Inf1-OP

Conditionals and Loops[1]

Volker Seeker, adapting earlier version by Perdita Stevens and Ewan Klein

School of Informatics

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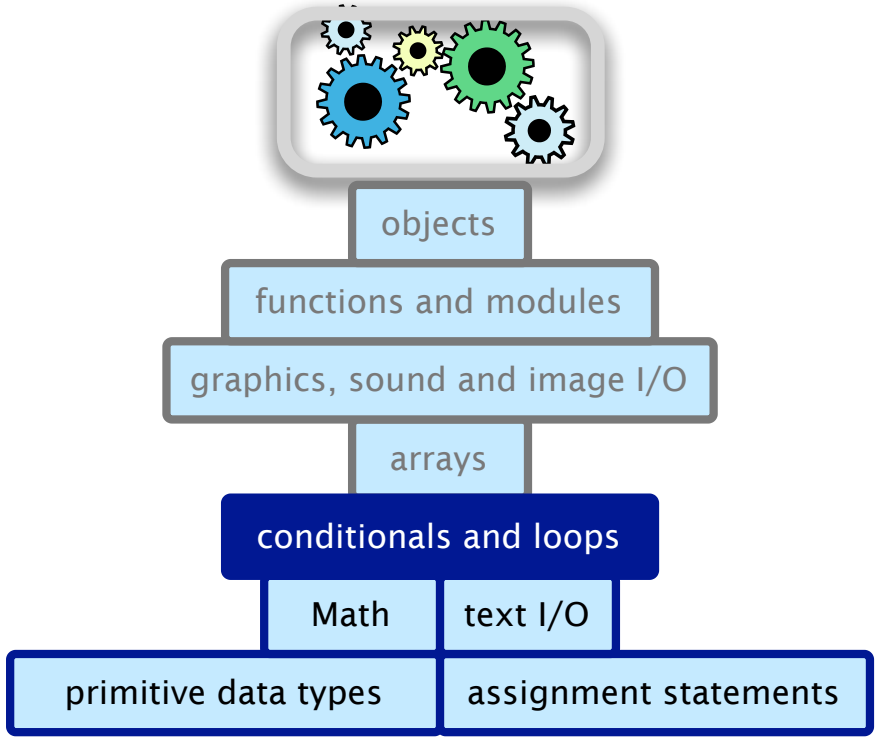
[1] Thanks to Sedgewick&Wayne for much of this content

A Foundation for Programming

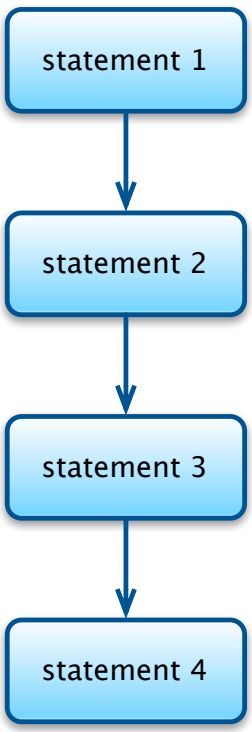


Conditional Statements

Control Flow

Control flow:

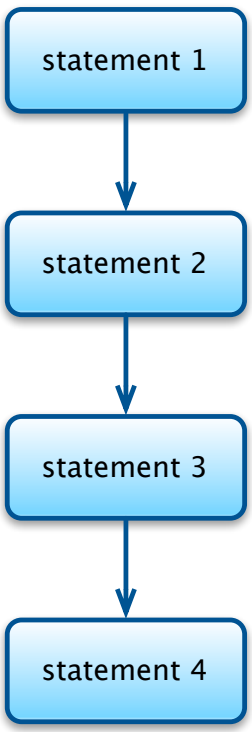
- A sequence of statements that are actually executed in a program

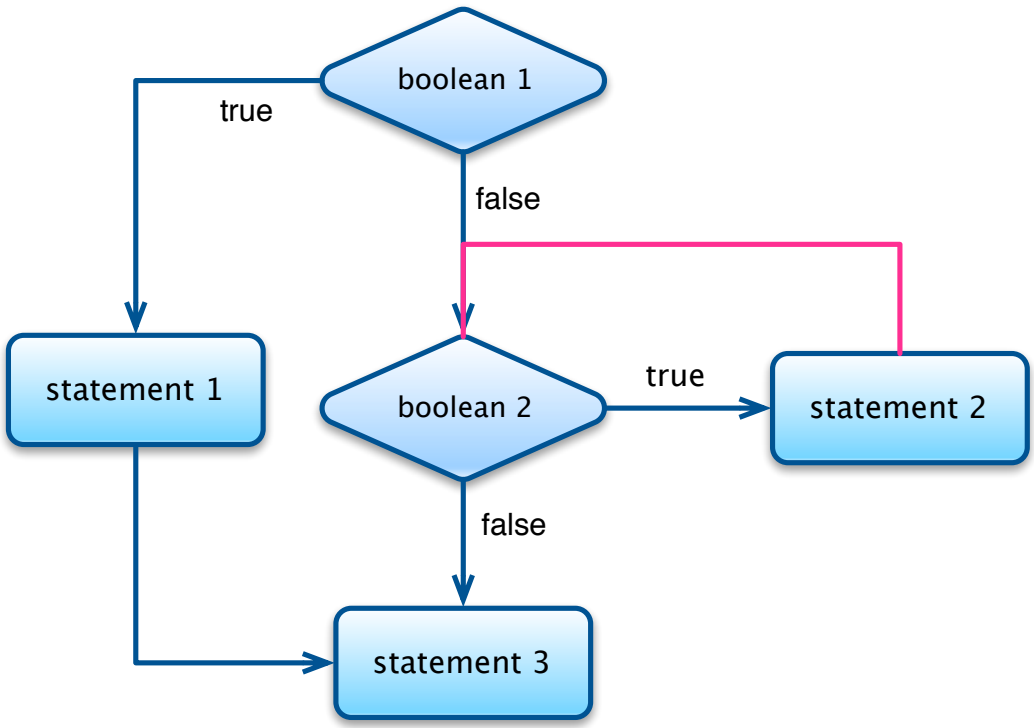


Control Flow

Control flow:

- A sequence of statements that are actually executed in a program
- Conditionals and loops enable us to choreograph control flow





If Statement

If / conditional statement:

- Evaluate a `boolean` expression E.
- If value of E is `true`, execute some statements.
- If value of E is `false`, execute some other statements — this is the *else* part of a conditional statement.

If Statement

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- Evaluate a `boolean` expression E.
- If value of E is `true`, execute some statements.
- If value of E is `false`, execute some other statements — this is the *else* part of a conditional statement.

```
if (boolean expression) {
    statement T;
}
else {
    statement F;
}
```

can be any sequence of statements

If Statement

If / conditional statement:

- Evaluate a `boolean` expression E.
- If value of E is `true`, execute some statements.
- If value of E is `false`, execute some other statements — this is the *else* part of a conditional statement.

```
if (boolean expression) {
    statement T;
}
else {
    statement F;
}
```

can be any sequence of statements

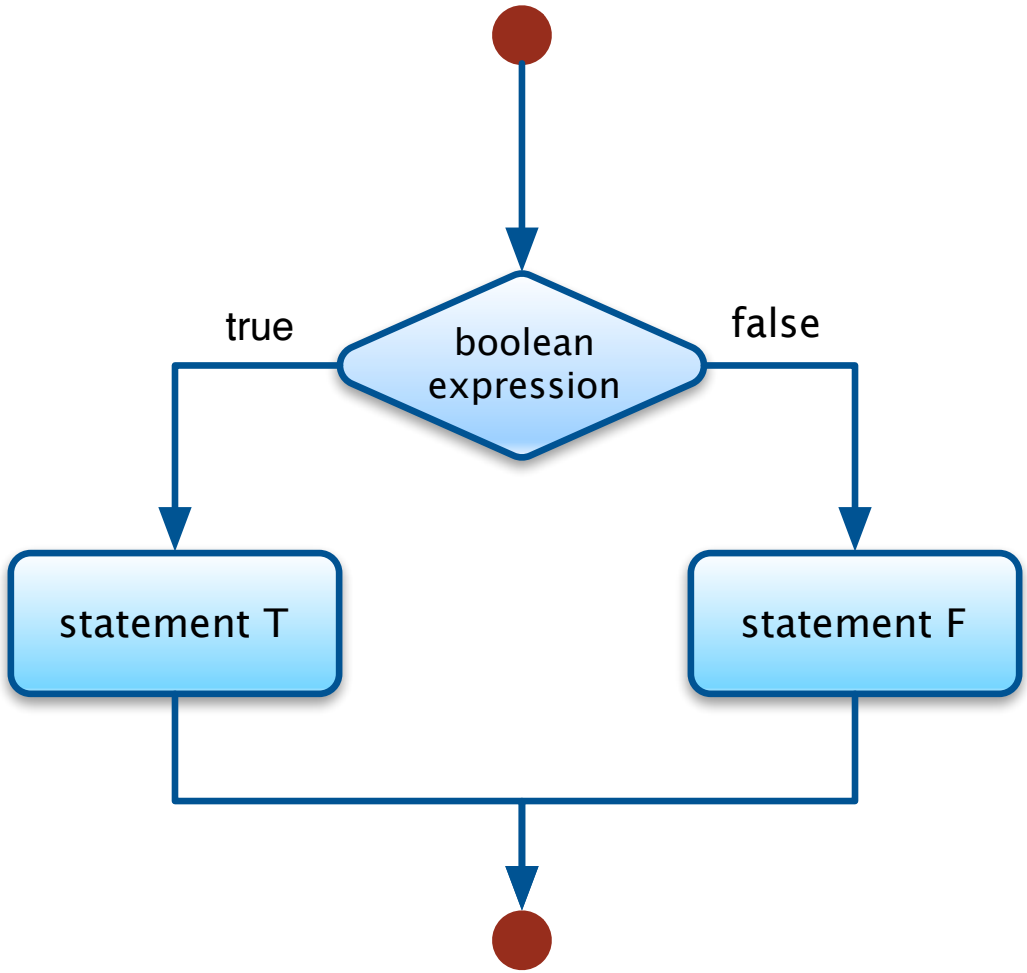
boolean expression

```
if (x > y) {

    int t = x;
    x = y;
    y = t;

}
```

sequence of statements

If Statement

If / conditional statement — sometimes called branching structures:

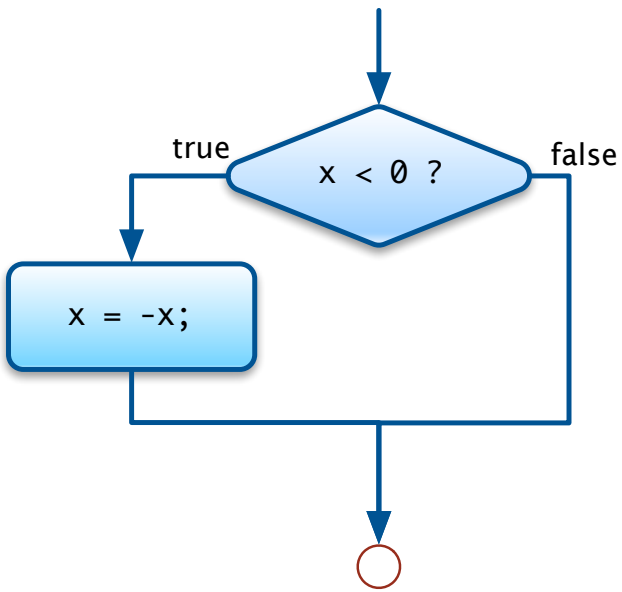


If Statement

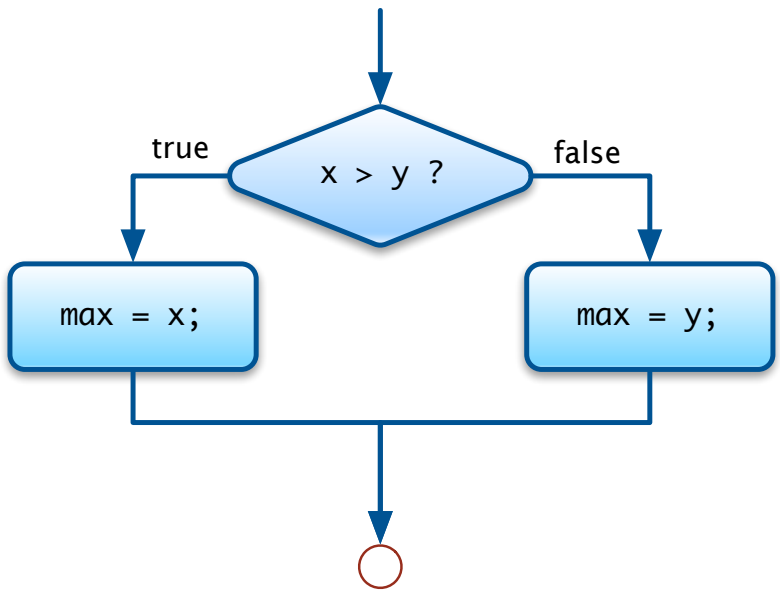
If / conditional statement:

- Evaluate a `boolean` expression.
- If `true`, execute some statements.
- If `false`, execute some other statements.

```
if (x < 0) x = -x;
```




```
if (x > y) max = x;
else       max = y;
```



If Statement: Examples

absolute value	`if (x < 0) x = -x;`

put `x` *and* `y` *into ascending order (swap)*	`if (x > y) {`
	`  int temp = x;`
	`  x = y;`
	`  y = temp;`
	`}`

maximum of `x` *and* `y`	`if (x > y) max = x;` `else  max = y;`

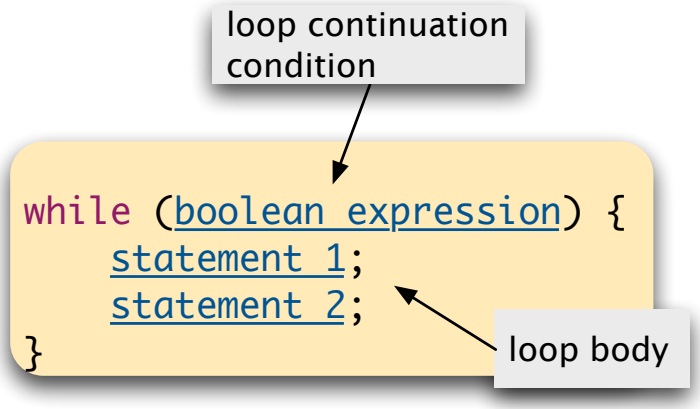
error check for division operation	`if (den == 0) {`
	`  System.out.println("Division by zero");`
	`} else {`
	`  System.out.println("Quotient = " + num / den);`
	`}`

Loops (While)

While Loop

The `while` loop is a structure for expressing repetition.

- Evaluate a `boolean` expression.
- If `true`, execute some statements.
- Repeat.



While Loop

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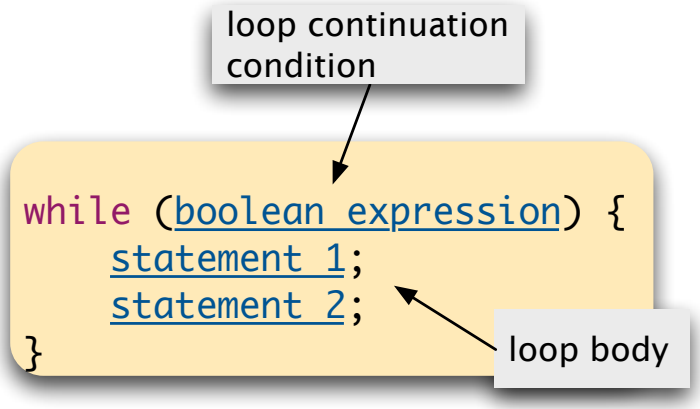

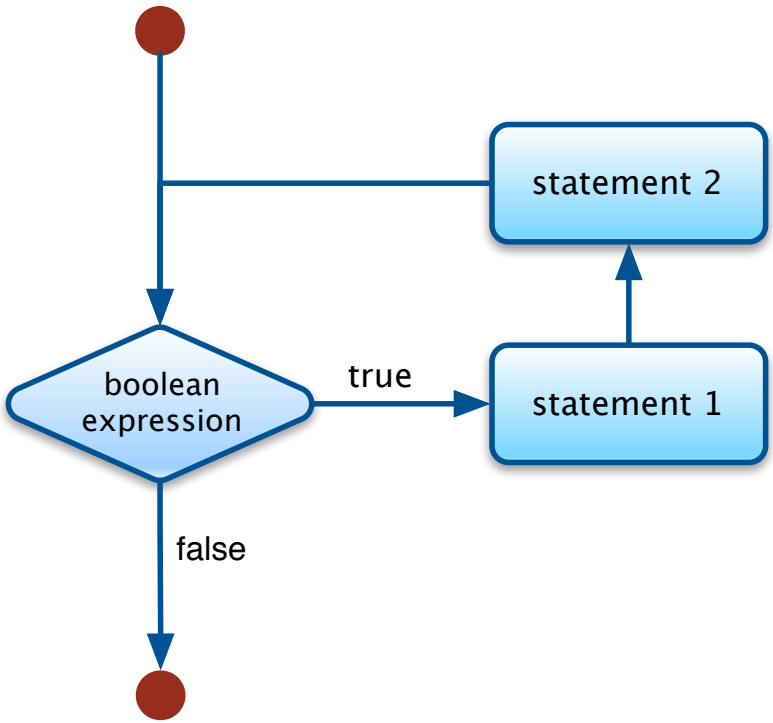

While Loop: Powers of Two

Print powers of 2 that are $\leq 2^n$ for some n.

- Increment loop counter `i` by `1`, from `0` to `n`.
- Double `val` each time.

```
int i = 0;
int val = 1;
while (i <= n) {
  System.out.println(i + " " + val);
  i = i + 1;
  val = 2 * val;
}
```

i
0

Start Again

While Loop: Powers of Two

Print powers of 2 that are $\leq 2^n$ for some n. Set `n = 6`.

- Increment loop counter `i` by `1`, from `0` to `n`.
- Double `val` each time.

```
int i = 0;
int val = 1;
while (i <= n) {
  System.out.println(i + " " + val);
  i = i + 1;
  val = 2 * val;
}
```

i	val
0	1

Start Again

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}
```

i	val	i ≤ n
0	1	true

Start Again

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i	val	i ≤ n	Output
0	1	true	0 1

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i	val	i ≤ n	Output
0	1	true	0 1
1			

Start Again

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1	2		

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1	2	true	

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```

i	val	i ≤ n	Output	
0	1	true	0	1
1	2	true	1	2
2				

Start Again

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i	val	i ≤ n	Output	
0	1	true	0	1
1	2	true	1	2
2	4			

Start Again

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i	val	i ≤ n	Output	
0	1	true	0	1
1	2	true	1	2
2	4	true		

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i	val	i $\leq$ n	Output	
0	1	true	0	1
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0	1	true	0	1
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2	4	true	2	4
3				

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i	val	i ≤ n	Output	
0	1	true	0	1
1	2	true	1	2
2	4	true	2	4
3	8			

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4				

Start Again

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i	val	i ≤ n	Output	
0	1	true	0	1
1	2	true	1	2
2	4	true	2	4
3	8	true	3	8
4	16			

Start Again

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5				

Start Again

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0	1	true	0	1
1	2	true	1	2
2	4	true	2	4
3	8	true	3	8
4	16	true	4	16
5	32			

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5	32	true		

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1	2	true	1	2
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3	8	true	3	8
4	16	true	4	16
5	32	true	5	32
6				

▸ Start Again

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}
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i	val	i ≤ n	Output	
0	1	true	0	1
1	2	true	1	2
2	4	true	2	4
3	8	true	3	8
4	16	true	4	16
5	32	true	5	32
6	64			

Start Again

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}
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i	val	i ≤ n	Output	
0	1	true	0	1
1	2	true	1	2
2	4	true	2	4
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5	32	true	5	32
6	64	true		

Start Again

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6	64	true	6	64

▸ Start Again

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1	2	true	1	2
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3	8	true	3	8
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5	32	true	5	32
6	64	true	6	64
7				

▸ Start Again

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1	2	true	1	2
2	4	true	2	4
3	8	true	3	8
4	16	true	4	16
5	32	true	5	32
6	64	true	6	64
7	128			

Start Again

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3	8	true	3	8
4	16	true	4	16
5	32	true	5	32
6	64	true	6	64
7	128	false		

▸ Start Again

Powers of Two

```
public class PowersOfTwo {
   public static void main(String[] args) {
      int n = Integer.parseInt(args[0]);
      int i = 0;
      int val = 1;
      while (i <= n) {
         System.out.println(i + " " + val);
         i = i + 1;
         val = 2 * val;
      }
   }
}
```

```
% java PowersOfTwo 3
0 1
1 2
2 4
3 8
```

While Loop Challenge

Q: Is anything wrong with the following version of `PowersOfTwo`?

```
int i = 0;
int val = 1;
while (i <= n)
   System.out.println(i + " " + val);
   i = i + 1;
   val = 2 * val;
```

While Loop Challenge

Q: Is anything wrong with the following version of `PowersOfTwo`?

```
int i = 0;
int val = 1;
while (i <= n)
   System.out.println(i + " " + val);
i = i + 1;
val = 2 * val;
```

A: Need curly braces around statements in `while` loop. Otherwise, only the first of the statements is executed before returning to `while` condition; enters an infinite loop, printing `0 1` for ever.

(How to stop an infinite loop? At the Linux command-line, hit Control-c.)

The Increment Operator

```
int i = 0;
int val = 1;
while (i <= n) {
   System.out.println(i + " " + val);
   i = i + 1;
   val = 2 * val;
}
```

The Increment Operator

```
int i = 0;
int val = 1;
while (i <= n) {
   System.out.println(i + " " + val);
   i = i + 1;
   val = 2 * val;
}
```

- standard assignment: `i = i + 1;`
- semantically equivalent shorthand: `i++;`

The Increment Operator

```
int i = 0;
int val = 1;
while (i <= n) {
   System.out.println(i + " " + val);
   i = i + 1;
   val = 2 * val;
}
```

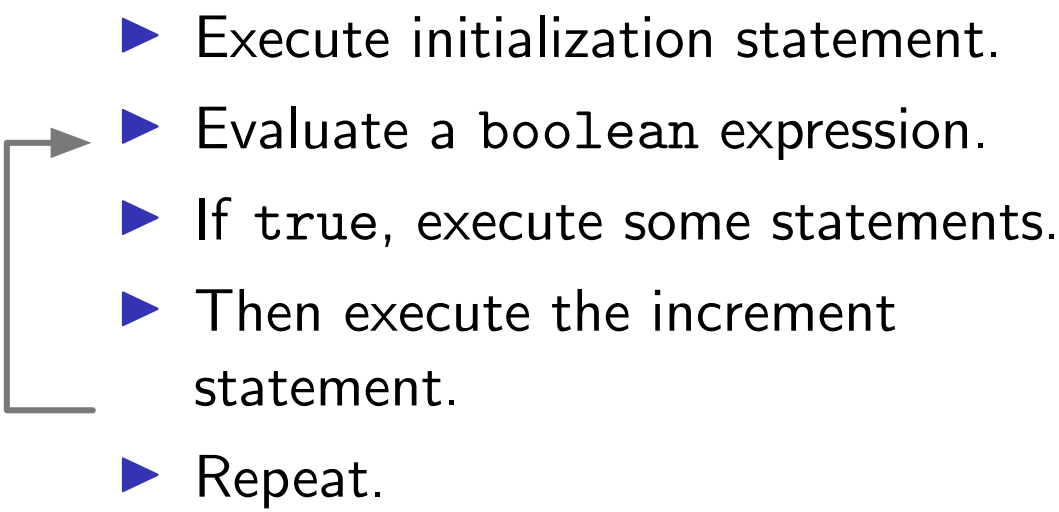
- standard assignment: `i = i + 1;`
- semantically equivalent shorthand: `i++;`

```
int i = 0;
int val = 1;
while (i <= n) {
   System.out.println(i + " " + val);
   i++;
   val = 2 * val;
}
```

Loops (For)

For Loop

The `for` loop is another common structure for repeating things.



- Execute initialization statement.
- Evaluate a `boolean` expression.
- If `true`, execute some statements.
- Then execute the increment statement.
- Repeat.

For Loop

The `for` loop is another common structure for repeating things.

- Execute initialization statement.
- Evaluate a `boolean` expression.
- If `true`, execute some statements.
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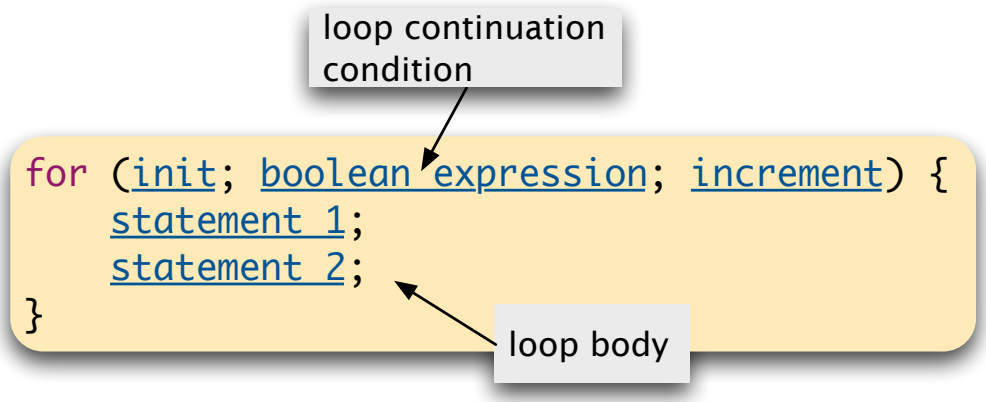
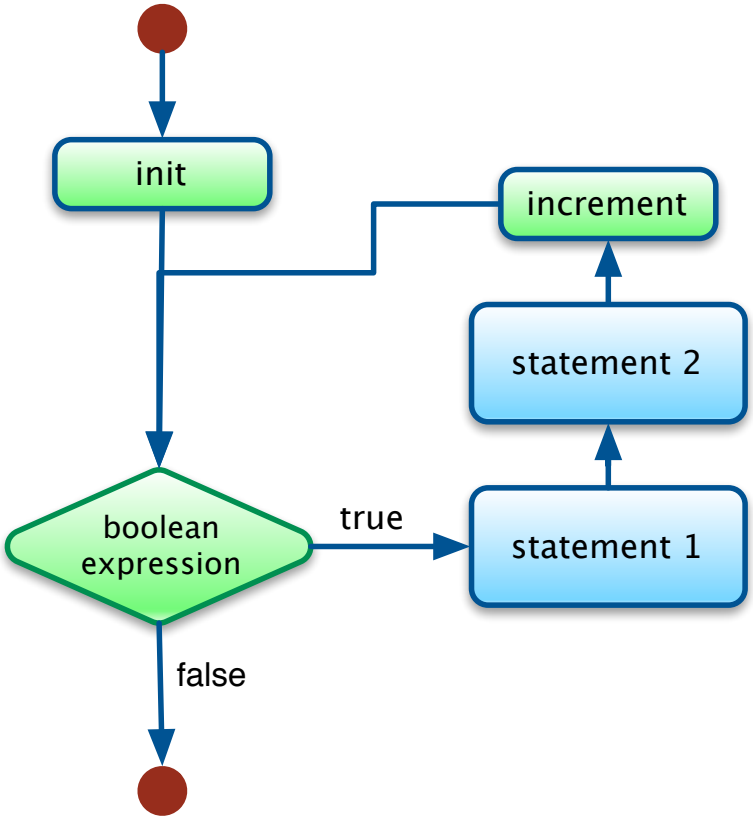
- Repeat.



For Loop

The `for` loop is another common structure for repeating things.

- Execute initialization statement.
- Evaluate a `boolean` expression.
- If `true`, execute some statements.
- Then execute the increment statement.
- Repeat.

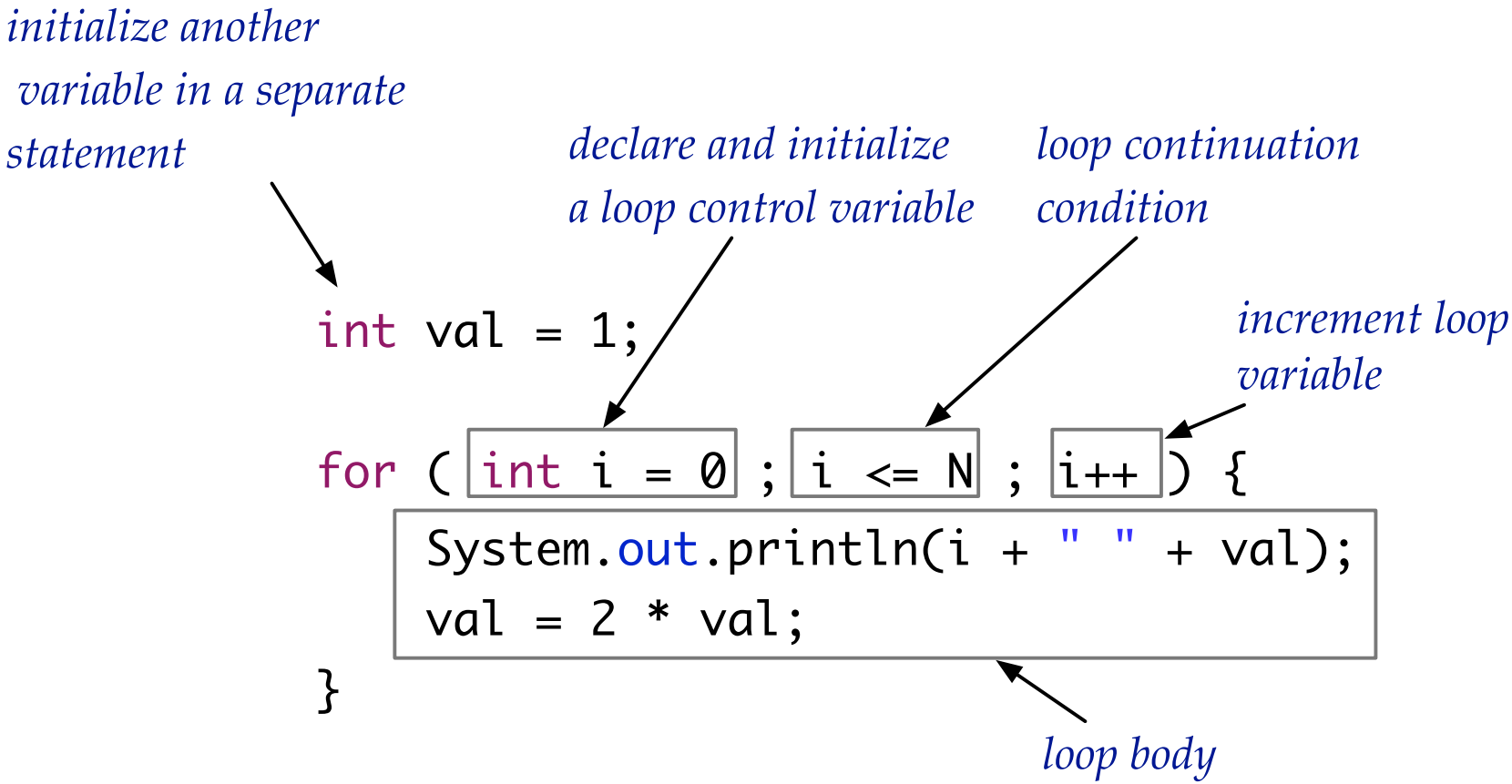


loop continuation condition

```
for (init; boolean expression; increment) {
    statement 1;
    statement 2;
}
```

loop body

Anatomy of a For Loop



For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val
1

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i
1	0

▸ Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n
1	0	true

▸ Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output
1	0	true	0 1
2			

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1			

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

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```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true		

Start Again

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Print the first n powers of 2. Set `n = 6`.

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```
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  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2

Start Again

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Print the first n powers of 2. Set `n = 6`.

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```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4				

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2			

Start Again

For Loop: Powers of Two

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  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true		

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

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int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4

Start Again

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Print the first n powers of 2. Set `n = 6`.

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```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8				

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3			

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true		

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

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```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8

Start Again

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  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16				

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

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```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4			

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

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int val = 1;
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  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true		

Start Again

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}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16

Start Again

For Loop: Powers of Two

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for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32				

Start Again

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Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5			

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true		

Start Again

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Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32

Start Again

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Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32
64				

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32
64	6			

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32
64	6	true		

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i $\leq$ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32
64	6	true	6	64

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32
64	6	true	6	64
128				

Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32
64	6	true	6	64
128	7			

▸ Start Again

For Loop: Powers of Two

Print the first n powers of 2. Set `n = 6`.

- Double `val` each time.

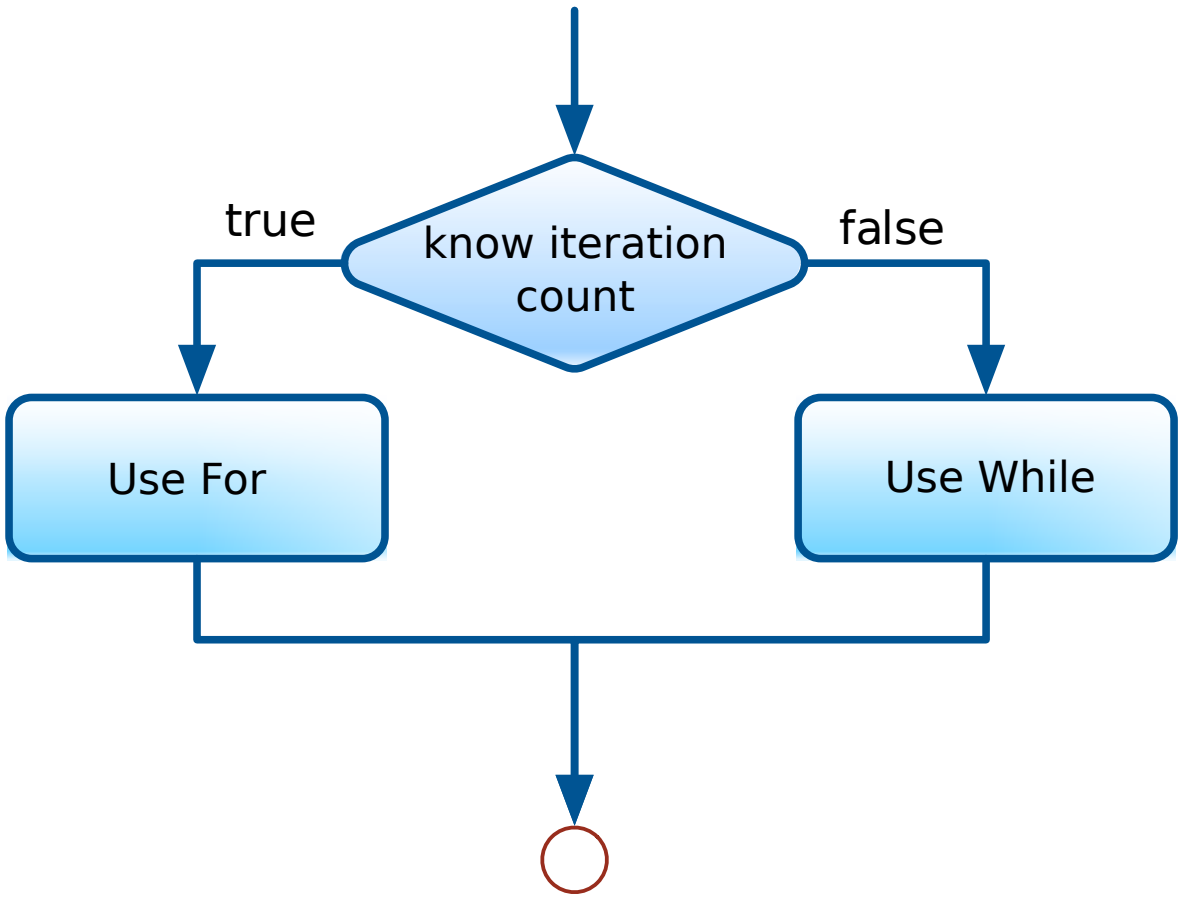
```
int val = 1;
for (int i = 0; i <= n; i++) {
  System.out.println(i + " " + val);
  val = 2 * val;
}
```

val	i	i ≤ n	Output	
1	0	true	0	1
2	1	true	1	2
4	2	true	2	4
8	3	true	3	8
16	4	true	4	16
32	5	true	5	32
64	6	true	6	64
128	7	false		

Start Again

When to use While and when to use For?

Rule of thumb



Loop Examples 1

Print largest power of two that is $\leq n$

Loop Examples 1

Print largest power of two that is $\leq n$

```
int val = 1;
while (val <= n / 2) {
   val = 2 * val;
}
System.out.println(val);
```

Loop Examples 2

Print the result of computing the finite sum
$(1 + 2 + \ldots + n)$

Loop Examples 2

Print the result of computing the finite sum
$(1 + 2 + \ldots + n)$

```
int sum = 0;
for (int i = 1; i <= n; i++) {
    sum += i;
}
```

Loop Examples 3

Print the result of computing the finite product
($n! = 1 \times 2 \times \ldots \times n$)

Loop Examples 3

Print the result of computing the finite product
($n! = 1 \times 2 \times \ldots \times n$)

```
int product = 1;
for (int i = 1; i <= n; i++) {
   product *= i;
}
```

Nested Conditionals

Nested If Statements

How to classify Scottish weather:

degrees C	verdict
< -5	wear a sweater
-5 to 0	nippy
1 to 10	normal
> 10	roastin'

4 mutually exclusive alternatives

Nested If Statements

How to classify Scottish weather:

degrees C	verdict
< -5	wear a sweater
-5 to 0	nippy
1 to 10	normal
> 10	roastin'

4 mutually exclusive alternatives

```
String verdict;
if (temp < -5) verdict = "wear a sweater";
else {
    if (temp < 1) verdict = "nippy";
    else {
        if (temp < 11) verdict = "normal";
        else verdict = "roastin'";
    }
}
```

Nested If Statements

We don't necessarily need all those braces.

```
public class ScottishWeather {
    public static void main(String[] args) {
        String verdict;
        int temp = Integer.parseInt(args[0]);
        if      (temp < -5) verdict = "wear a sweater";
        else if (temp < 1)  verdict = "nippy";
        else if (temp < 11) verdict = "normal";
        else                verdict = "roastin'";
        System.out.println("Verdict: " + verdict);
    }
}
```

Output

```
% java ScottishWeather -1
Verdict: nippy

% java ScottishWeather 1
Verdict: normal
```

Nested If Statements

Is there anything wrong with the logic of the following code?

degrees C	verdict
< -5	wear a sweater
-5 to 0	nippy
1 to 10	normal
> 10	roastin'

4 mutually exclusive alternatives

```
String verdict;
int temp = Integer.parseInt(args[0]);
if (temp < -5) verdict = "wear a sweater";
if (temp < 1)  verdict = "nippy";
if (temp < 11) verdict = "normal";
if (temp >= 11) verdict = "roastin'";
```

Summary

Control flow:

- Sequence of statements that are actually executed in a program run.
- Conditionals and loops: enable us to choreograph the control flow.

Control Flow	**Description**	**Examples**
straight-line programs	all statements are executed in the order given	
conditionals	certain statements are executed depending on the values of certain variables	`if`, `if-else`
loops	certain statements are executed repeatedly until certain conditions are met	`while`, `for`

Learning Outcomes

- Use `if` and `if-else` statements to execute a sequence of statements based on the truth value of Boolean expressions.
- Use nested `if-else` statements to compute results based on a number of mutually exclusive alternatives.
- Use `while`-loops to repeatedly execute a sequence of statements based on the truth value of Boolean expressions.
- Use `for`-loops to repeatedly execute a sequence of statements based on an initialization statement, a Boolean test, and an increment statement.
- Use `for`-loops to compute finite sums and finite products.

Reading

Java Tutorial

pp68-86, i.e. Chapter 3 *Language Basics* from *Expressions, Statements and Blocks* to the end of the chapter.