Chapter 4

Fundamental types

- Remember: Java has two kinds of types
  - primitive types
    - e.g. `int`, `float`, etc.
  - reference types
    - all object and array types
- What are the differences?

Primitive types

- Three basic categories:
  - Whole numbers
  - Numbers with fractional parts
  - Truth values (i.e. `boolean`)

Whole-number types

name	size	range
long	8 bytes	+/- $9.2 * 10^{18}$
int	4 bytes	+/- ~2 billion
short	2 bytes	-32768 - 32767
byte	1 byte	-128 - 127
char	2 bytes	Unicode

Fractional-number types

name	size	range
double	8 bytes	+/- 10^{308} 15 sig. digits
float	4 bytes	+/- 10^{38} 7 sig. digits

Arithmetic operators

`z = -x;`	unary negation
`z = +x;`	unary positive
`z = x % y;`	modulus
`z = x / y;`	division
`z = x * y;`	multiplication
`z = x - y;`	subtraction
`z = x + y;`	addition

Number basics

- We’ve seen string literals; there are also numeric literals:
  - `1234L (long)`
  - `1234.0F (float)`
  - `1234.0D (double)`
- Why is it important to be able to declare the type of a numeric literal?

Arithmetic operations

- Add, subtract, and multiply work as you'd expect
- Two kinds of division
  - Integer division
  - Floating-point division
- Modulus/remainder

Integer vs. FP division

- Floating-point division works as you'd expect:
  - `5.0F / 2.0F == 2.5F`
- Integer division discards the remainder:
  - `5 / 2 == 2`
- Which is used for given operands?
  - Integer if *all* operands are integers
  - FP if *any* operand is floating-point

Assignment

- Remember the assignment operator?
  - `x = 5;  // “x gets the value 5”`
- Other assignment operators:
  - `x++;  // “increment x, evaluate to old x”`
  - `++x;  // “increment x, evaluate to new x”`
  - `x+=5; // “increment x by 5”`
- Also: *=, -=, /=

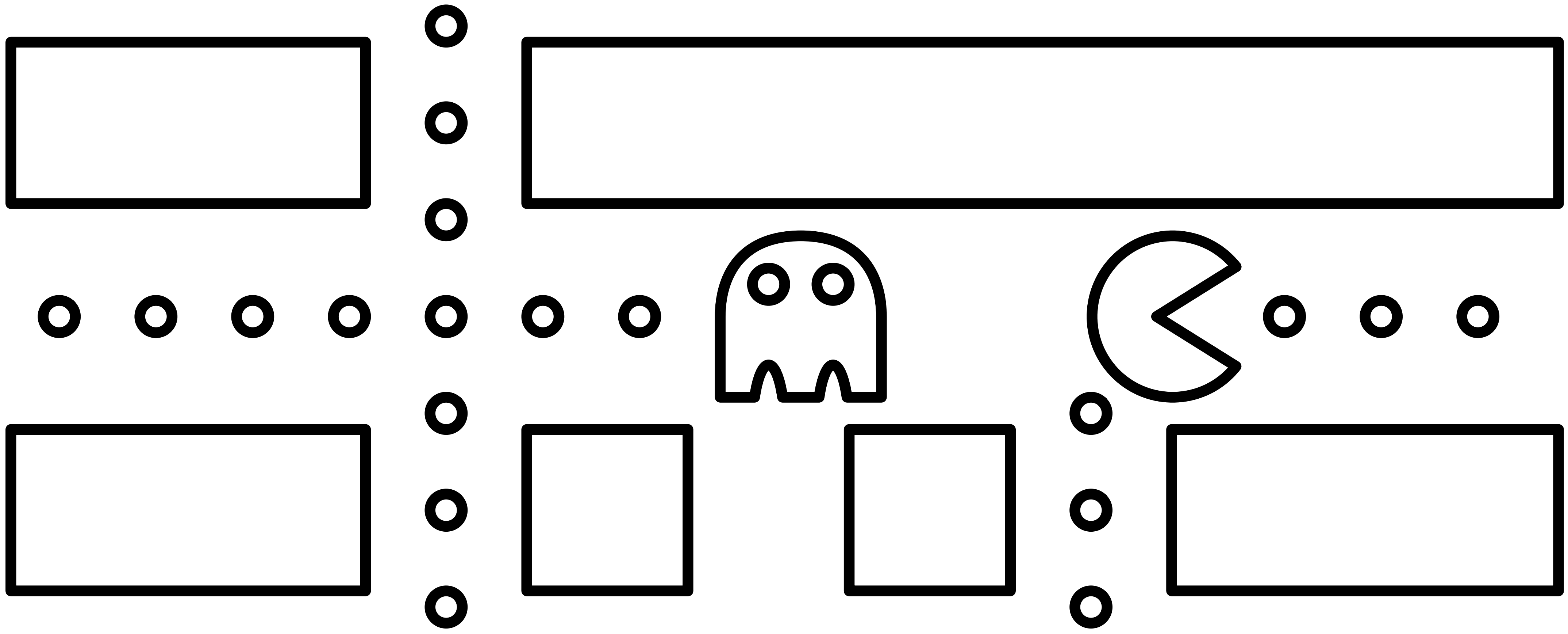
Operator precedence

- This slide is simple: **when in doubt, use parentheses!**

Things to lose sleep over

- Overflow
    - Integer types have limited range
- Rounding errors
- Division by zero
    - Unfortunately, still undefined. May crash your program.

Overflow



Rounding errors

- Floating-point arithmetic is not totally precise.
  - Remember, FP types only have a finite number of significant digits
  - Good enough for most applications, maybe not for all
- Rounding errors can be magnified in a sequence of operations
- Financial institutions, etc., use (slow but) precise classes for FP math

Casting

- You can treat an expression as if it has a different type:
  - (*typeName*)*exp*
- Example: `(int)4.2F`
- Why do this? What are the tradeoffs?

String

- Strings are very useful
- Many of the methods in String will make your life easier
  - Note that none of these modifies the base String -- String is *immutable*.
- You can use the + operator to concatenate Strings

```
String s1 = “x”;
String s2 = s1 + s1;
String s3 = “banana”;
String s4 = s3.substring(1, 3);
String s5 = s4.replace(‘a’, ‘o’);
```

Wrapper classes

- What’s a primitive type?
- What’s a reference type?
- Remember that Java maintains a divide between primitive types and reference types. Wrapper classes provide a way around this!

Wrapper classes

- One for each primitive type: e.g. `Integer` for `int`, etc.
- Can make an `Integer` from an `int`, and can get the `int` value from an `Integer`
- All wrapper classes are *immutable*, just like `String`.
- Why might we use these?

Constants: why?

- What does the following line of code mean?
  - `x = 42 * y;`
- What does “42” mean? Why?
- Constants make programs easier to read and maintain.

final locals

- `final int NUM_SHELVES = 42;`
- `x = NUM_SHELVES * y;`
- Can only be assigned to *once*!

Constants

- Why are we interested in constants?
- How can we use named constants in our Java programs?

Constants: Why?

- Even if we choose good names for local variables, “magic numbers” can make our programs **worse**
  - harder to understand
  - harder to maintain
- Consider:
  - `products = 42 * perShelf;  // vs.`
  - `products = NUM_SHELVES * perShelf;`

Constants: How?

```
public int totalProducts(int pps) {
    final int NUM_SHELVES = 42;


    return NUM_SHELVES * pps;
}
```

Constants: How?

```
public int totalProducts(int pps) {
    final int NUM_SHELVES = 42;

    NUM_SHELVES = 36;
    return NUM_SHELVES * pps;
}
```

Constants: How?

```
public int totalProducts(int pps) {
    final int NUM_SHELVES = 12;

    NUM_SHELVES = 36;
    return NUM_SHELVES * pps;
}
```

Constants: How?

```
public int totalProducts(int pps) {
    final int NUM_SHELVES = 12;

    NUM_SHELVES = 36;
    return NUM_SHELVES * pps;
}
```

`final` variables can **only** get **one** value!

A limitation of `final` locals

- What if you want to use the same constant in multiple methods?
- Is there a good way to do this?
- Is there any way to do this at all?

Well....

- You could just declare a `final` local in each method that is to use the constant.
- That's sort of clunky.
- Duplicating constant declarations in each method is tedious and error-prone.
  - Why are we using constants in the first place?

If some programming task is *tedious and error-prone*, it probably indicates *bad design, bad style, or both*!

A better solution

- `final` data members
- Two kinds:
  - `final` instance variables
  - `static final` variables
- Different applications for each

`final` instance vars

- These correspond to something that can’t change once the object is created
- “Factory-installed options”
- Examples:
  - “Parents” of a `Dog` instance
  - “Capacity” of `Mug` instance

`final` instance vars

accessSpecifier `final` *type id;*

or

accessSpecifier `final` *type id = expression;*

```java
class Beer {
    public final Date expiration;
    /* ... */

    public void consume() {
        /* ... */
    }
}
```

`static final` fields

- Sometimes, it makes sense for a constant to belong to a *class* instead of to an *instance*
- Fields that belong to a class are called *static fields* or *class fields*
- Example:
  - `CashRegister.NICKEL_VALUE = 0.05;`
  - Can you think of another static field we've seen in class so far?

Other examples

- Math.PI
- Math.E
- Can you think of any other useful constants that should be static?

`static final` vars

accessSpecifier `static final` *type id* = *expression;*

```
public static final int COURSE
  = 302;
```

Constants wrap-up

- Use constants instead of “magic numbers” whenever possible
  - `final` local variables when a constant is only needed in *one method*
  - `final` instance fields when a field cannot be changed once an object is created
  - `static final` fields when a constant can be shared between methods in different classes (or between every instance of one class)

Static methods

- Remember that class constants are fields that *belong to a class rather than to an instance*
  - We use the `static` reserved word to indicate this
- We can also declare *methods* that belong to a class rather than to an instance.

Static methods belong to a class, not to an instance.

Static methods

- Static methods are those that don’t operate on any particular instance of the class in which they’re declared
  - These have no implicit parameter; you can’t refer to `this`!
- Why might we want to declare such a method?

Examples

- Factory methods: methods that return references to newly-created instances.
- Utility methods: methods that operate on primitive types.
  - e.g. `Math.sqrt()`, `Math.pow()`, etc.
- Accessor and mutator methods for non-`final static` fields.
  - e.g. `System.setIn()`

Syntax example

```
public static void main(String[] args) {
  System.out.println("Hello, world!");
}
```

`main` is a static method.
(`println` is an instance method,
but `System.out` is a static field.
Confused yet?)

User input

- Remember `System.out`?
  - It’s a static field of class `System`
  - and a reference to an instance of class `OutputStream`
  - that sends output to the console
- `System` has another field for input from the console

User input

- `System.in` is a reference to an instance of class `InputStream`
- `InputStream` has methods to read one byte or a sequence of bytes at a time.
  - e.g. `read()`, `read(byte[])`, etc.

User input

- However, it isn't convenient to deal in bytes!
- For example:
  - `Hello, world!\n`
  - `72 101 108 108 111 44 32 119 111 114 108 100 33 10`

The `Scanner` class interacts with an `InputStream` and provides an improved interface

```
Scanner in = new Scanner(System.in);
System.out.print("Enter your name: ");
String name = in.next();
```

Scanner methods

- `next()` and `nextWord()` return next *token* (i.e., until space)
- `nextInt()` interprets next token as an `int`, returns `int` value
- `nextDouble()`, etc., are similar to `nextInt()`
- `nextLine()` returns the next line