University of British Columbia
CPSC 111, Intro to Computation
Jan-Apr 2006

Tamara Munzner

Loops II

Lecture 13, Thu Feb 22 2006

based on slides by Kurt Eiselt

http://www.cs.ubc.ca/~tmm/courses/cpsc111-06-spr

News

- Assignment 2 out
  - it's challenging, start **now**!!

Reading

- This week: Chapter 7 all (7.1-7.4)
- Next week: 8.1, 8.5-8.7, topics 6.3 and 6.4

String Comparison Followup

- Why did `(name == "Kermit")` work?
  - vs. object comparison with `equals` method

- Strings are special case
  - `intern` method stores them in central table, then equality check with “==“ works
  - Strings are often but not always interned automatically
    - details tricky, see

http://javatechniques.com/public/java/docs/basics/string-equality.html

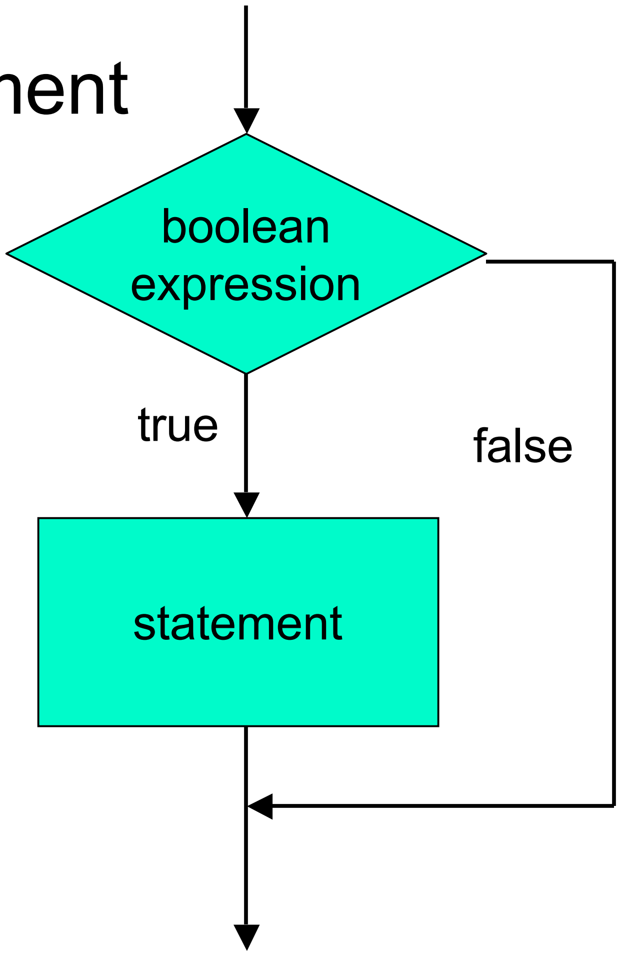
Recap: `While` Statement

```
while (boolean expression)
    body
```

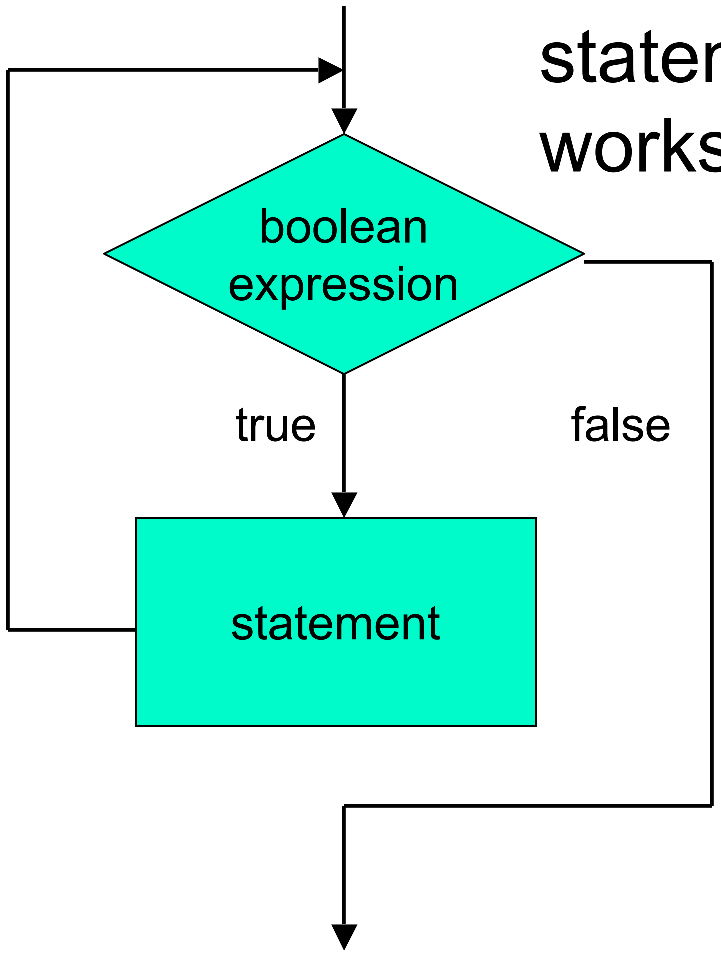
- Body of loop can be
  - single statement
  - whole block of many statements in curly braces
- Control flow
  - body executed if expression is true
  - then boolean expression evaluated again
  - if expression still true, body executed again
  - repetition continues until expression false
  - then processing continues with next statement after loop

Recap: `If` Versus `While` Statements

how if statement works



how while statement works



Recap: Loop Termination

```
while (termination condition) {
    body
}
```

- Loop boolean expression aka termination condition
- Logic of termination condition must match logic in loop body for updating variables used in condition
- If termination condition always true, infinite loop never ends
- If termination condition always false, body never executed

Objectives

- Understand when and how to use
    - for loops
    - nested loops

Fun With Loops

```
public class BeerSong
{
  public static void main (String[] args)
  {
    int beerNum = 99;
    String word = "bottles";
    while (beerNum > 0)
    {
      if (beerNum == 1)
      {
        word = "bottle";
      }

      System.out.println(beerNum + " " + word + " of beer on the wall.");
      System.out.println(beerNum + " " + word + " of beer.");
      System.out.println("If one of the bottles");
      System.out.println("should happen to fall...");
      beerNum = beerNum - 1;

      if (beerNum < 1)
      {
        System.out.println("No more bottles of beer on the wall.");
      }
    }
  }
}
```

Fun With Loops

```
import java.util.Scanner;

public class BeerSong2
{
  public static void main (String[] args)
  {
    int beerNum = 99;
    String word = "bottles";

    boolean keepgoing = true;
    String answer;
    Scanner in = new Scanner(System.in);

    while ((beerNum > 0) && keepgoing)
    {
      if (beerNum == 1)
      {
        word = "bottle";
      }

      System.out.println(beerNum + " " + word + " of beer on the wall.");
      System.out.println(beerNum + " " + word + " of beer.");
      System.out.println("If one of the bottles");
      System.out.println("should happen to fall...");
      beerNum = beerNum - 1;
```

Fun With Loops

```
      System.out.println("Continue? (y/n): ");
      answer = in.nextLine();
      if (answer.equals("n"))
      {
        keepgoing = false;
      }
      if (beerNum < 1)
      {
        System.out.println("No more bottles of beer on the wall.");
      }
    }
  }
}
```

Other Loop Statements

```
public class WhileDemo
{
  public static void main (String[] args)
  {
    int limit = 3;
    int counter = 1;

    while (counter <= limit)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
      counter = counter + 1;
    }
    System.out.println("End of demonstration");
  }
}
```

- Equivalent to...

Other Loop Statements

```
public class ForDemo
{
  public static void main (String[] args)
  {

    for (int counter = 1; counter <= 3; counter = counter + 1)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
    }
    System.out.println("End of demonstration");
  }
}
```

- ...this loop using **`for`** statement

`For` Statement

```
public class ForDemo
{
  public static void main (String[] args)
  {
    for (int counter = 1; counter <= 3; counter = counter + 1)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
    }
    System.out.println("End of demonstration");
  }
}
```

- **`for`** statement

`For` Statement

```
public class ForDemo
{
  public static void main (String[] args)
  {

    for (int counter = 1; counter <= 3; counter = counter + 1)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
    }
    System.out.println("End of demonstration");
  }
}
```

- Header has three parts
  - separated by semicolons

`For` Statement

```
public class ForDemo
{
  public static void main (String[] args)
  {

    for (int counter = 1; counter <= 3; counter = counter + 1)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
    }
    System.out.println("End of demonstration");
  }
}
```

- Initialization: first part
  - executed only one time, at beginning

For Statement

```
public class ForDemo
{
  public static void main (String[] args)
  {

    for (int counter = 1; counter <= 3; counter = counter + 1)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
    }
    System.out.println("End of demonstration");
  }
}
```

- boolean expression: second part
  - evaluated just before loop body, like in **`while`**

`For` Statement

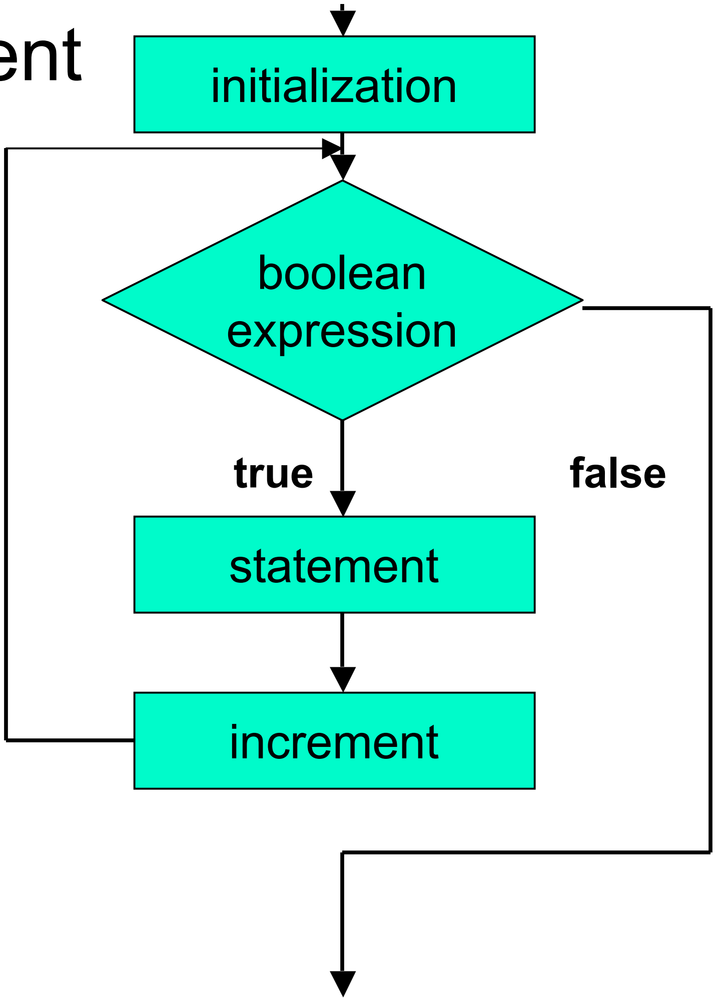
```
public class ForDemo
{
  public static void main (String[] args)
  {

    for (int counter = 1; counter <= 3; counter = counter + 1)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
    }
    System.out.println("End of demonstration");
  }
}
```

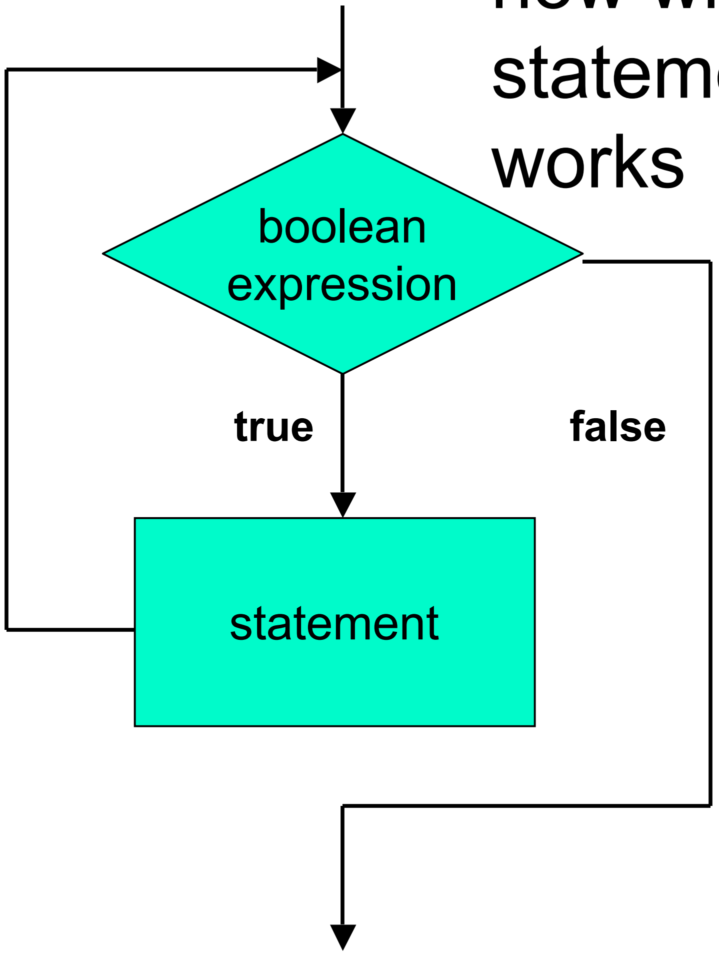
- Increment: third part
  - executed at end of loop body
- Despite name, arbitrary calculation allowed
  - could decrement, for example!

`For` Versus `While` Statement

how for statement works

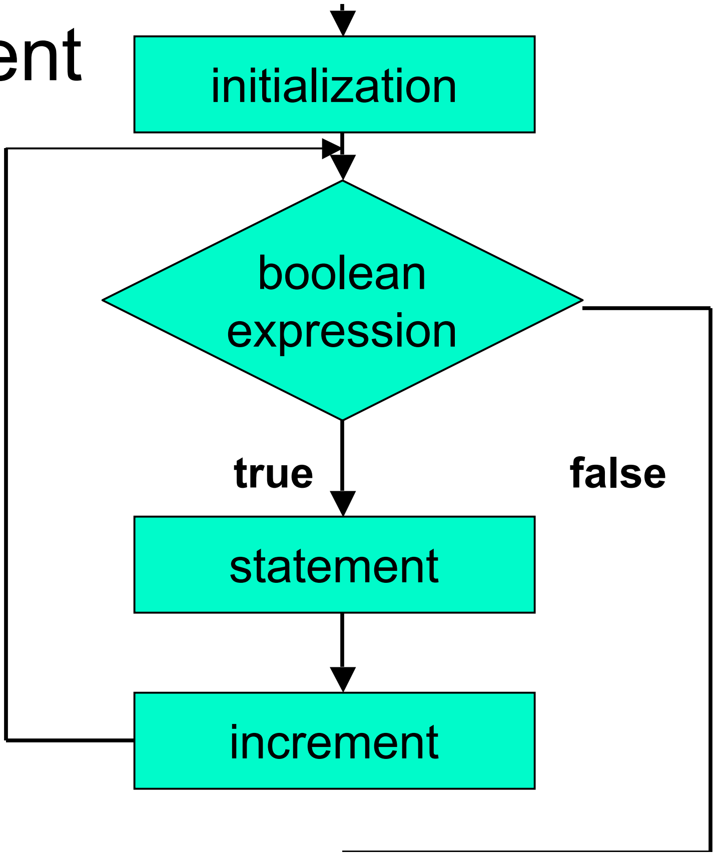


how while statement works

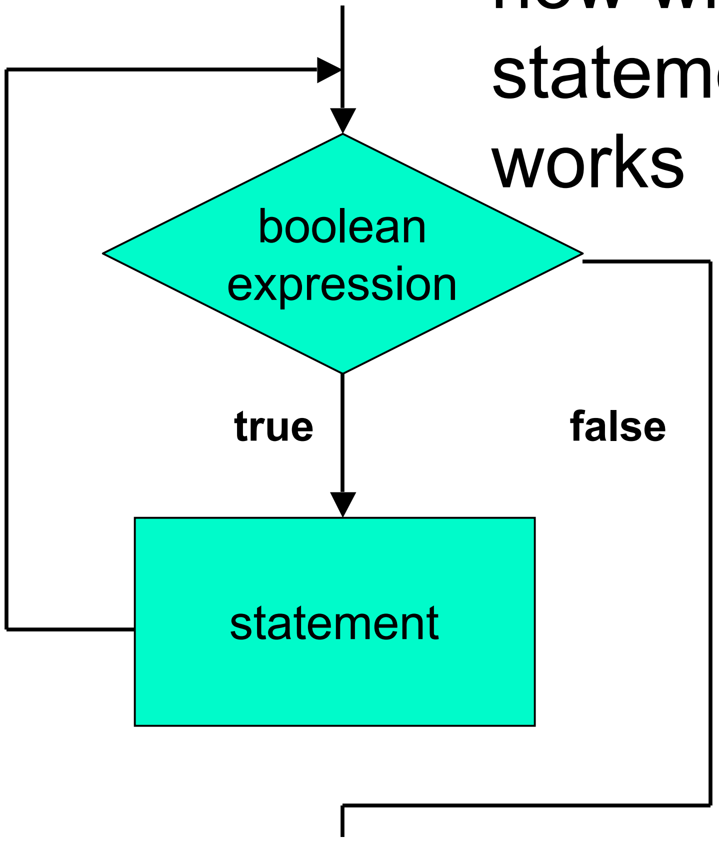


`For` Versus `While` Statement

how for statement works



how while statement works

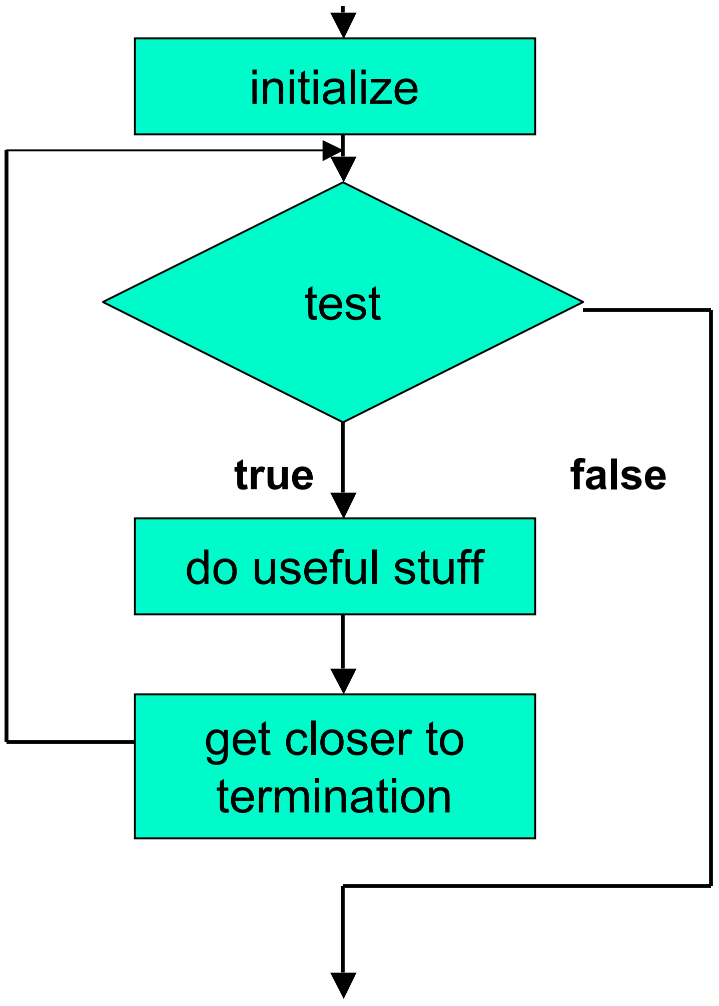


- flowcharts can be somewhat deceptive
  - need initialization and incrementing/modifying in while loop too
  - although syntax does not require it in specific spot

`For` Versus `While` Statement

- Anything that can be done with one type of loop can be done with another
  - **`for`** and **`while`** are equivalent
- **`For`** statement convenient when
  - loop should be executed specific number of times
  - number can be determined before loop starts
- **`While`** statement convenient when
  - don't know yet how many times to execute loop body
  - but can check if it’s time to end loop as you go

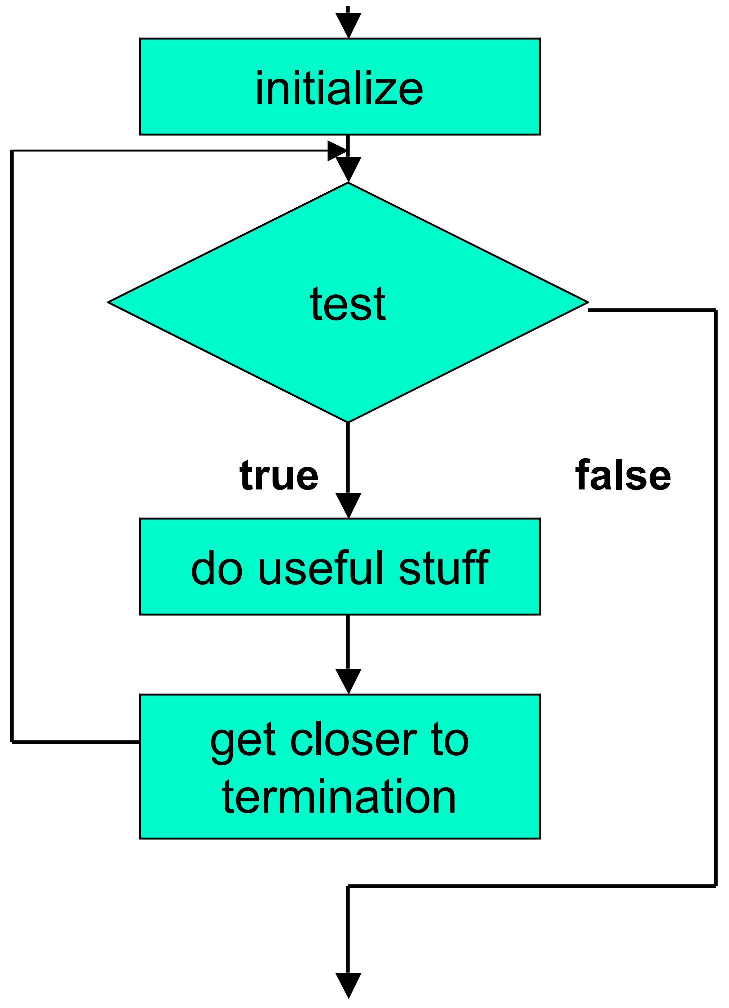
Four Things Needed In Any Loop



- Give starting values to one or more variables used in loop

how loops work in general

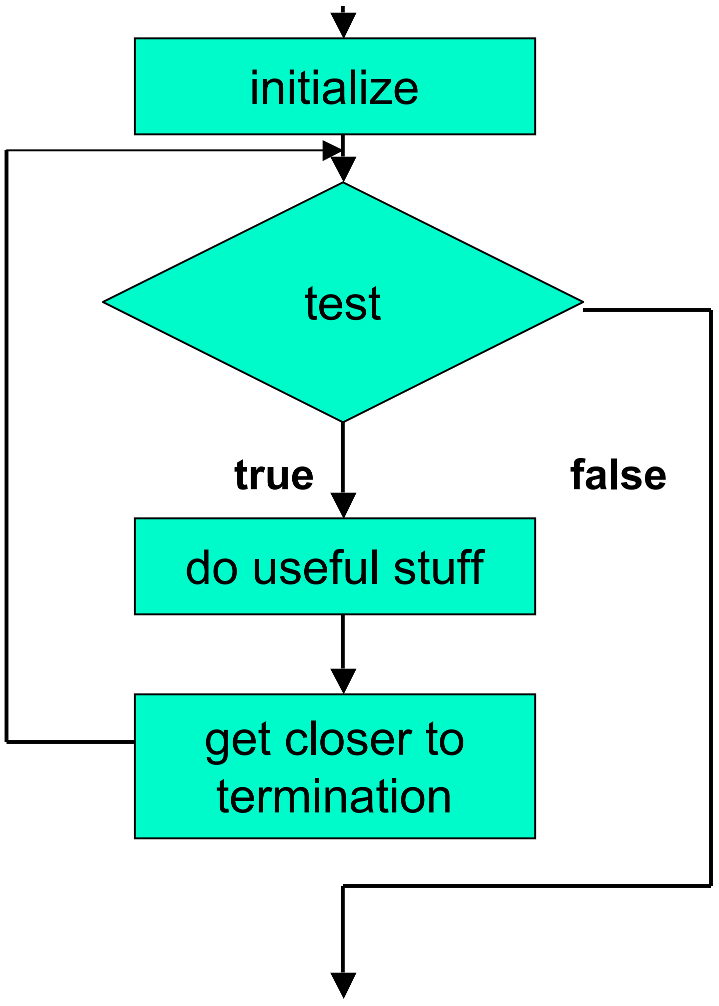
Four Things Needed In Any Loop



- Give starting values to one or more variables used in loop
- Test to see when looping stops

how loops work in general

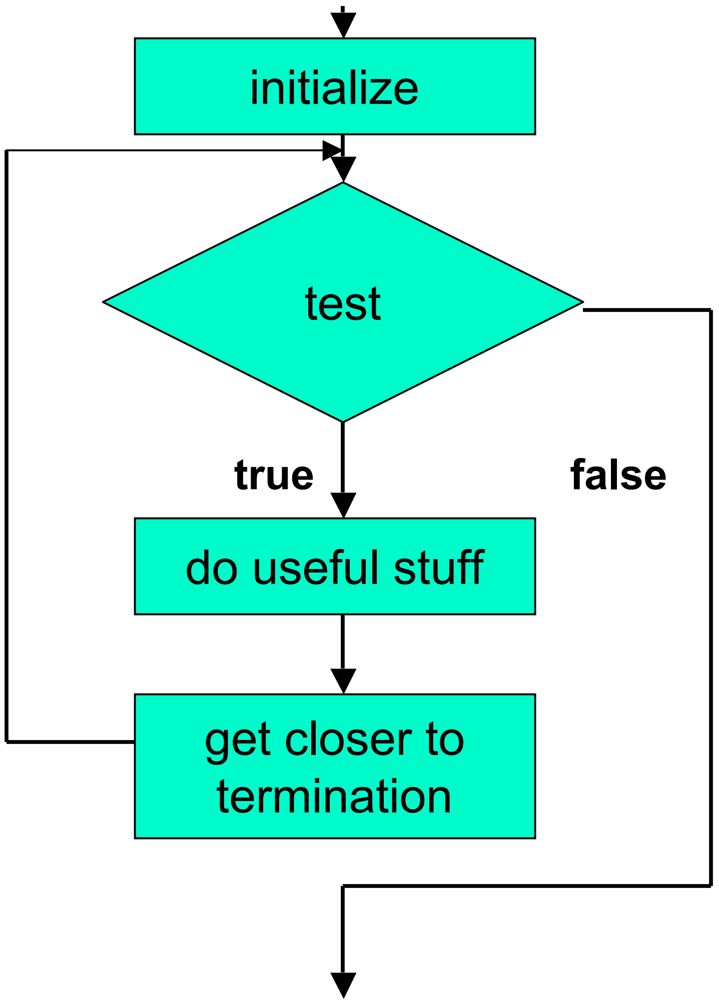
Four Things Needed In Any Loop



- Give starting values to one or more variables used in loop
- Test to see when looping stops
- One or more useful operations here

how loops work in general

Four Things Needed In Any Loop



- Give starting values to one or more variables used in loop
- Test to see when looping stops
- One or more useful operations here
- Change something to move process closer termination

how loops work in general

Yet Another Loop Statement

```
public class WhileDemo
{
  public static void main (String[] args)
  {
    int limit = 3;
    int counter = 1;

    while (counter <= limit)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
      counter = counter + 1;
    }
    System.out.println("End of demonstration");
  }
}
```

- **`while`** version

Yet Another Loop Statement

```
public class ForDemo
{
  public static void main (String[] args)
  {

    for (int counter = 1; counter <= 3; counter = counter + 1)
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
    }
    System.out.println("End of demonstration");
  }
}
```

- `for` version

Yet Another Loop Statement

```
public class DoDemo
{
  public static void main (String[] args)
  {
    int limit = 3;
    int counter = 1;

    do
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
      counter = counter + 1;
    } while (counter <= limit);

    System.out.println("End of demonstration");
  }
}
```

- do version

Do Statement

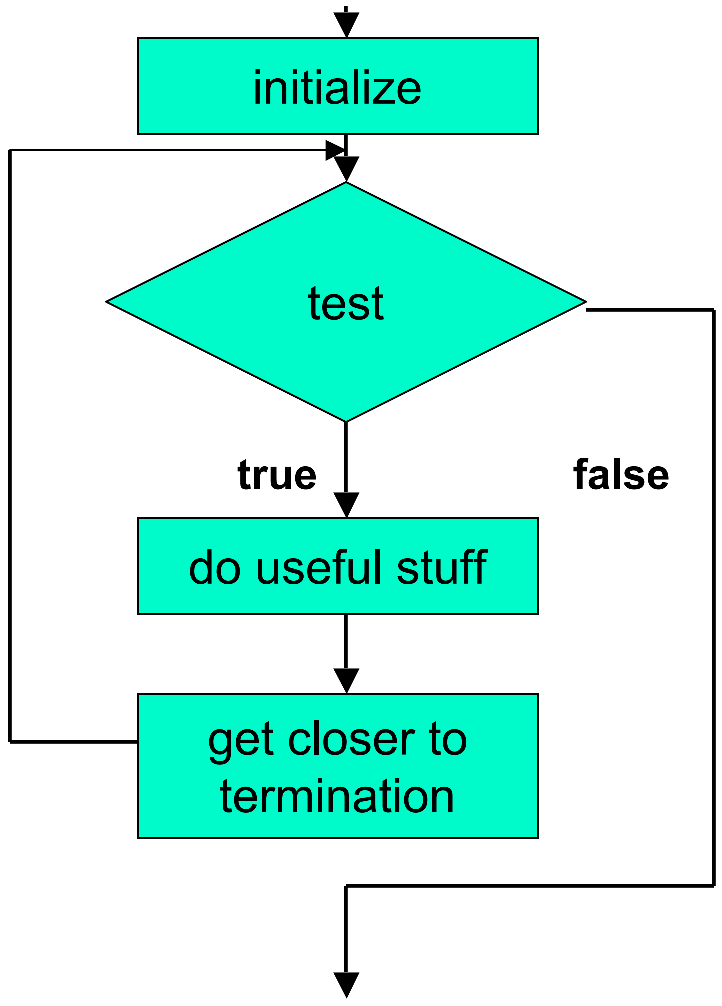
```
public class DoDemo
{
  public static void main (String[] args)
  {
    int limit = 3;
    int counter = 1;

    do
    {
      System.out.println("The square of " + counter +
                         " is " + (counter * counter));
      counter = counter + 1;
    } while (counter <= limit);

    System.out.println("End of demonstration");
  }
}
```

- `do` version: not quite equivalent
  - termination test at end, so body executed at least once

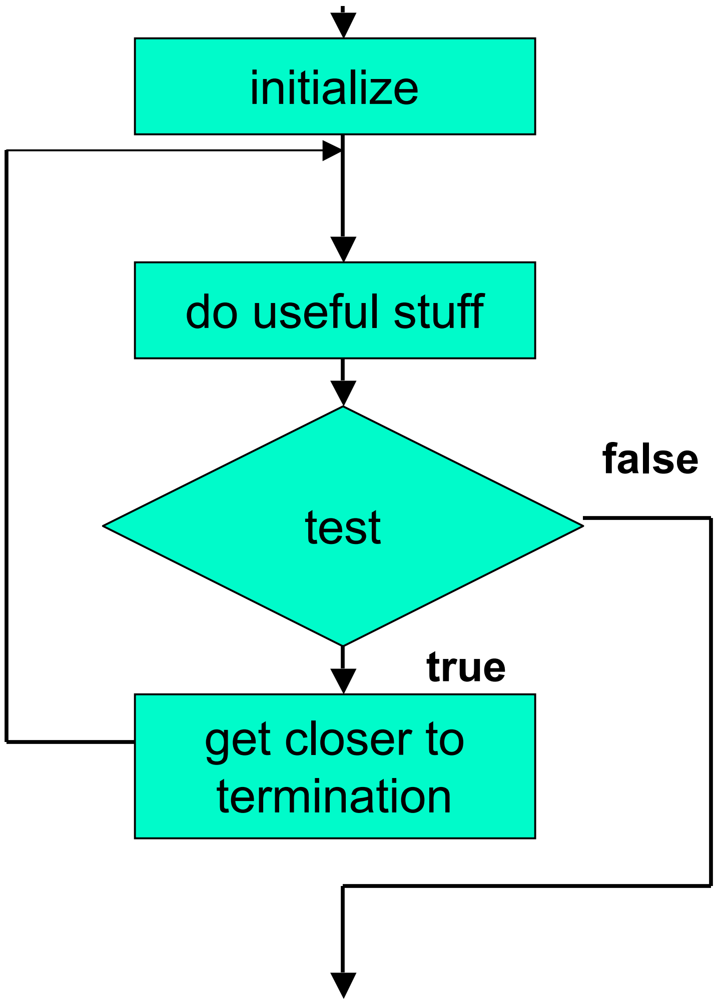
Four Things Needed In Any Loop



- Give starting values to one or more variables used in loop
- Test to see when looping stops
- One or more useful operations here
- Change something to move process closer termination

how loops work in general

Do Statement



- Body always executed at least once

order of four things can change, but need them all

Nested Loops

- Very simple for loop

```
public class SimpleLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      System.out.println(i);
    }
  }
}
```

- What does it do?

Nested Loops

- Very simple for loop

```
public class SimpleLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      System.out.println(i);
    }
  }
}
```

- What does it do? Prints

```
1
2
3
```

Nested Loops

- Very simple for loop

```
public class SimpleLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      System.out.println(i);
    }
  }
}
```

- What if for every number below, want multiplication table of value times 2, x3, etc?

```
1 2 3
2 4 6
3 6 9
```

Nested Loops

- Very simple for loop

```
public class SimpleLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      System.out.println(i);
    }
  }
}
```

- For every number printed by loop above

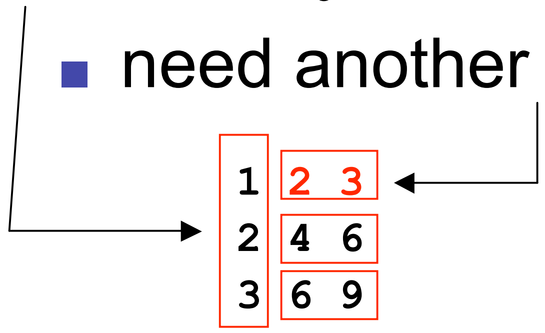
```
1 2 3
2 4 6
3 6 9
```

Nested Loops

- Very simple for loop

```
public class SimpleLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      System.out.println(i);
    }
  }
}
```

- For every number printed by loop above
  - need another loop to print numbers in row

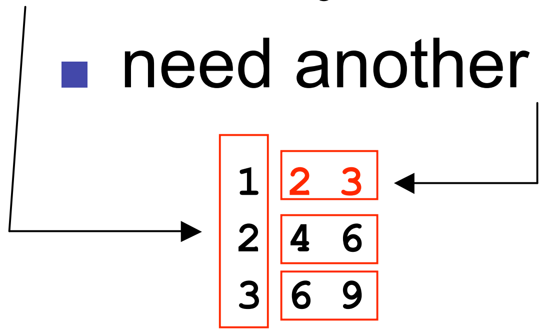


Nested Loops

- Very simple for loop

```
public class SimpleLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      System.out.println(i);
    }
  }
}
```

- For every number printed by loop above
  - need another loop to print numbers in row



How do we do that?

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 1

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i $\boxed{1}$

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i	1
j	1

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i    1

j    1
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i	1
j	1

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i	1
j	2

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

i	1
j	2

```
1_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 1

j 2

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1  2_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i   1

j   3
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i	1
j	3

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 1

j 3

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1  2  3_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 1

j 4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1  2  3_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 1

j 4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 1

j 4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 2

j 4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i $\boxed{2}$

j $\boxed{4}$

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

i 2

j 1

```
1   2   3
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i $\boxed{2}$

j $\boxed{1}$

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 2

j 1

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1  2  3
2_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 2

j 2

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

i	2
j	2

```
1   2   3
2_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

i	2
j	1

```
1   2   3
2   4_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i $\boxed{2}$

j $\boxed{3}$

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i    2

j    3
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i  2

j  3
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
       System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i   2

j   4
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 2

j 4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6_
```

Nested Loops

- Put a loop inside a loop
    - trace to see how it works

i 2

j 4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1  2  3
2  4  6
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i   3

j   4
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i   3

j   4
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i	3
j	1

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
_
```

Nested Loops

- Put a loop inside a loop
    - trace to see how it works

```
i   3

j   1
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i   3

j   1
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1  2  3
2  4  6
3_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i   3

j   2
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i	3
j	2

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i  3

j  2
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 3

j 3

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i $\boxed{3}$

j $\boxed{3}$

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

i	3
j	3

```
1   2   3
2   4   6
3   6   9_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i    3

j    4
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6   9_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

i $\boxed{3}$

j $\boxed{4}$

```
1  2  3
2  4  6
3  6  9_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i `3`

j `4`

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6   9
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

```
i  4

j  4
```

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6   9
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i	4
j	4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6   9
_
```

Nested Loops

- Put a loop inside a loop
  - trace to see how it works

i 4

j 4

```
public class NestedLoop
{
  public static void main (String[] args)
  {
    for (int i = 1; i <= 3; i++)
    {
      for (int j = 1; j <= 3; j++)
      {
        System.out.print((i * j) + "  ");
      }
      System.out.println();
    }
  }
}
```

```
1   2   3
2   4   6
3   6   9
_
```

Exit!

Practice Problem

- Write program using loop to simulate flipping a coin one million times
  - keep track of how many times it's heads up and how many heads down
  - print results
- Make version for each loop type
  - `while`, `for`, `do`