Data and Expressions

- Objectives - when we have completed this set of notes, you should be familiar with:
  - Character strings and escape sequences
  - Variables and assignment
  - Primitive data
  - *if* and *if-else* statements with simple boolean expressions
  - Arithmetic expressions and operator precedence
  - Accepting standard input from the user
  - Data conversions

Character Strings

- A string of characters can be represented as a *string literal* by putting double quotes around the text:
- Examples:

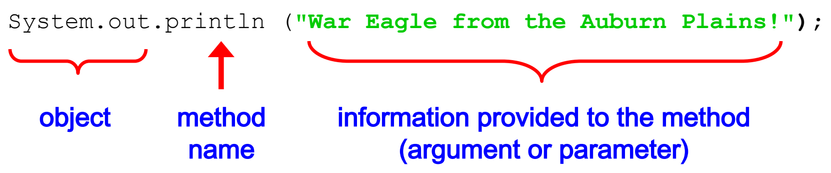
```
"This is a string literal."
"Pat Doe, 123 Main Street"
"7"
```

- When your program is running, a character string is an object in Java, defined by the `String` class
- Every string literal represents a `String` object

The println Method

Q1

- Recall that the `println` method prints a character string and then advances to the next line
- The `System.out` object is an output stream corresponding to a standard output (stdout) which is usually the computer screen



```
System.out.println ("War Eagle from the Auburn Plains!");
```

The print Method

- The `print` method for the System.out object is similar to the `println` method, except that it does not advance to the next line after it prints
- Therefore anything printed after a `print` statement will appear on the same line
- See CountOff.java

String Concatenation

- The *string concatenation operator* (+) appends one string to the end of another

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

- A string literal cannot be broken across two lines in a program
- It can also append a **number** to a **string**
- See ConcatenationExample1

String Concatenation

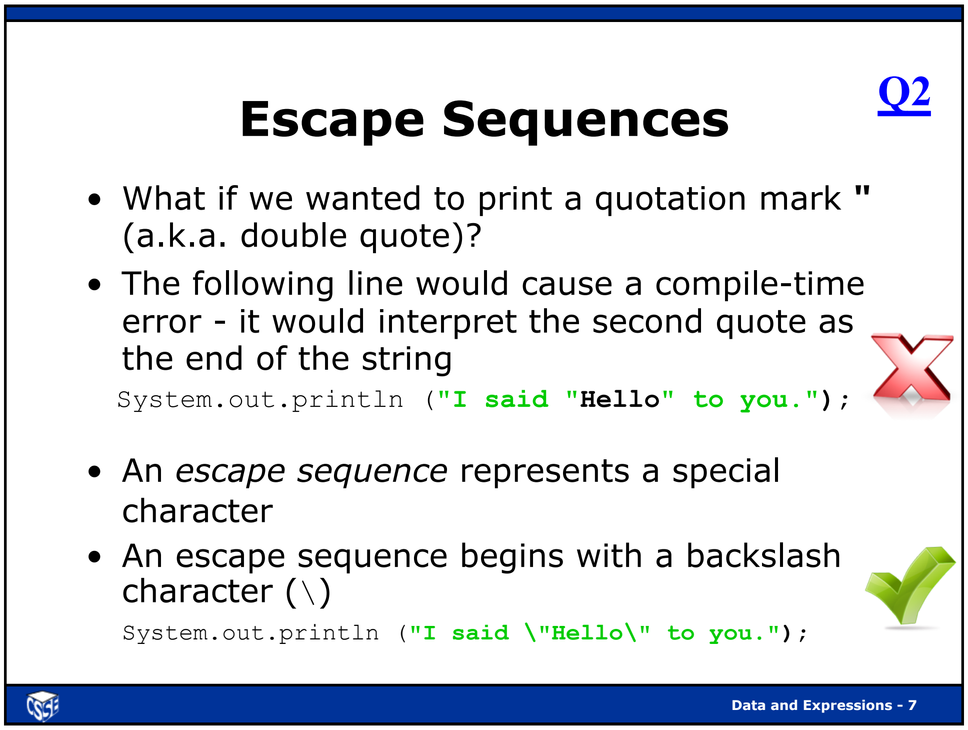
- The + operator is a binary operator applied to two operands; if at least one the operands is a String then string concatenation is done

```
5 + " years"      results in    "5 years"
```

- The + operator also used for addition if both operands are numeric

```
5 + 10            results in    15
```

- The + operator is evaluated left to right, but parentheses can be used to force the order
- See ConcatenationExample2
  (Experiment with String expressions in the interactions pane in jGRASP)



Escape Sequences

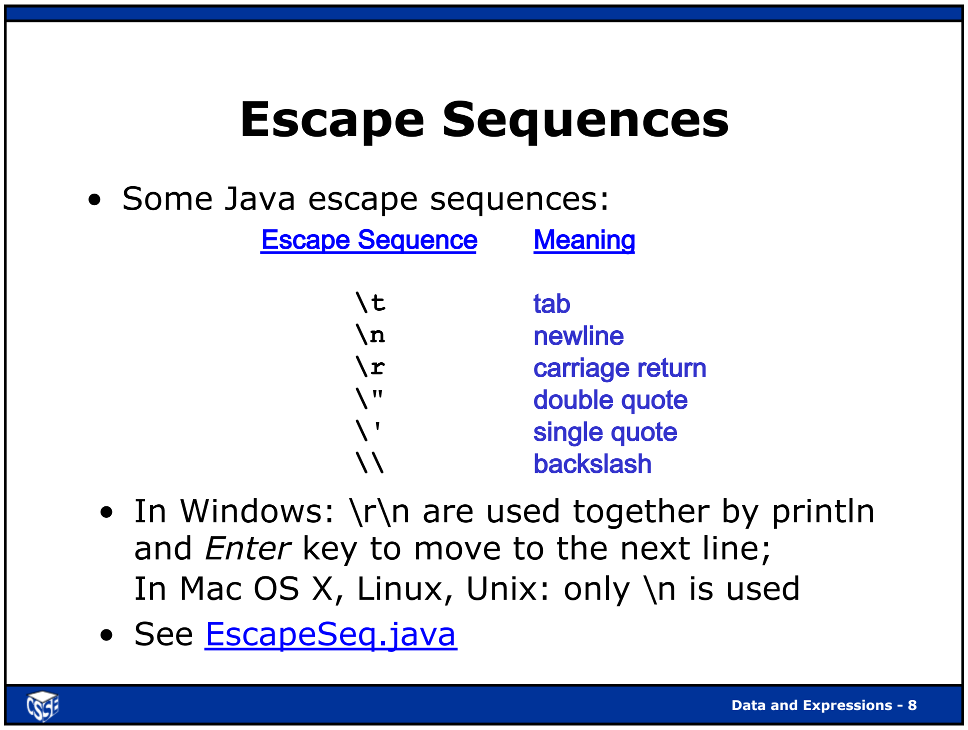
Q2

- What if we wanted to print a quotation mark " (a.k.a. double quote)?
- The following line would cause a compile-time error - it would interpret the second quote as the end of the string

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

- An *escape sequence* represents a special character
- An escape sequence begins with a backslash character (\)

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



Escape Sequences

- Some Java escape sequences:

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

- In Windows: \r\n are used together by println and *Enter* key to move to the next line; In Mac OS X, Linux, Unix: only \n is used
- See EscapeSeq.java

Variables

- A *variable* is a name for a “location” in memory that holds a value
- There are many types of values or data…
  - integers values (e.g., -60, 0, 1, 7, 23)
  - floating point values (e.g., -5.6, 0.0, 2.4, 35.2)
  - characters values (e.g., `'j'`, `'P'`, `'5'`)
  - boolean values (`true`, `false`)
  - references to objects
- We’ll focus on `int` types (integer values) for now and then examine the other types later

Variables

- A variable must be *declared* with the type of information that it will hold or reference

type (integer)　　variable name

```
int total;
```

Multiple variables can be created in one declaration

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

Variable Initialization

- A variable can be "initialized" to a particular value

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

- When a variable is referenced in a program, its current value is used

```
System.out.println("base is " + base);
```

would print…

```
base is 32
```

Assignment

- An *assignment statement* changes value of variable

```
total = 55;
```

- The *asssignment operator* **=**
- How does it work?
  - Evaluate the expression on the right side
  - Store the result in the variable on the left side

    (previous value is overwritten)
- Java is *strongly typed*: variable type and expression type must be compatible!
- See VariablesExample.java (Run in Canvas ,)

Primitive Data

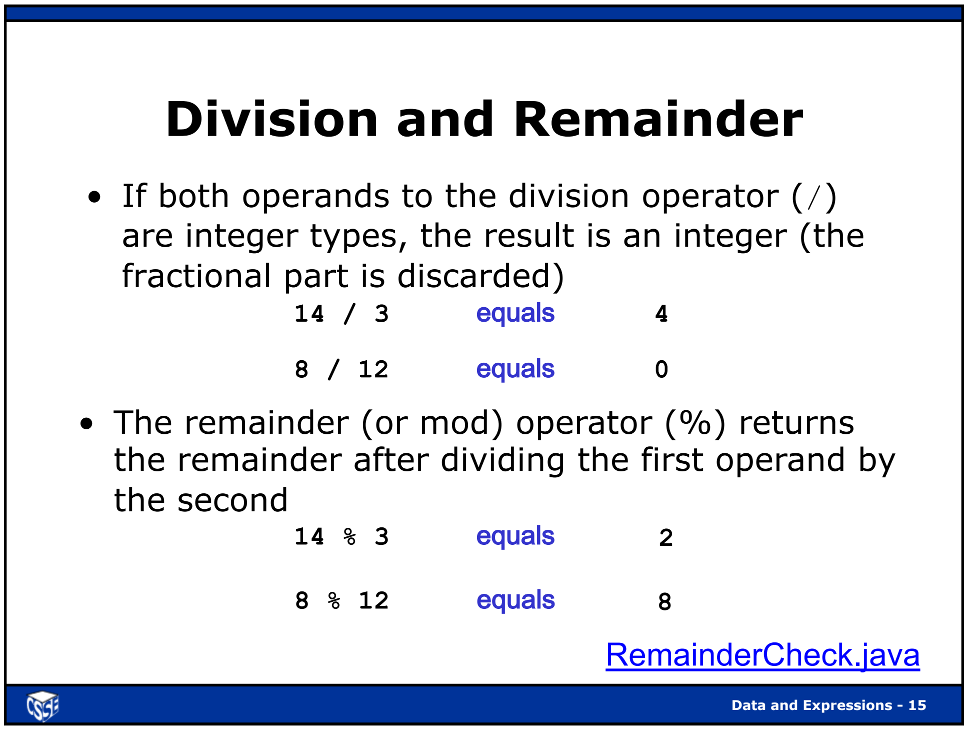
- There are 8 primitive data types in Java
- Integer types:
  - `byte`, `short`, **`int`**, `long` `int age = 19;`
- Floating point types:
  - `float`, **`double`** `double avg = 94.8;`
- Character type:
  - `char` `char letter = 'A';`
- Boolean type:
  - `boolean` `boolean isCold = false;`

Expressions

- An *expression* is made up of one or more variables, operators, and/or method invocations that evaluates to a single value
- *Arithmetic expressions* compute numeric results and make use of the *arithmetic operators*:

Addition	+
Subtraction	-
Multiplication	*
Division	/
Remainder (Modulus)	%

If either operand is a floating point value, then the result is a floating point value



Division and Remainder

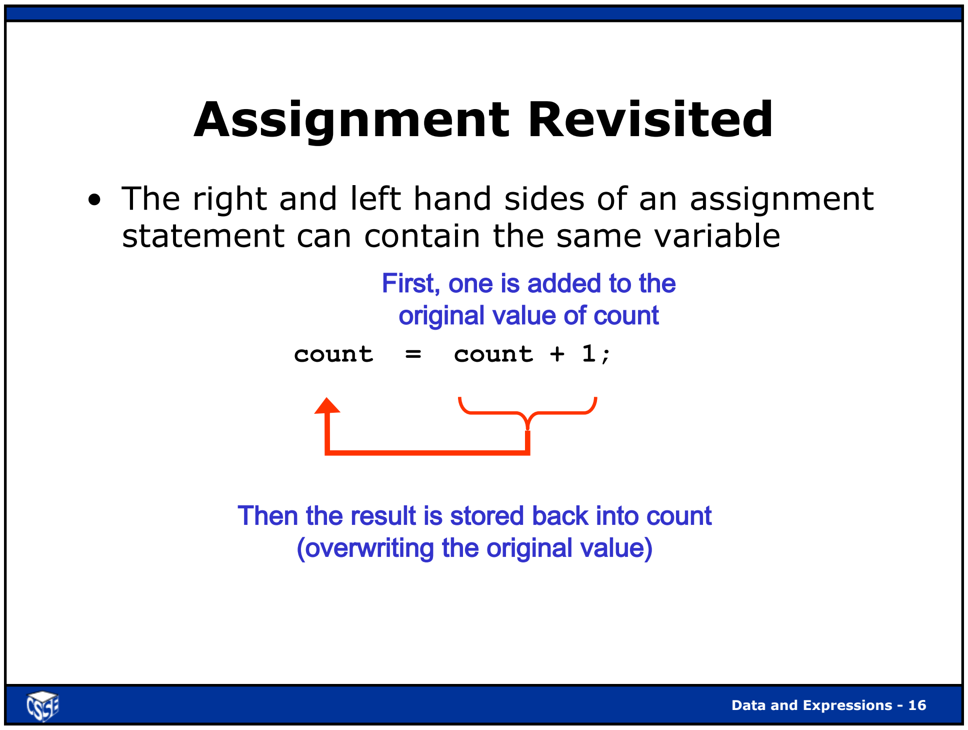
- If both operands to the division operator (`/`) are integer types, the result is an integer (the fractional part is discarded)

```
14 / 3     equals     4

8 / 12     equals     0
```

- The remainder (or mod) operator (`%`) returns the remainder after dividing the first operand by the second

```
14 % 3     equals     2

8 % 12     equals     8
```

RemainderCheck.java



Assignment Revisited

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

First, one is added to the original value of count

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

Then the result is stored back into count (overwriting the original value)

Increment and Decrement

- The increment and decrement operators use only one operand
- The *increment operator* (`++`) adds one to its operand
- The *decrement operator* (`--`) subtracts one from its operand
- The statement

```
count++;
```

is functionally equivalent to

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

Assignment Operators

- Often we perform an operation on a variable, and then store the result back into that variable
- Java provides *assignment operators* to simplify that process
- For example, the statement

```
num += count;
```

is equivalent to

```
num = num + count;
```

Characters

- A `char` variable stores a single character
- *Character literals* are in single quotes:

```
    'a'   'X'   '7'   '$'   ','   '\n'
```

- Example declarations:

```
char topGrade = 'A';

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

- A primitive character variable holds only one character, while a `String` object holds multiple characters

Q3

Boolean

- A `boolean` value represents a true or false condition
- The reserved words `true` and `false` are the only valid values for a boolean type

```
boolean done = false;
```

- A `boolean` variable can also be used to represent any two states, such as a light bulb being *on* or *off*

Relational Operators

- Boolean values can be calculated using relational operators

Operator	Meaning
= =	Equal
! =	Not equal
<	Less than
<=	Less than or equal
>	Greater than
>=	Greater than or equal

- Example:

```
boolean greater = 89 > 50; // greater set to true
int temp = 99;
boolean isCold = temp < 50; // isCold set to false
```

if Statements

- Allows a program to execute a statement or block { } only under certain conditions:

```
int temp = 39;
if (temp < 50) {
   System.out.println("It's cold!");
}
System.out.println("Temp = " + temp);
```

IfExample.java

if Statements

- You can also use a boolean variable:

```
int temp = 39;
boolean isCold = temp < 50;
if (isCold) {
   System.out.println("It's cold!");
}
System.out.println("Temp = " + temp);
```

IfExample2.java

if-else Statements

- What if you wanted to execute one statement or block { } for a true condition and a different statement or block { } for a false condition?

```
int num1 = 9, num2 = 7;
if (num1 < num2) {
   System.out.println(num1 + " is < " + num2);
}
else {
   System.out.println(num1 + " is >= " + num2);
}
System.out.println("Done!");
```

- What is the output? IfElseExample.java
- What if num1 and num2 both hold value 10?

Interactive Programs Using Standard Input

- Programs generally need user input
- The `Scanner` class in Java class library, provides methods for reading input
- It is imported into a program by placing the following line at the beginning of the file:

  ```
  import java.util.Scanner;
  ```
- A `Scanner` object can be set up to read input from various sources including keyboard input which is represented by the `System.in` object

Numerical Input Example

- The following line creates a Scanner object that reads from the keyboard:

  ```
  Scanner scan = new Scanner(System.in);
  ```
- The `new` operator creates the `Scanner` object
- Once created, the `Scanner` object can be used to get user input. For example, nextInt retrieves an integer value:

  ```
  int numberItems = scan.nextInt();
  ```
- See Difference.java (also Run in Canvas ; ▶)

Part 2

- More on primitive types
- Character sets
- Operator precedence
- Increment and Decrement: prefix and postfix form
- Data conversion
- Reading user input

Numeric Primitive Data

- Why have multiple types for integer and floating point values? They are different sizes in memory, which dictate the range of possible values

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 x 10^{18}	> 9 x 10^{18}
`float`	32 bits	+/- 3.4 x 10^{38} with 7 significant digits	
`double`	64 bits	+/- 1.7 x 10^{308} with 15 significant digits	

Numeric Primitive Data

- Suppose you want to declare a variable to hold an integer value
- You could use a byte value…

```
byte scheduledCourses;
```

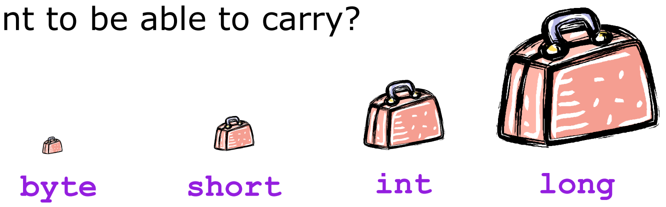
  - Takes up only a small space (8 bits)
  - However, it can only be between -127 and 127
- Or an int value

```
int storeInventory;
```

  - Now you can go all the way to **2,147,483,647!**
  - However, reserves much more space (32 bits)

Numeric Primitive Data

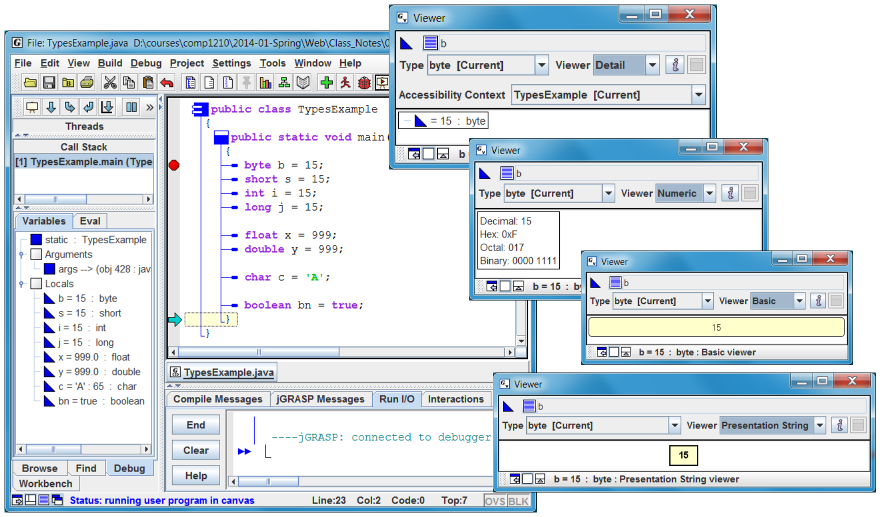
- **Think of it as picking out a suitcase.** How much space do you have? How much do you want to be able to carry?



- Your computer/phone/etc has plenty of space, so use **<u>int</u>** and **<u>double</u>** values "just in case"

TypesExample.java (set breakpoint; Debug ; single step ; open viewers by dragging variables from Debug tab)

jGRASP Viewers for byte


File: TypesExample.java D:\courses\comp1210\2014-01-Spring\Web\Class_Notes\
File Edit View Build Debug Project Settings Tools Window Help
Threads
Call Stack
Variables Eval
Browse Find Debug
Workbench
TypesExample.java
Compile Messages jGRASP Messages Run I/O Interactions
End
Clear
Help
Viewer
OVS BLK

[1] TypesExample.main (Type

```
static : TypesExample
Arguments
   args --> (obj 428 : jav
Locals
   b = 15 : byte
   s = 15 : short
   i = 15 : int
   j = 15 : long
   x = 999.0 : float
   y = 999.0 : double
   c = 'A' : 65 : char
   bn = true : boolean
```

```java
public class TypesExample
{
   public static void main(
   {
      byte b = 15;
      short s = 15;
      int i = 15;
      long j = 15;

      float x = 999;
      double y = 999;

      char c = 'A';

      boolean bn = true;
   }
}
```

```
 ----jGRASP: connected to debugger
```

Status: running user program in canvas   Line:23 Col:2 Code:0 Top:7

Viewer: b — Type byte [Current] — Viewer Detail — Accessibility Context TypesExample [Current]

= 15 : byte

Viewer: b — Type byte [Current] — Viewer Numeric

```
Decimal: 15
Hex: 0xF
Octal: 017
Binary: 0000 1111
```

b = 15 : by

Viewer: b — Type byte [Current] — Viewer Basic

15

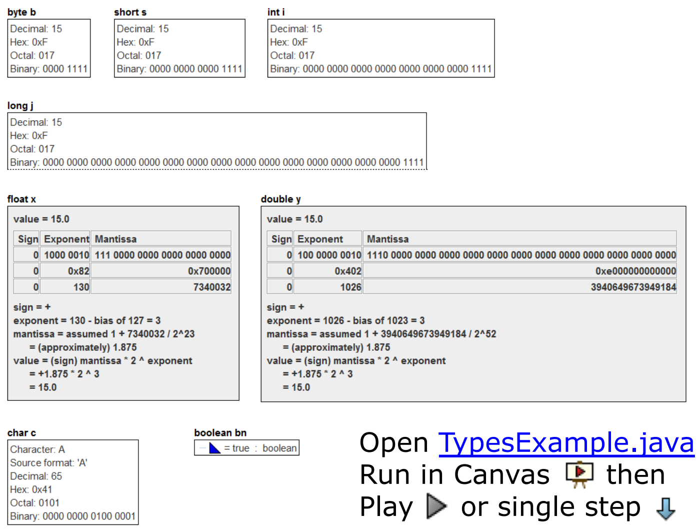
b = 15 : byte : Basic viewer

Viewer: b — Type byte [Current] — Viewer Presentation String

15

b = 15 : byte : Presentation String viewer

jGRASP Numeric Viewers for Primitive Types (except boolean) in a Canvas Window



byte b

```
Decimal: 15
Hex: 0xF
Octal: 017
Binary: 0000 1111
```

short s

```
Decimal: 15
Hex: 0xF
Octal: 017
Binary: 0000 0000 0000 1111
```

int i

```
Decimal: 15
Hex: 0xF
Octal: 017
Binary: 0000 0000 0000 0000 0000 0000 0000 1111
```

long j

```
Decimal: 15
Hex: 0xF
Octal: 017
Binary: 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 1111
```

float x

value = 15.0

Sign	Exponent	Mantissa
0	1000 0010	111 0000 0000 0000 0000 0000
0	0x82	0x700000
0	130	7340032

```
sign = +
exponent = 130 - bias of 127 = 3
mantissa = assumed 1 + 7340032 / 2^23
    = (approximately) 1.875
value = (sign) mantissa * 2 ^ exponent
    = +1.875 * 2 ^ 3
    = 15.0
```

double y

value = 15.0

Sign	Exponent	Mantissa
0	100 0000 0010	1110 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0	0x402	0xe000000000000
0	1026	3940649673949184

```
sign = +
exponent = 1026 - bias of 1023 = 3
mantissa = assumed 1 + 3940649673949184 / 2^52
    = (approximately) 1.875
value = (sign) mantissa * 2 ^ exponent
    = +1.875 * 2 ^ 3
    = 15.0
```

char c

```
Character: A
Source format: 'A'
Decimal: 65
Hex: 0x41
Octal: 0101
Binary: 0000 0000 0100 0001
```

boolean bn

= true : boolean

Open TypesExample.java
Run in Canvas then
Play or single step

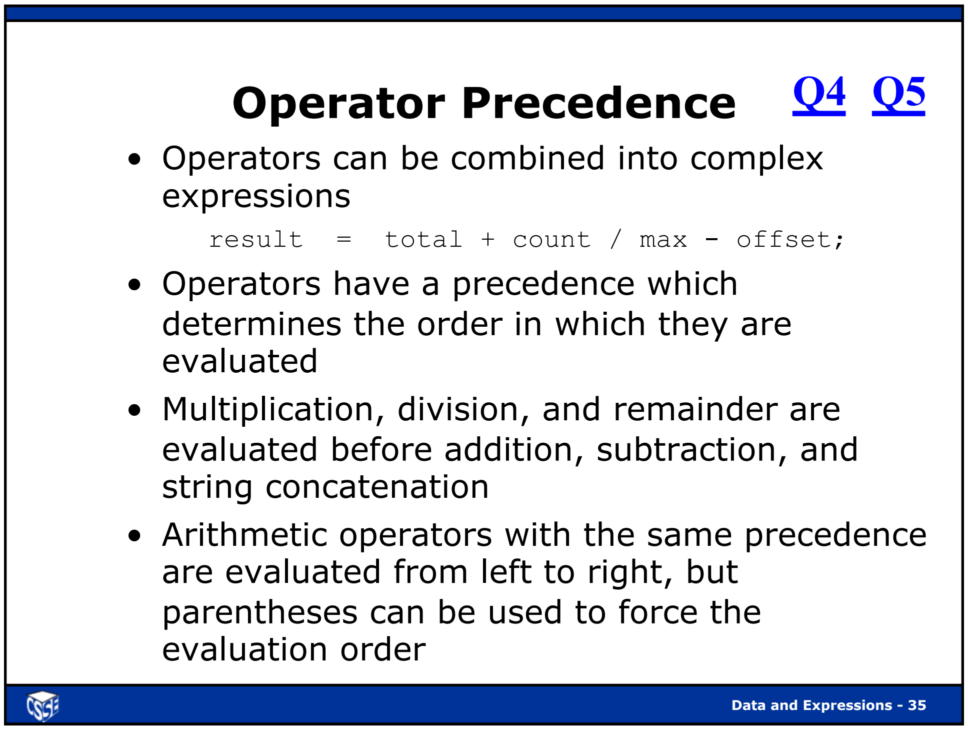
Character Sets

- A *character set* is an ordered list of characters, and character represents a unique number
  - A `char` variable in Java can store any 16-bit character from the *Unicode character set*
  - Sixteen bits allowing for 65,536 unique values
  - It is an international character set, containing symbols and characters from most of the world's languages
- *Experiment with char and String literals in expressions in the interactions pane in jGRASP*

Character Sets

- The *ASCII character set* is older and smaller than Unicode, but is still quite popular
- The ASCII characters are a subset of the Unicode character set, including:

uppercase letters	A, B, C, …
lowercase letters	a, b, c, …
punctuation	period, semi-colon, …
digits	0, 1, 2, …
special symbols	&, |, \, …
control characters	carriage return, tab, ...

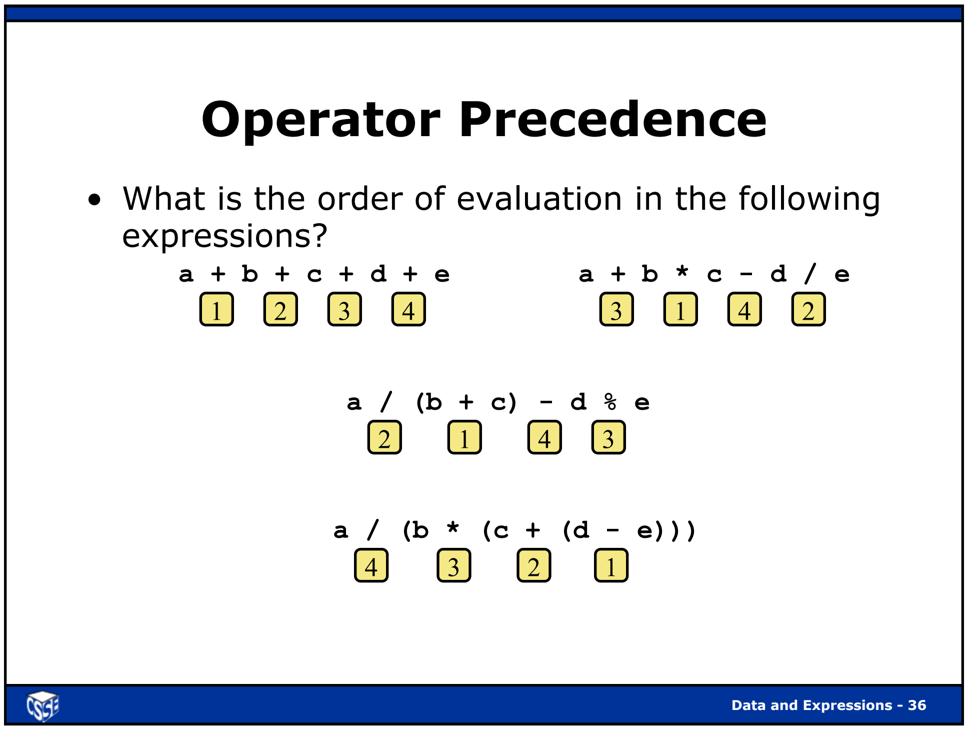


Operator Precedence Q4 Q5

- Operators can be combined into complex expressions

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

- Operators have a precedence which determines the order in which they are evaluated
- Multiplication, division, and remainder are evaluated before addition, subtraction, and string concatenation
- Arithmetic operators with the same precedence are evaluated from left to right, but parentheses can be used to force the evaluation order



Operator Precedence

- What is the order of evaluation in the following expressions?

```
a + b + c + d + e          a + b * c - d / e
  1   2   3   4              3   1   4   2

          a / (b + c) - d % e
            2    1    4   3

          a / (b * (c + (d - e)))
            4    3    2    1
```

Assignment Revisited

- The assignment operator has a lower precedence than the arithmetic operators

First the expression on the right hand side of the = operator is evaluated

```
answer  =  sum / 4 + MAX * lowest;
        4        1   3       2
```

Then the result is stored in the variable on the left hand side

Q6

Increment and Decrement

Q7

- The increment and decrement operators can be applied in *postfix form*:

`count++`	uses old value in the expression, then increments

- or *prefix form*:

`++count`	increments then uses new value in the expression

- When used as part of a larger expression, the two forms can have different effects
  - Use the increment and decrement operators with care

IncrementOperatorExample

Assignment Operators

- There are many assignment operators in Java, including the following:

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`

Assignment Operators

- The right hand side of an assignment operator can be a complex expression
- The entire right-hand expression is evaluated first, then the result is combined with the original variable
- Therefore

```
result /= (total-MIN) % num;
```

is equivalent to

```
result = result / ((total-MIN) % num);
```

Data Conversion

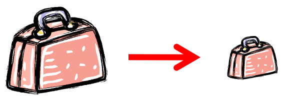
- Sometimes it is necessary to convert data from one type to another
- For example, we may want to treat an integer as a floating point value
- Conversions must be handled carefully to avoid losing information

Data Conversion

- *Narrowing conversions* go from a large data type to a smaller one *or* from a floating point type to an integer type which has less detail
  - If the an int value was 700 (larger than the max byte value of 127), information would be lost when converted to an byte
  - If your grade of 89.8 (a double) was converted to an int type, the new value would be 89 (a ‘B’!) ☹
- *Widening conversions* go from a smaller to larger data type *or* from an integer type to a floating point type which has more detail
  - If a ‘byte’ with value 95 was converted to an ‘int’ type, the new value would still be 95 (your new grade could now go up to 2,147,483,647!) ☺

Data Conversion

- Think about the suitcase example…
  - Narrowing conversion : you may lose data going from a larger data type to a smaller data type



Not ok if the larger one was full!

- In Java, data conversions can occur in three ways:
  - assignment conversion
  - promotion
  - casting

Assignment Conversion

Q8

- *Assignment conversion*: a value of one type is assigned to a variable of another; example:
  - Variable `money` is type **`double`**. Variable `dollars` is type **`int`**.
  - The assignment below converts the <u>value</u> in `dollars` to a **`double`** as it assigns it to `money`

```
money = dollars;
```

- The type and value of `dollars` did not change
- Allows only widening conversions

Data Conversion

Q9 Q10

- *Promotion* happens when operators in expressions convert their operands
- For example:

  `sum` is a **`double`** (as is result)

  `count` is an **`int`**

  The value from `count` is converted (or promoted) to a **`double`** value in the expression on the right before the division is done:

```
result = sum / count;
```

Casting

Q11

- *Casting* allows narrowing conversions and widening conversions, so be careful!
- It is also easy to detect in code
- To cast, the type (in parentheses) is placed in front of the value being converted
- For example, if `total` and `count` are integers, the value of `total` could be converted to a **`double`** with a cast to avoid integer division:

```
result = (double) total / count;
```

Constants

- A *constant* is similar to a variable, but it is placed at the class level (e.g., above the main method), written in all CAPS with underscores, and its initial value cannot be changed
- The `static` modifier allows it to be shared among all methods in the class; the `final` modifier prevents the initial value from changing

```
static final int MIN_HEIGHT = 69;
```

- The compiler will issue an error if you try to change the value of a constant

Constants

- Constants are useful for three important reasons…

1. Constants improve code readability
   - For example, MAX_LOAD means more than the literal 250 (a.k.a., a magic number)
2. Second, they facilitate program maintenance
   - If a constant is used in multiple places, its value need only be updated in one place
3. Third, they prevent a value from changing, avoiding inadvertent errors by other programmers

Reading Input

- The `Scanner` class is part of the `java.util` package in the Java class library, and must be imported into a program to be used:

```
import java.util.Scanner;
```

- The `nextLine` method reads all of the input until the end of the line is found
- See ReadLineExample
- The `next` method reads the next token or items and returns it as String

Input Tokens

- Unless specified otherwise, tokens are delimited by *white space,* which includes spaces, tabs, newlines, and return characters
- In addition to the `nextLine` and `next` methods of the `Scanner` class which return a String value, we have methods such as `nextInt` and `nextDouble` that read a token and convert it to the type indicated by the method name
- See DinnerForGroup (Run in Canvas ▶; ▷)

Scanning a String

Q12

- A Scanner object can be created to scan any String, breaking it into tokens
- Suppose we want to separate a phrase into words and print each word on a separate line

```
Scanner scan = new Scanner("this is a test");
System.out.println(scan.next());
System.out.println(scan.next());
. . .
```

StringScan.java (Run in Canvas ; single step)