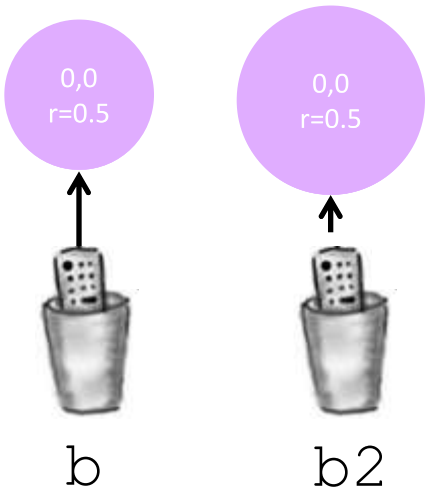
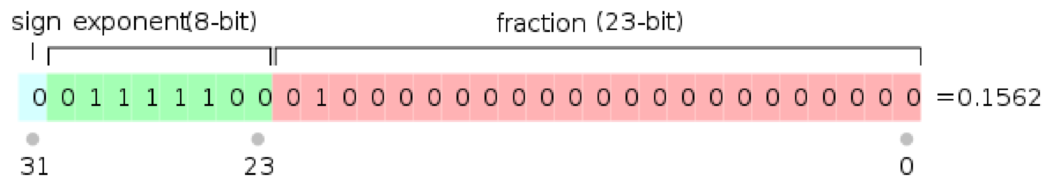
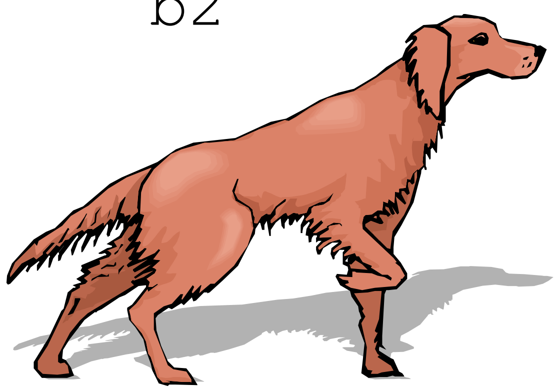
# Equality, access modifiers, strings



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# Overview

- Equality and inequality
  - Not always that simple:
    - floating-point variables
    - reference variables
- Data encapsulation
  - Important consideration when designing a class
  - Access modifiers
- Changing parameter values
  - Primitive types, reference types, arrays, `String`
- `String` class
  - Methods
  - Efficiency

# Equality: integer primitives

- Boolean operator ==
  - See if two variables are exactly equal
  - i.e. they have identical bit patterns
- Boolean operator !=
  - See if two variables are NOT equal
  - i.e. they have different bit patterns

```
int a = 5;

if (a == 5)
   System.out.println("yep it's 5!");

while (a != 0)
  a--;
```

This is a safe comparison since we are using an integer type.

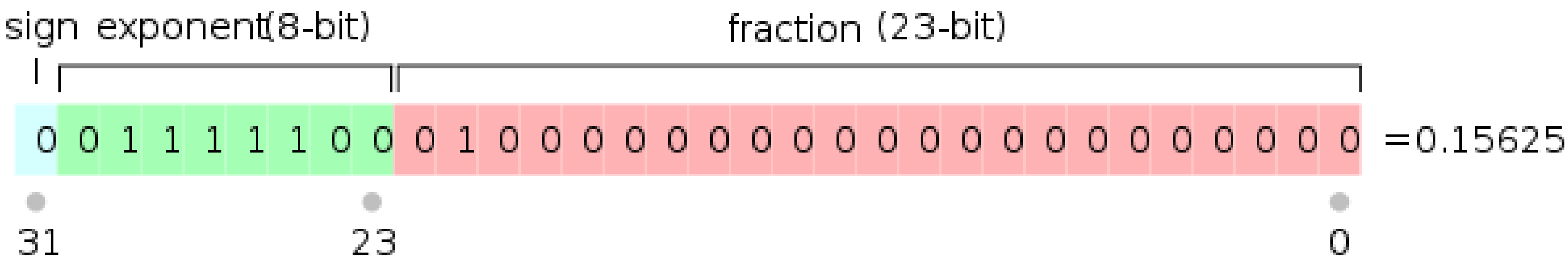
# Equality: floating-point primitives

- Floating-point primitives
  - i.e. `double` and `float`
  - Only an approximation of the number
  - Use == and != at your own peril

```
double a = 0.1 + 0.1 + 0.1;
double b = 0.1 + 0.1;
double c = 0.0;

if (a == 0.3)
   System.out.println("a is 0.3!");

if (b == 0.2)
   System.out.println("b is 0.2!");

if (c == 0.0)
   System.out.println("c is 0.0!");
```

# Equality: floating-point primitives

- Floating-point primitives
  - i.e. `double` and `float`
  - Only an approximation of the number




Floating-point numbers are shoved into a binary number.
32 bits for a `float`, 64-bits for a `double`

# Equality: floating-point primitives

- Floating-point primitives
  - i.e. `double` and `float`
  - Only an approximation of the number
  - Use == and != at your own peril

```
double a = 0.1 + 0.1 + 0.1;
double b = 0.1 + 0.1;
double c = 0.0;

if (a == 0.3)
   System.out.println("a is 0.3!");

if (b == 0.2)
   System.out.println("b is 0.2!");

if (c == 0.0)
   System.out.println("c is 0.0!");
```

This works as long as no calculation has been done on 0.0 value and both are typed `double`.

```
b is 0.2!
c is 0.0!
```

# Safe floating-point equality check

- Floating-point primitives
  - Check if sufficiently close to target value

```
double a = 0.1 + 0.1 + 0.1;
double b = 0.1 + 0.1;
double c = 0.0;
final double EPSILON = 1e-10;

if (Math.abs(a - 0.3) < EPSILON)
   System.out.println("a is 0.3!");

if (Math.abs(b - 0.2) < EPSILON)
   System.out.println("b is 0.2!");

if (c == 0.0)
   System.out.println("c is 0.0!");
```

```
a is 0.3!
b is 0.2!
c is 0.0!
```

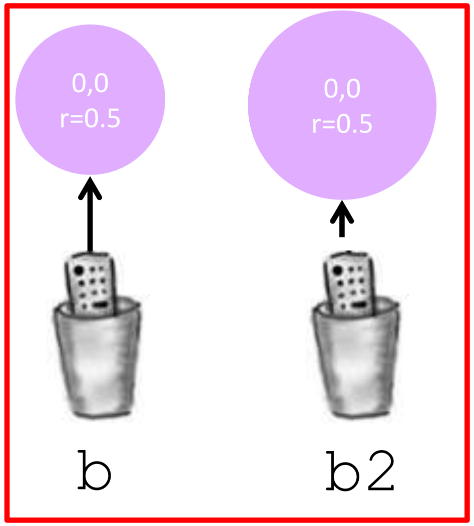
# Equality: reference variables

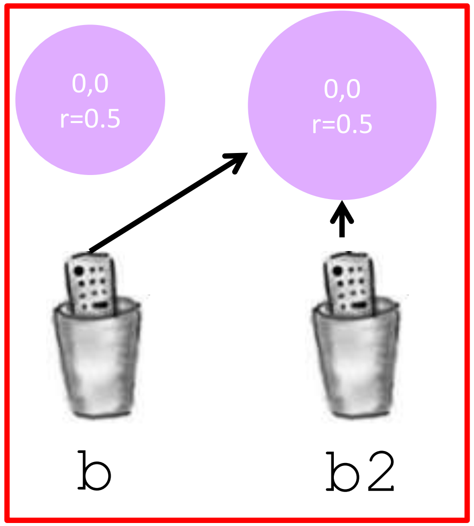
- Boolean operator ==, !=
  - Compares bit values of remote control
    - Not the values stored in object's instance variables
  - Usually not what you want

```
Ball b = new Ball(0.0, 0.0, 0.5);
Ball b2 = new Ball(0.0, 0.0, 0.5);

if (b == b2)
   System.out.println("balls equal!");

b = b2;
if (b == b2)
   System.out.println("balls now equal!");
```

# Equality: reference variables

```java
Ball b = new Ball(0.0, 0.0, 0.5);
Ball b2 = new Ball(0.0, 0.0, 0.5);



if (b == b2)
    System.out.println("balls equal!");





b = b2;
if (b == b2)
    System.out.println("balls now equal!");
```




```
balls now equal
```

# Object equality

- Implement `equals()` instance method
  - Up to class designer exactly how it works
  - Client needs to call `equals()`, not == or !=

```
public class Ball
{
   // See if this Ball is at the same location and radius
   // as some other Ball (within a tolerance of 1e-10).
   // Ignores the color.
   public boolean equals(Ball other)
   {
      final double EPSILON = 1e-10;
      return ((Math.abs(posX   - other.posX)   < EPSILON) &&
              (Math.abs(posY   - other.posY)   < EPSILON) &&
              (Math.abs(radius - other.radius) < EPSILON));
   }
   ...
}
```

# Access modifiers

- Access modifier
  - All instance variables and methods have one
    - public - everybody can see/use
    - private - only class can see/use
    - protected - only class and subclasses (stay tuned)
    - default - everybody in package, what you get if you don't specify a access modifier
  - Normally:
    - Instance variables are private
    - Methods the world needs are public
    - Helper methods used only inside the class are private

# Data encapsulation

- Data encapsulation
  - Hides implementation details of an object
  - Clients don't have to care about details
  - Allows class designer to change implementation
    - Won't break previously developed clients
  - Don't expose implementation details
    - Use private access modifier

# Data encapsulation example

- Person class
  - Originally stored first and last name together in one instance variable
  - Now we want them separated
  - Change instance variables

```
public class Person
{
   private String name  = "";
   private double score = 0.0;

   public String toString()
   {
      return name;
   }
   ...
}
```

Original version, combined names

```
public class Person
{
   private String first = "";
   private String last  = "";
   private double score = 0.0;

   public String toString()
   {
      String result = first;
      result += " ";
      result += last;
      return result;
   }
   ...
}
```

New version, names separated.

# Non-encapsulated example

- If instance variables were `public`:
  - Client program might use instead of methods

```
public class Person
{
    public String first = "";
    public String last  = "";
    public double score = 0.0;

    public String toString()
    {
        String result = first;
        result += " ";
        result += last;
        return result;
    }
    ...
}
```

Non-encapsulated version, instance variables are `public`.

```
...
Person p = new Person("Bob Dole");

System.out.println(p.name +
                   " " +
                   p.score);

...
```

Client program. Changing instance variables causes compile error. Client should have been using `toString()` but used instance variable because it was publically available.

# Getters and setters

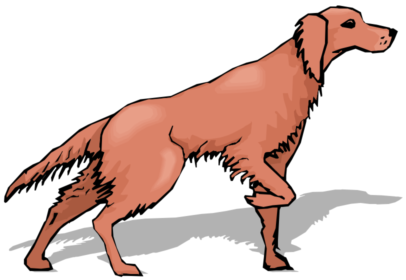
- Encapsulation does have a price
  - If clients need access to instance var, must create:
    - getter methods - "get" value of an instance var
    - setter methods - "set" value of an instance var

```
public double getPosX()
{
    return posX;
}
```

Getter method.
Also know as an ***accessor*** method.

```
public void setPosX(double x)
{
    posX = x;
}
```

Setter method.
Also know as a ***mutator*** method.



# Pass by value: primitive types

- Java passes parameters by value (by copy)
  - Changes to primitives do not persist after method
    - Applies to instance methods as well as static methods
    - Primitive types: `int, double, char, long, boolean, byte, short, float`

```
public void move(double deltaX, double deltaY)
{
   posX += deltaX;
   posY += deltaY;
   deltaX = 0.0;
   deltaY = 0.0;
}
```

This has no effect on the values of `mx` and `my` in the client program.

```
Ball big = new Ball(0.0, 0.0, 0.1);
double mx = 0.5;
double my = -0.3;
big.move(mx, my);
System.out.println("mx=" + mx + " my=" + my);
```

```
mx=0.5 my=-0.3
```

# Changing elements of an array parameter

- Changes to reference types CAN persist
  - References types: arrays, objects

This changes the elements of the passed in array.

The changes persist after the method call!

```
public void move(double [] vals)
{
   posX += vals[0];
   posY += vals[1];
   vals[0] = 0.0;
   vals[1] = 0.0;
}
```

```
d0=0.0 d1=0.0
```

```
Ball big = new Ball(0.0, 0.0, 0.1);
double [] delta = new double[2];
delta[0] = 0.5;
delta[1] = -0.3;
big.move(delta);
System.out.println("d0=" + delta[0] + " " +
                   "d1=" + delta[1]);
```

# Changing an object parameter

- Passing object parameters
  - Can be changed using methods or instance vars

This will move the passed in `Ball` object's location and change its color to black.

```
public boolean overlap(Ball other)
{
    double deltaX = posX - other.posX;
    double deltaY = posY - other.posY;
    double d = Math.sqrt(deltaX * deltaX +
                         deltaY * deltaY);

    other.move(100.0, 100.0);
    other.color = new Color(0.0f, 0.0f, 0.0f);

    return (d < (radius + other.radius));
}
```

# `String` parameters

- String is a reference type
  - But it is a special kind called immutable
  - Changes to `String` parameters do NOT persist

```
// Change the name of this Person object
public void changeName(String newName)
{
   name = newName;
   newName = "";
}
```

```
first=bob
```

```
Person me = new Person("keith");
String first = "bob";
me.changeName(first);
System.out.println("first=" + first);
```

Since `String` is an immutable reference type, this change does NOT persist.

# new'd reference parameters

- Using new on reference parameter
  - Changes to new'd variable do NOT persist

We end up creating a local array.

The changes do not persist after the method call since changes were not actually to memory of `delta` array

```
public void move(double [] vals)
{
    posX += vals[0];
    posY += vals[1];
    vals = new double[2];
    vals[0] = 0.0;
    vals[1] = 0.0;
}
```

```
d0=0.5 d1=-0.3
```

```
Ball big = new Ball(0.0, 0.0, 0.1);
double [] delta = new double[2];
delta[0] = 0.5;
delta[1] = -0.3;
big.move(delta);
System.out.println("d0=" + delta[0] + " " +
                   "d1=" + delta[1]);
```

# Handy String methods

- `String` is an object with lots of methods:

| Method | |
|---|---|
| `int length()` | How many characters in this string |
| `char charAt(int index)` | `char` value at specified index |
| `String substring(int start, int end)` | Substring [`start, end` - 1] inclusive |
| `boolean equals(String other)` | Is this string the same as another? |
| `boolean equalsIgnoreCase(String other)` | Is this string the same as another ignoring case? |
| `String trim()` | Remove whitespace from start/end |
| `String toLowerCase()` | Return new string in all lowercase |
| `String toUpperCase()` | Return new string in all uppercase |
| `int indexOf(String str)` | Index of first occurrence of specified substring, -1 if not found |
| `int indexOf(String str, int from)` | Index of next occurrence of substring starting from index `from`, -1 if not found |

# String search example

- Goal: count occurrences of a string in a file

Call me Ishmael. Some years ago- never mind how long precisely- having little or no money in my purse, and nothing particular to interest me on shore, I thought I would sail about a little and see the watery part of the world. It is a way I have of driving off the spleen and regulating the circulation. Whenever I find myself growing grim about the mouth; whenever it is a damp, drizzly November in my soul; whenever I find myself involuntarily pausing before coffin warehouses, and bringing up the rear of every funeral I meet; and

mobydick.txt

```
% java StringCounter call < mobydick.txt
293
% java StringCounter Call < mobydick.txt
293
% java StringCounter "call me" < mobydick.txt
3
% java StringCounter Keith < mobydick.txt
0
```

# String counter program

```
public static void main(String [] args)
{
   String find = args[0];
   String text = StdIn.readAll();
   text = text.toLowerCase();
   find = find.toLowerCase();

   int index = 0;
   int count = 0;
   while (index != -1)
   {
      index = text.indexOf(find, index);
      if (index != -1)
      {
          count++;
          index = index + find.length();
      }
    }
    System.out.println(count);
}
```

# String efficiency

- Normal `String` class is immutable
  - Every time you append:
    - New object created, old one destroyed
    - This can really slow things down

```
public class StringEfficiency
{
    public static void main(String [] args)
    {
        String str   = "";
        int    num   = Integer.parseInt(args[0]);
        long   start = System.currentTimeMillis();

        for (int i = 0; i < num; i++)
            str = str + "blah ";

        long elapsed = System.currentTimeMillis() - start;
        System.out.println("Time = " + (elapsed / 1000.0));
    }
}
```

# String efficiency

```
public class StringTest
{
    public static void main(String [] args)
    {
        String str   = "";
        int    num   = Integer.parseInt(args[0]);
        long   start = System.currentTimeMillis();

        for (int i = 0; i < num; i++)
            str = str + "blah ";

        long elapsed = System.currentTimeMillis() - start;
        System.out.println("Time = " + (elapsed / 1000.0));
    }
}
```

```
% java StringTest 10000
Time = 0.383
```

```
% java StringTest 20000
Time = 1.358
```

```
% java StringTest 40000
Time = 5.551
```

```
% java StringTest 80000
Time = 25.935
```

```
% java StringTest 160000
Time = 112.63
```

```
% java StringTest 320000
Time = 477.454
```

# StringBuilder

```
public class StringTest2
{
    public static void main(String [] args)
    {
        StringBuilder str = new StringBuilder();
        int    num   = Integer.parseInt(args[0]);
        long   start = System.currentTimeMillis();

        for (int i = 0; i < num; i++)
            str.append("blah ");

        long elapsed = System.currentTimeMillis() - start;
        System.out.println("Time = " + (elapsed / 1000.0));
    }
}
```

```
% java StringTest2 10000
Time = 0.0040
```

```
% java StringTest2 20000
Time = 0.0070
```

```
% java StringTest2 40000
Time = 0.0090
```

```
% java StringTest2 80000
Time = 0.011
```

```
% java StringTest2 160000
Time = 0.015
```

```
% java StringTest2 320000
Time = 0.019
```

# Summary

- Equality
  - Usually avoid == or != with floating-point types
  - Usually avoid == or != with reference types
    - Implement an `equals()` method
- Passing parameters
  - Changing primitive → does NOT persist
  - Changing element in array → persists
  - Changing an object (via method/instance var) → persists
- Strings
  - Small stuff, use `String`
  - Big strings, use `StringBuilder`