatrix();

  // Left branch
  pushMatrix();
  rotate(-theta);
  line(0, 0, 0, -h * scale);
  translate(0, -h * scale);
  branch(h * scale);
  popMatrix();
}
```

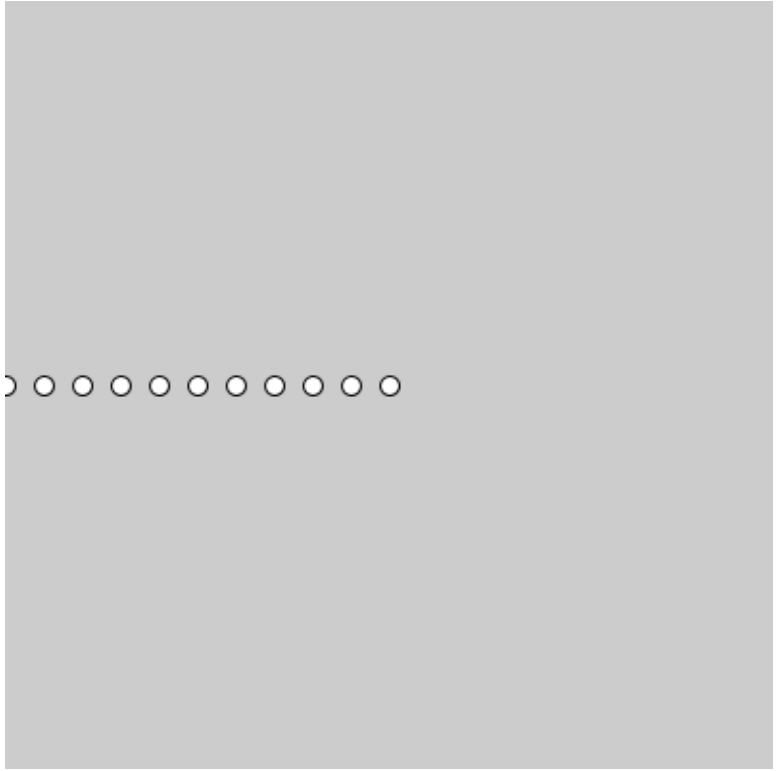




Recap

Example: Circles

```
// Initialize x
float x = 0;

// Draw the circles
while (x <= 200) {
  circle(x, 200, 10);
  x += 20;
}
```



break vs return vs exit()

```
void setup() {
  size(400, 400);
}

void draw() {
  while (condition) {
    doSomething();

    if (condition2) {
      break;
    }
  }
  doSomethingElse();
}
```

```
void setup() {
  size(400, 400);
}

void draw() {
  while (condition) {
    doSomething();

    if (condition2) {
      return;
    }
  }
  doSomethingElse();
}
```

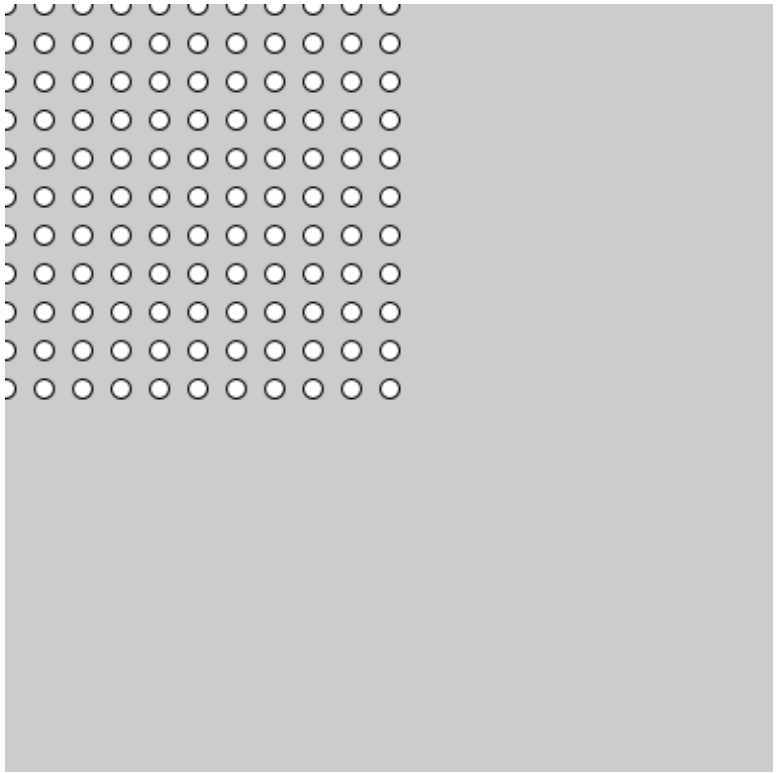
```
void setup() {
  size(400, 400);
}

void draw() {
  while (condition) {
    doSomething();

    if (condition2) {
      exit();
    }
  }
  doSomethingElse();
}
```

🧐 **Exercise**: Grid of Circles

- Draw a grid of circles using `while` loops
- You'll need two `while` loops
  - One inside the other, i.e., ***nested* loops**

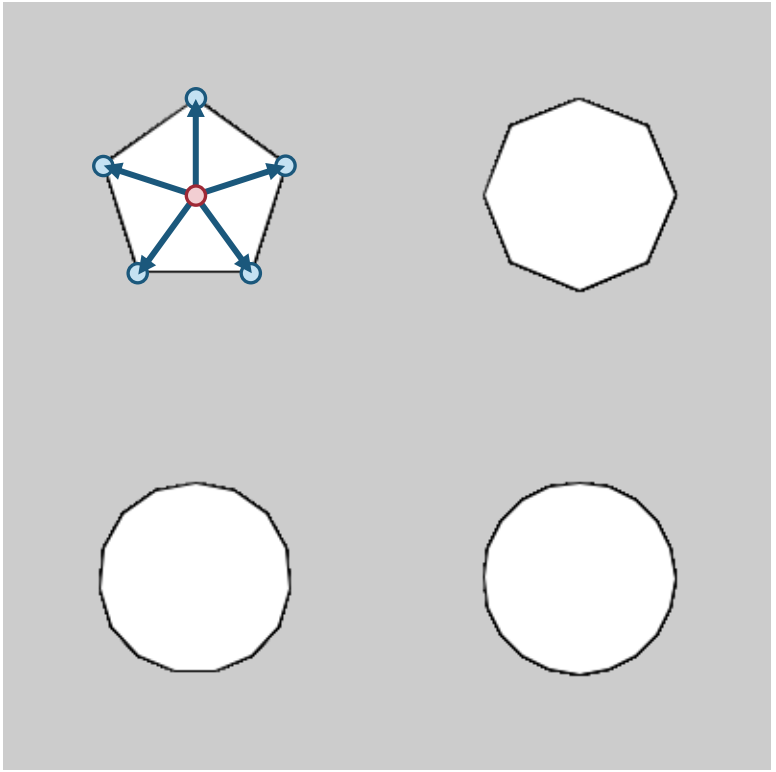
```
float x = 0, y = 0;

while (x <= 200) {
  y = 0;
  while (y <= 200) {
    circle(x, y, 10);
    y += 20;
  }
  x += 20;
}
```

Don't forget to reset y to 0



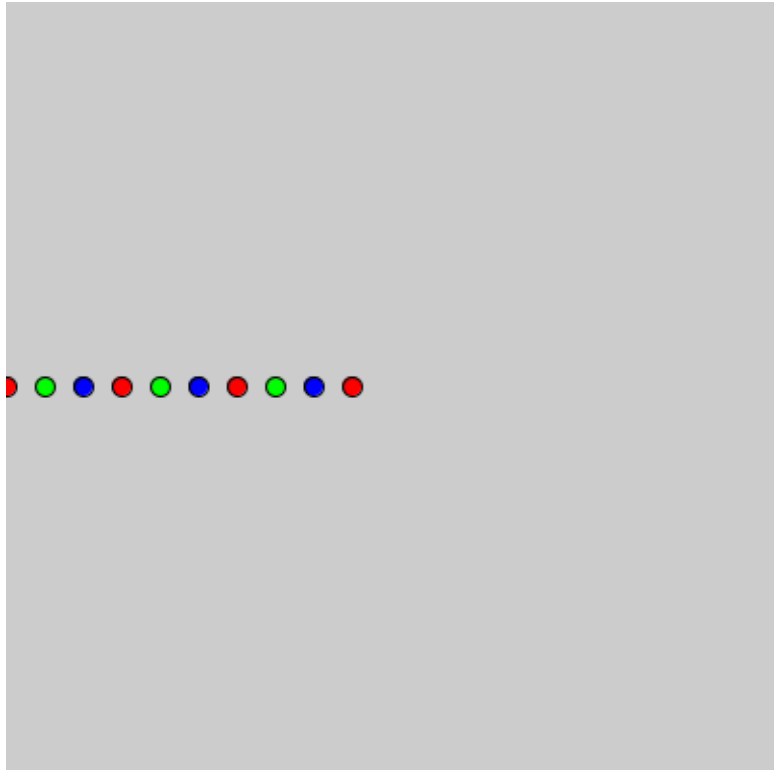
🧐 **Exercise**: Regular Polygons

```
void polygon(float x, float y, float radius, int n) {
  float vertexX, vertexY;
  beginShape();
  for (float a = 0; a < TWO_PI; a += TWO_PI / n) {
    vertexX = x + radius * cos(a - HALF_PI);
    vertexY = y + radius * sin(a - HALF_PI);
    vertex(vertexX, vertexY);
  }
  endShape(CLOSE);
}
```



Modulo Operator: %

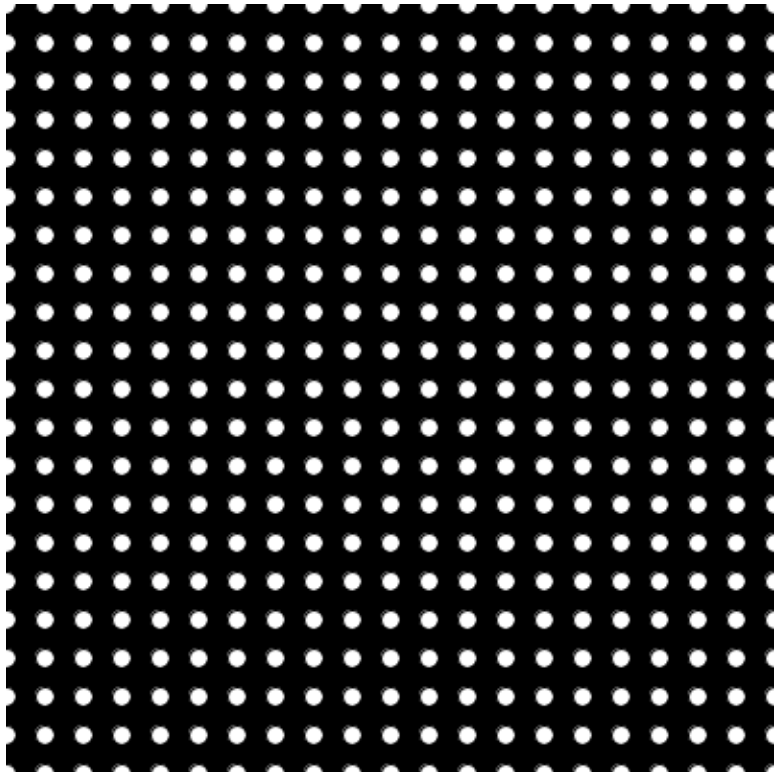
```
for (int i = 0; i <= 10; i++) {
  if (i % 3 == 0) {
    fill(255, 0, 0);
  } else if (i % 3 == 1) {
    fill(0, 255, 0);
  } else {
    fill(0, 0, 255);
  }

  circle(i * 20, 200, 10);
}
```



🧐 **Exercise**: Grid of Circles

- Draw a grid of circles using `for` loops
- Again, you'll need two nested for loops

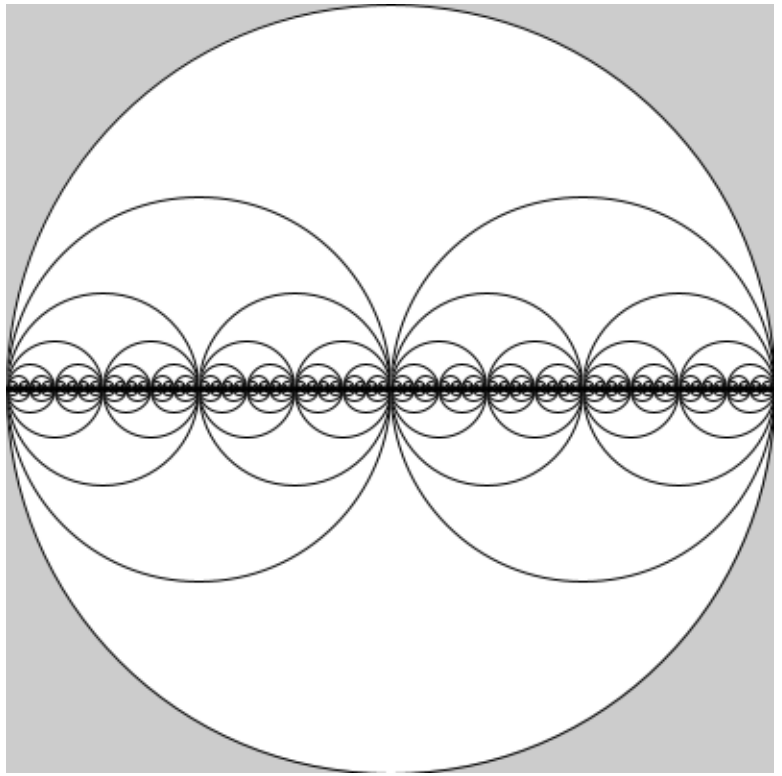
```
for (int i = 0; i <= 20; i++) {
  for (int j = 0; j <= 20; j++) {
    circle(i * 20, j * 20, 10);
  }
}
```



Example: Recursive Circles

```
void drawCircles(float x, float y, float w) {
  if (w < 1) return;
  circle(x - w / 4, y, w / 2);
  drawCircles(x - w / 4, y, w / 2);

  circle(x + w / 4, y, w / 2);
  drawCircles(x + w / 4, y, w / 2);
}

void draw() {
  circle(200, 200, 400);
  drawCircles(200, 200, w);
}
```

Stop condition



Example: Recursive Tree

```
void branch(float h) {
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  // Right branch
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  translate(0, -h * scale);
  branch(h * scale);
  popMatrix();

  // Left branch
  pushMatrix();
  rotate(-theta);
  line(0, 0, 0, -h * scale);
  translate(0, -h * scale);
  branch(h * scale);
  popMatrix();
}
```

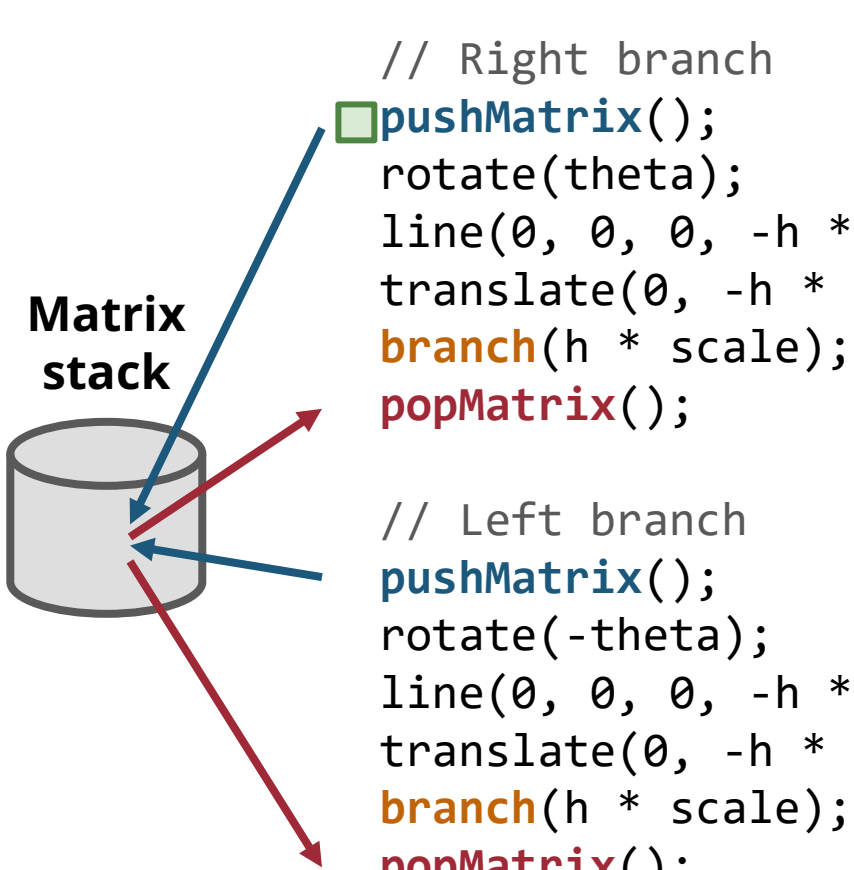

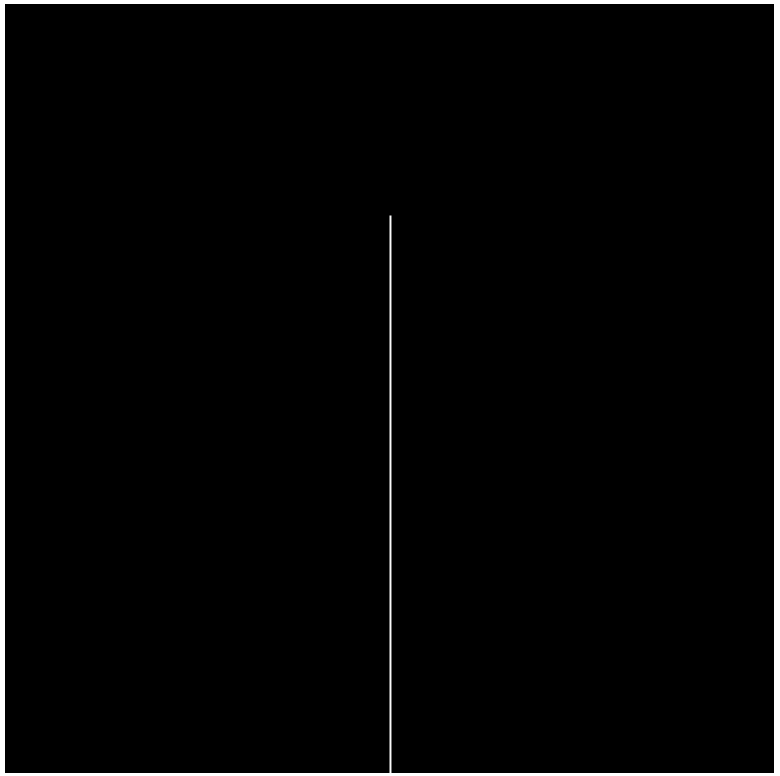

Next Lecture

Data Types & Arrays