CS1004: Intro to CS in Java, Spring 2005

Lecture #6: Data representation, Java expressions

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Administrivia

- HW#1 due next Tuesday
- Does everyone have both textbooks? (Bookstore is asking us)

Representing real numbers

- Representing real numbers
  - First, convert into binary numbers
    - A little trickier than it first seems: to the right, each bit represents ½, ¼, 1/8, etc.
    - 5.75 = ?
  - Next, put into binary scientific notation: $a \times 2^b$
    - 101.11×2^0
  - Normalize so that first significant digit is immediately to the right of the binary point
    - $.10111 \times 2^3$
  - Mantissa and exponent (and signs) then stored
  - What's the ultimate result?

Representing text

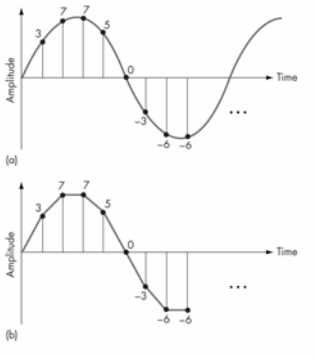
- Characters are mapped onto binary numbers
  - ASCII code set
    - 8 bits per character (byte!); 256 character codes
  - UNICODE code set
    - 16 bits per character; 65,536 character codes
    - Much more complex, but better international support
  - Let's Google "ASCII"
- Text strings are sequences of characters in some encoding

Sound

- Multimedia data is sampled to store a digital form, with or without detectable differences
- Representing sound data
  - Sound data must be digitized for storage in a computer
  - Digitizing means periodic sampling (*frequency*) of amplitude values (*levels*)
  - From samples, original sound may be approximated
  - To improve the approximation:
    - Sample more frequently
    - Use more bits for each sample value
  - CD quality: 44KHz sampling, 16-bit levels, stereo = 176kbps
  - DVD audio/SACD different; effectively 100KHz

(a) Sampling the Original Signal

(b) Recreating the Signal from the Sampled Values



Images

- Representing image data
  - Images are sampled by reading color and intensity values at even intervals across the image
  - Each sampled point is a pixel
  - Image quality depends on number of bits at each pixel *and* the number of pixels in an image
  - 24bpp common for consumer-grade equipment today
  - "Megapixel": what does it mean?

And now…

- We're about to delve deep into Java syntax
- Don't be afraid to write test programs to fully understand the concepts discussed here
- I'll write a number of test programs today and make them downloadable
- **ASK QUESTIONS** if you don't understand things
  - Much easier now than later; we're only going to become more complex

Character strings in Java

- A string of characters can be represented as a *string literal* by putting double quotes around the text
- For example…
- Every character string is an object in Java, defined by the `String` class
- Every string literal represents a `String` object
- Don't worry about all the implications just yet

The println Method

- We used `println` method to print a character string
- `System.out` is an object that represents a destination

```
System.out.println("Whatever you are, be a good one.");
```

object — method name — information provided to the method (parameters)

The print Method

- There are other methods in System.out
- For example, the `print` method is similar to the `println` method, except that it does not advance to the next line
- How do we find out more information about such methods? *Java API documentation*
  - http://java.sun.com/j2se/1.5.0/docs/api/index.html
  - A little overwhelming at first, but ultimately useful
  - We'll spend more time on this later

String Concatenation

- The *string concatenation operator* (+) is used to append one string literal to the end of another

```
"Peanut butter " + "and jelly"
```

- It can also be used to append a number to a string

```
"I am not " + 65 + " years old"
```

  - We could just represent the number as a string in this case
- A single string literal cannot be broken across two lines in a program

Escape Sequences

- What if we wanted to print a the quote character?
- The following line would confuse the compiler because it would interpret the second quote as the end of the string

```
System.out.println("I said "Hello" to
                you.");
```

Escape Sequences (II)

- An *escape sequence* is a series of characters that represents a special character
- An escape sequence begins with a backslash character (\)

```
System.out.println("I said \"Hello\"
             to you.");
```

Escape Sequences (III)

- Some Java escape sequences:

Escape Sequence	Meaning
\b	backspace
\t	tab
\n	newline
\r	carriage return
\"	double quote
\'	single quote
\\	backslash

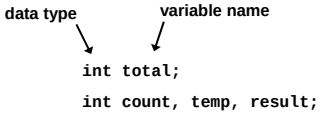
Example

- What does the following print? (Roses.java, p. 68)

```
System.out.println("Roses are red,\n\tViolets are blue,\n" +
   "Sugar is sweet,\n\tBut I have \"commitment issues\",\n\t" +
   "So I'd rather just be friends\n\tAt this point in our " +
   "relationship.");
```

Variables

- A *variable* represents a piece of information in memory. It's *declared* by specifying
  - The *type* of information (e.g., **int**eger)
  - The *name* of the variable
- You can name more than one variable per statement




```
int total;
int count, temp, result;
```

Variable initialization

- You can give an initial value in the declaration:

```
int sum = 0;
int base = 32, max = 149;
```

- When a variable is *referenced* in a program, its current value is used
- You change the value of the variable by *assigning* it a new value

```
sum = 55;
```

Assignment

- The *assignment operator* is the `=` sign
- The expression on the right is evaluated and the result is stored in the variable on the left
- Previous value in `sum`, if any, is overwritten
- You can only assign a value to a variable that is consistent with the variable's declared type

Constants

- Identifier that is similar to a variable except that it holds the same value during its entire existence, i.e., *constant*
  - Usually ALL_CAPITALS to avoid confusion
- The compiler will issue an error if you try to change the value of a constant
- In Java, we use the `final` modifier to declare a constant

```
final int NUM_DAYS_IN_YEAR = 365;
```

- Useful in making program easier to read, or to change some predefined concepts

Primitive Data

- There are eight *primitive data types* in Java
  - Integers: `byte`, `short`, `int`, `long`
  - Floating point numbers: `float`, `double`
  - Characters: `char`
  - Boolean values: `boolean`
    - Can be assigned `true` or `false`; one bit of info
- Note that they're all lowercase
- Strings are *not* primitive data types
  - They're a *reference type*, but can be used in a similar fashion (with some caveats)
  - `String` (note uppercase S)

Numeric Primitive Data

- The difference between the various numeric primitive types is their size, and therefore the values they can store:

Type	Storage	Min Value	Max Value
`byte`	8 bits	-128	127
`short`	16 bits	-32,768	32,767
`int`	32 bits	-2,147,483,648	2,147,483,647
`long`	64 bits	$< -9 \times 10^{18}$	$> 9 \times 10^{18}$
`float`	32 bits	$+/- 3.4 \times 10^{38}$ with 7 significant digits	
`double`	64 bits	$+/- 1.7 \times 10^{308}$ with 15 significant digits	

Characters

- A `char` variable stores a single character
- Character literals are delimited by single quotes:
  `'a'  'X'  '7'  '$'  ','  '\n'`
- Example declarations:

```
char topGrade = 'A';
char terminator = ';', separator = ' ';
```

- Note the distinction between a primitive character variable, which holds only one character, and a `String` object, which can hold multiple characters
- Java supports *both* ASCII and Unicode characters

Expressions

- An *expression* is a combination of one or more operators and operands
- *Arithmetic expressions* compute numeric results and make use of the arithmetic operators:

Addition	+
Subtraction	-
Multiplication	*
Division	/
Remainder	%

- If either or both operands used by an arithmetic operator are floating point, then the result is a floating point

Division and Remainder

- If both operands to the division operator (/) are integers, the result is an integer (the fractional part is discarded)

```
14 / 3      equals      4
8 / 12      equals      0
```

- The remainder operator (%) returns the remainder after dividing the second operand into the first
  - Also called **mod** operator (modulus)

```
14 % 3      equals      2
8 % 12      equals      8
```

Operator Precedence

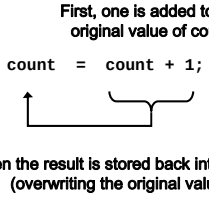
- Given the following compound expression, in what order are the operands evaluated?

```
result = total + count / max -
         offset;
```

- Variation on PEMDAS (no exponents)
- Arithmetic operators with the same precedence are evaluated from left to right
- The assignment operator itself has lower precedence, so this works

Assignment Revisited

- The right and left hand sides of an assignment statement can contain the same variable



Assignment Operators

- This is such a common paradigm, Java provides *assignment operators* to simplify the process
- For example, `count += 1;` is equivalent to `count = count + 1;`

Operator	Example	Equivalent To
+=	x += y	x = x + y
-=	x -= y	x = x - y
*=	x *= y	x = x * y
/=	x /= y	x = x / y
%=	x %= y	x = x % y

- What does `result /= (total-MIN) % num;` do?

Assignment Operators (II)

- The behavior of some assignment operators depends on the types of the operands
- If the operands to the += operator are strings, the assignment operator performs string concatenation
- The behavior of an assignment operator (+=) is always consistent with the behavior of the corresponding operator (+)

Increment and Decrement

- Also turns out that adding or subtracting one is extremely common, so much so there are special one-operand operators for these tasks
- The *increment operator* (`++`) adds 1 to its operand
- The *decrement operator* (`--`) subtracts 1 from its operand
- The statement

```
count++;
```

  is functionally equivalent to

```
count = count + 1;
```

Next time

- Finish chapter 2 of Lewis/Loftus