v1.0

THE UNIVERSITY OF MELBOURNE

Programming and Software Development
COMP90041

Lecture 2

Console IO

NOTE: Some of the Material in these slides are adopted from
* Lectures Notes prepared by Dr. Peter Schachte and
* the Textbook resources

Udaya Parampalli & Thuan Pham
Semester 1 2021, 20-02-2021

- Object Oriented Programming (Class vs Object)
- “Hello World” Java program
- Javac
- Java
- Variables
  - Primitive data types
  - Declaration and Assignment

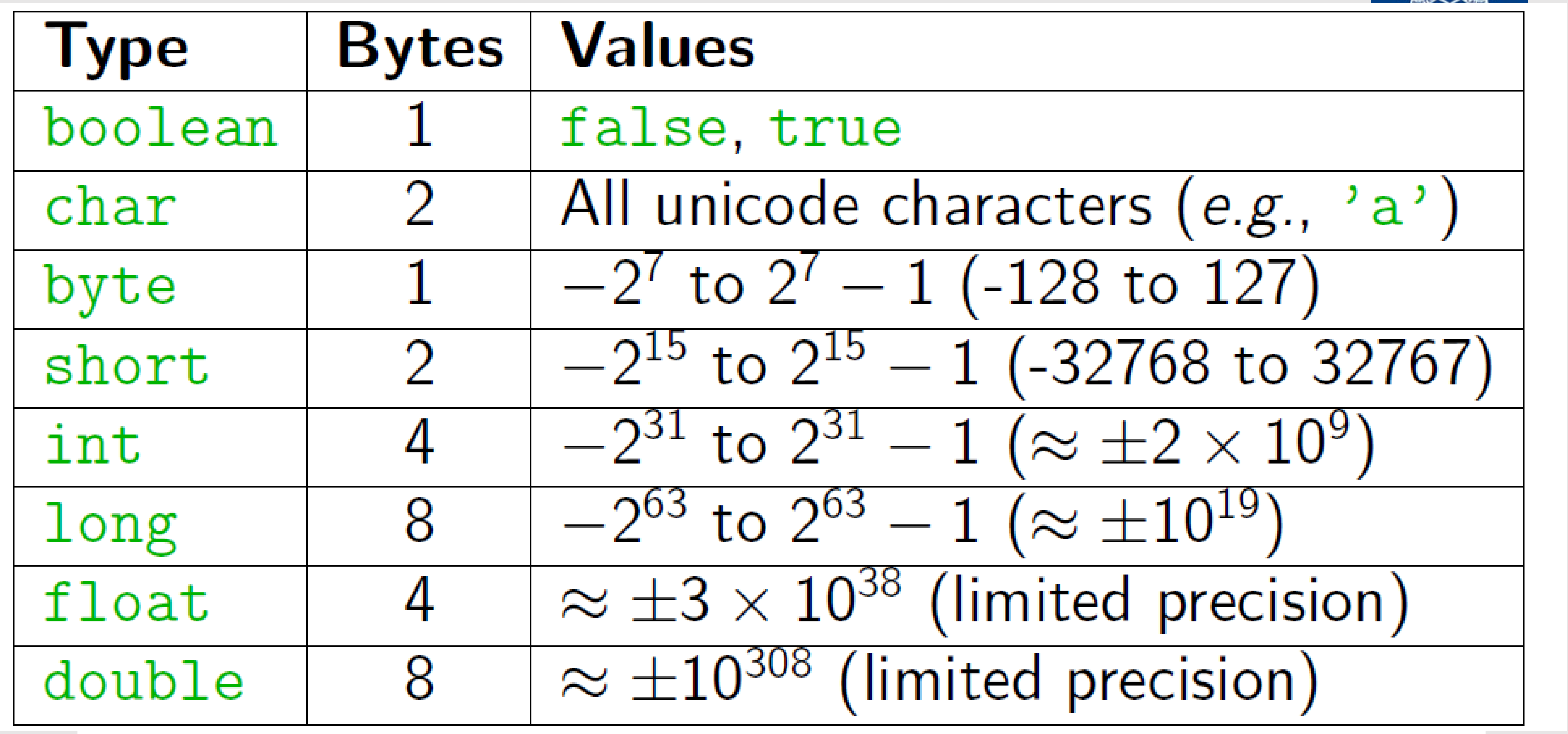
Review

- Operations for primitive data types & type conversions
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

Outline

- Operations for primitive data types & type conversions
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

Outline



Type	Bytes	Values
`boolean`	1	`false`, `true`
`char`	2	All unicode characters (*e.g.*, `'a'`)
`byte`	1	-2^7 to $2^7 - 1$ (-128 to 127)
`short`	2	-2^{15} to $2^{15} - 1$ (-32768 to 32767)
`int`	4	-2^{31} to $2^{31} - 1$ ($\approx \pm 2 \times 10^9$)
`long`	8	-2^{63} to $2^{63} - 1$ ($\approx \pm 10^{19}$)
`float`	4	$\approx \pm 3 \times 10^{38}$ (limited precision)
`double`	8	$\approx \pm 10^{308}$ (limited precision)

Primitive Data Types

- Each type has certain *operations* that apply to it
- Common operations for primitive number types: + - * / (division) % (modulus / remainder)
  - Type of result is same as type of operands
- Use operations to construct **expressions**, which have values that can be assigned or used as operands
  - E.g., answer = (2 + 4) * 7;
  - count = count + 1;

Operations for Number Types

Operations for Number Types (cont)

- Comparison operations also work for number type
  - < : less than
  - <= : less than or equal to
  - > : greater than
  - >= : greater than or equal to
  - == : equal to
  - != : not equal to
- Comparisons return boolean values
  - E.g., 5 != 4 returns true

- **&& (AND)** is true if both operands are true
  - E.g., int x = 5; then (x != 4) && (x > 3) is true
- **|| (OR)** is true if either operand is true
  - E.g., int x = 5; then (x != 4) || (x < 3) is true
- Both are short-circuit operations: they only evaluate the second operand if necessary
  - E.g., int x = 5; then (x != 4) || expr is true no matter what expr is because x != 4 is true
- **! (NOT)** is true if its operand is false
  - E.g., int x = 5; !(x == 4) is true

Operations for booleans

- **++x** is a special expression that increments x (for any variable x) and returns the incremented value
  - E.g., if x is 7, ++x is 8, and after that, x is 8
  - Called "pre-increment" because it increments variables *before* returning
- **--x** (pre-decrement) is similar: it decrements x and returns it
- **x++** (post-increment) returns x and then increments it
  - E.g., if x is 7, x++ is 7, and after that, x is 8
- **x--** (post-decrement) returns x and then decrements it

Pre/Post Increment/Decrement

Pre/Post Increment/Decrement

What will this code print?

```
int x = 10; int y = 5;
System.out.println(x++ - ++y);
```

A. 3
B. 4
C. 5
D. 6
E. 7

Quick Poll

Pre/Post Increment/Decrement

What will this code print?

```
int x = 10; int y = 5;
System.out.println(x++ - ++y);
```

A. 3

[✓ B. 4]

C. 5

D. 6

E. 7

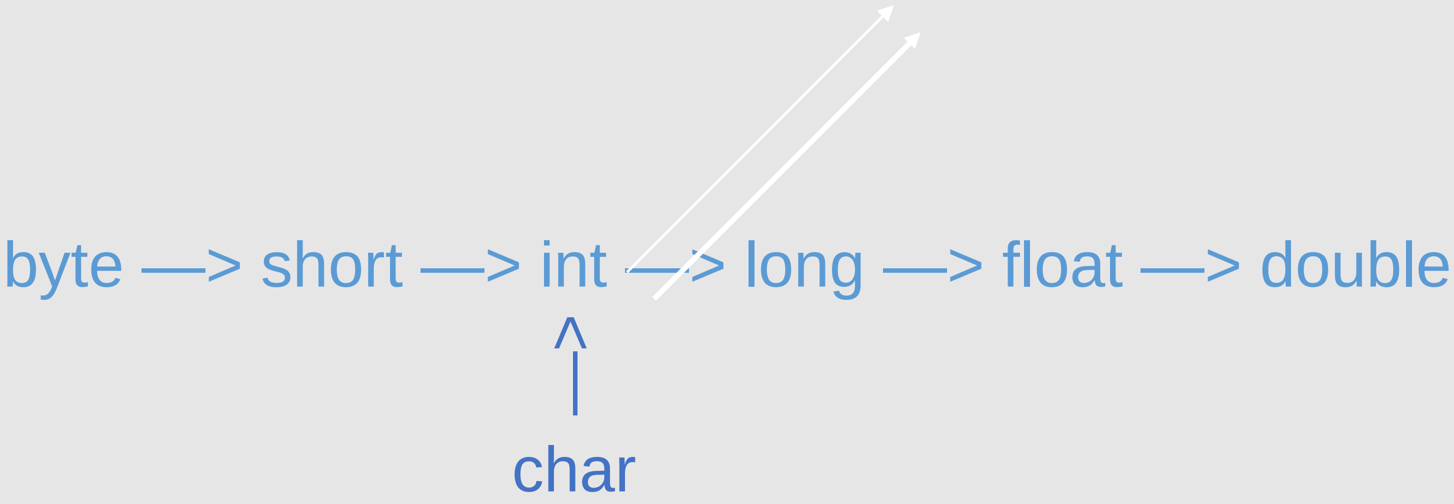
Quick Poll

Pre/Post Increment/Decrement Use

- Pre/post increment/decrement can be confusing (like the last example)
- They can also be used as statements rather than expressions
  - E.g., ++x; or x++;
  - Used as statements, these both just increment x

Type Conversions

- Primitive operations work on operands of the *same* type
- But Java can convert types automatically
- A *widening* conversion converts a number to a wider type (so the value can always be converted successfully)
- Automatic conversions in Java



byte —> short —> int —> long —> float —> double

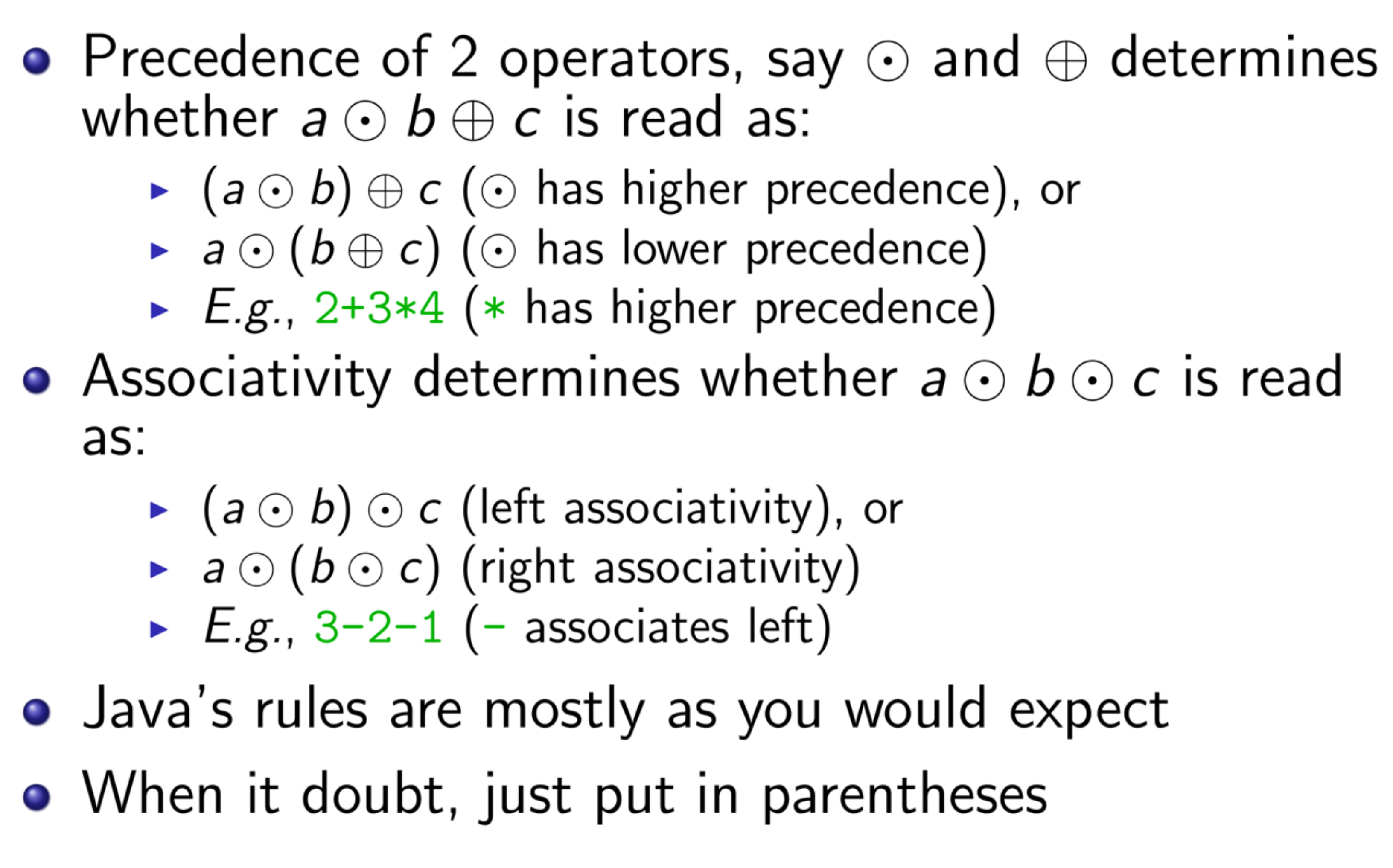
^
|
char

- *Narrowing* conversions are also possible. But they must be performed explicitly using a ***cast***
- Cast is specified by writing the name of the type to convert to in parentheses before the value to be converted
  - E.g., short x; int y = 50; x = (short) y;
- Cast can also be used to explicitly ask for a widening conversion

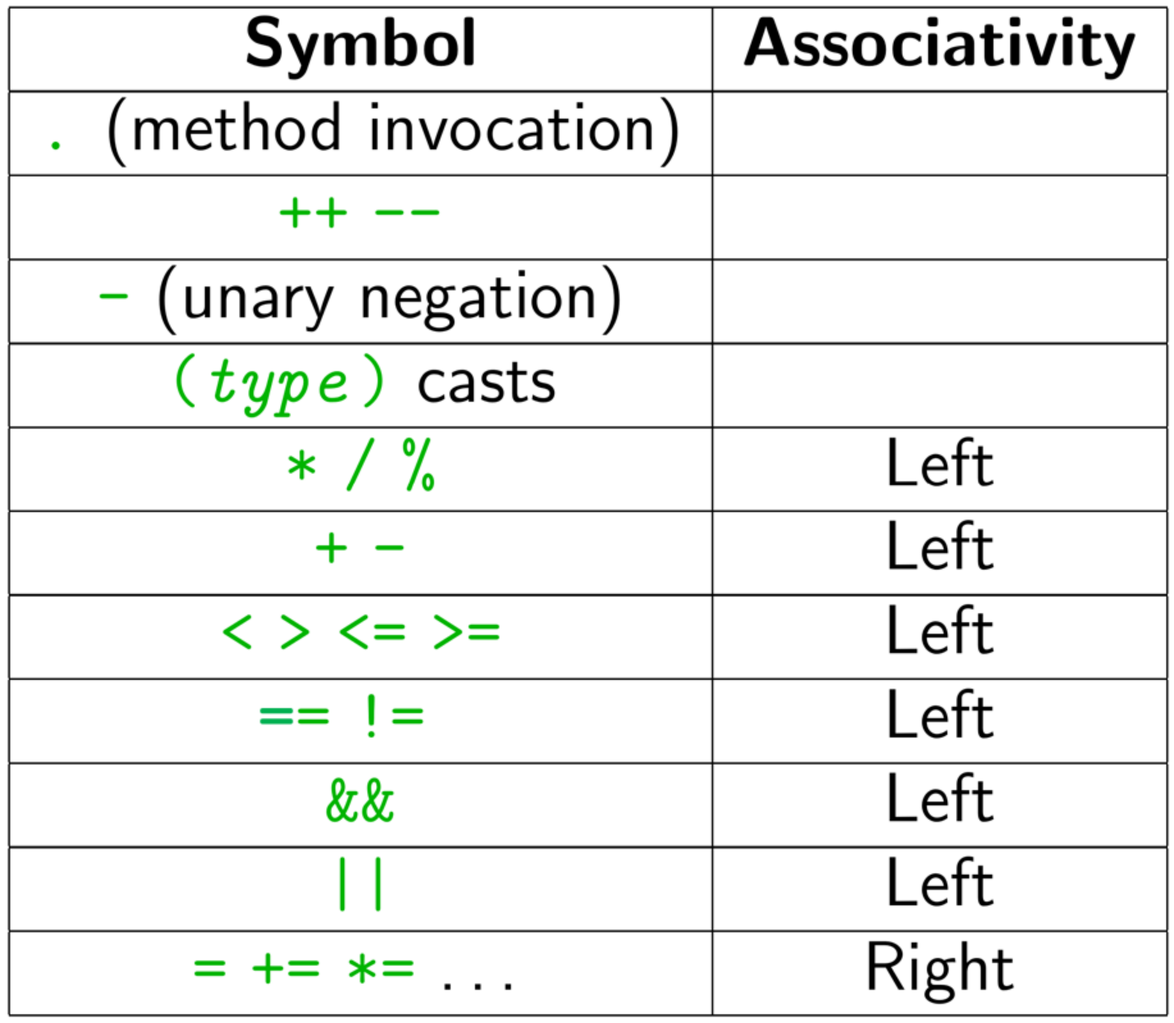
```
int sum;
int count;
//compute sum and count …
double average = (double) sum / count;
```

Casting

Precedence and Associativity



- Precedence of 2 operators, say $\odot$ and $\oplus$ determines whether $a \odot b \oplus c$ is read as:
  - $(a \odot b) \oplus c$ ($\odot$ has higher precedence), or
  - $a \odot (b \oplus c)$ ($\odot$ has lower precedence)
  - *E.g.*, 2+3∗4 (∗ has higher precedence)
- Associativity determines whether $a \odot b \odot c$ is read as:
  - $(a \odot b) \odot c$ (left associativity), or
  - $a \odot (b \odot c)$ (right associativity)
  - *E.g.*, 3−2−1 (− associates left)
- Java's rules are mostly as you would expect
- When it doubt, just put in parentheses



Symbol	Associativity
. (method invocation)	
++ --	
- (unary negation)	
(*type*) casts	
* / %	Left
+ -	Left
< > <= >=	Left
== !=	Left
&&	Left
||	Left
= += *= ...	Right

Operators, High to Low Precedence

- After running the following piece of code, what will be the value of x, y, and z?

```
int x = 10, y = 5;
int z;
z = --x - y * 5 + x * (y++ - 4);
```

A. x = 10, y = 5, z = 5
B. x = 9, y = 5, z = -7
C. x = 9, y = 5, z = 5
D. x = 9, y = 6, z = -7

Quick Poll

- After running the following piece of code, what will be the value of x, y, and z?

```
int x = 10, y = 5;
int z;
z = --x - y * 5 + x * (y++ - 4);
```

A. x = 10, y = 5, z = 5

B. x = 9, y = 5, z = -7

C. x = 9, y = 5, z = 5

[✓ D. x = 9, y = 6, z = -7]

Quick Poll

- Operations for primitive data types & type conversions
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

Outline

- **String** is a class type, not a *primitive* type, so strings are *objects*
- Specify a string constant by enclosing in double-quotes ("")
  - E.g., String s = "Hello, World!";

- Use backslash (\) to include double-quote and other special characters (e.g., % and \) in a string
  - E.g., println("He said \"backslash (\\) is special!\"")
  - Prints "He said "backslash (\) is special!""
- Certain letters after backslash are treated specially
  - Eg., \n - new line, \t - tab character

Strings

- You can use + to append two strings
  - E.g., System.out.println(“Hello ” + “World”);
  - Prints “Hello World”
- If either operand is string, + operation will turn the other into a string
  - E.g., System.out.println(“a = ” + a);
  - If a is 1, this prints “a = 1”
- Beware:
  - System.out.println(“a + a = ” + a + a);
  - Actually prints “1 + 1 = 11”, not “1 + 1 = 2”

String Operations

- String class has many more operations, e.g.:
- Assume String s, s2; int i, j;
  - s.length() returns length of the string
  - s.toUpperCase() returns ALL UPPER CASE version of the string
  - s.substring(i, j) returns the substring of s from character I through j-1, counting the first char at 0
  - s.equals(s2) returns true if s and s2 are identical
  - s.indexOf(s2) returns the first position of s2 in s
- Don’t use ==, <, >= etc. to compare strings
- See String class in documentation for more operations
  - Java API 8: https://docs.oracle.com/javase/8/docs/api/

More String Operations

- Operations for primitive data types & type conversions
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

Outline

Formatted Output

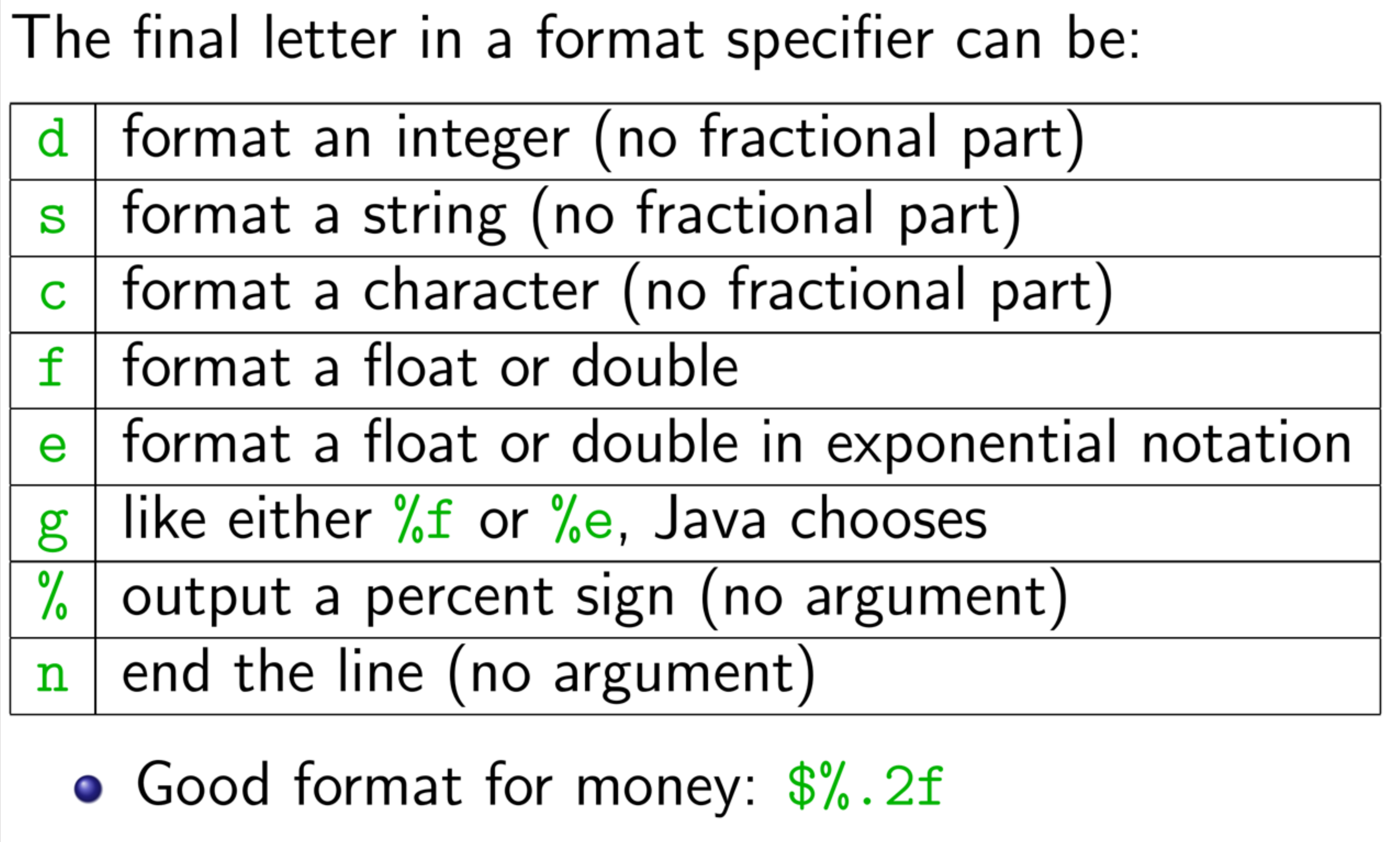
- **printf** is like **print**, but it lets you control how data is formatted
- Method form:
  - System.out.printf(format-string, args ...);
- Example:
  - System.out.printf("Average: %5.2f", average);
- *Format-string* is an ordinary string, but can contain *format specifiers*, one for each of the arguments (args)
  - A format specifier begins with **%**
  - It may have a number specifying how to format the next value in the args list
  - It ends with a letter specifying the type of the value
- Ordinary text in format-string is printed as is

%X.Y

- The (optional) number(s) following % is/are interpreted:
  - **X** (before decimal point) specifies the *minimum* number of characters to be printed
    - The ***full*** number will be printed, even if it takes more characters than X
    - If X is omitted, the value will be printed in its minimum width
    - If X is negative, the value will be left-justified, otherwise right-justified
  - **Y** (after decimal point) specifies the number of digits of the value to print after the decimal point
    - If Y is omitted, Java decides how to format

Format specifiers

Format Letters

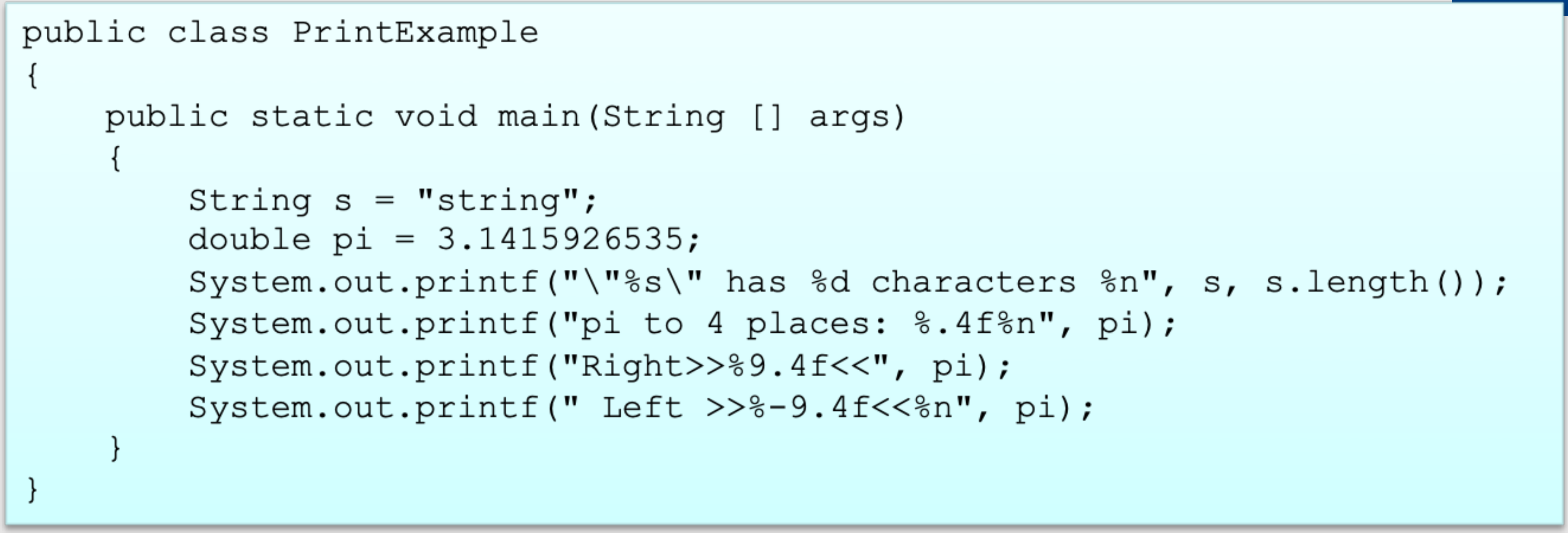


The final letter in a format specifier can be:

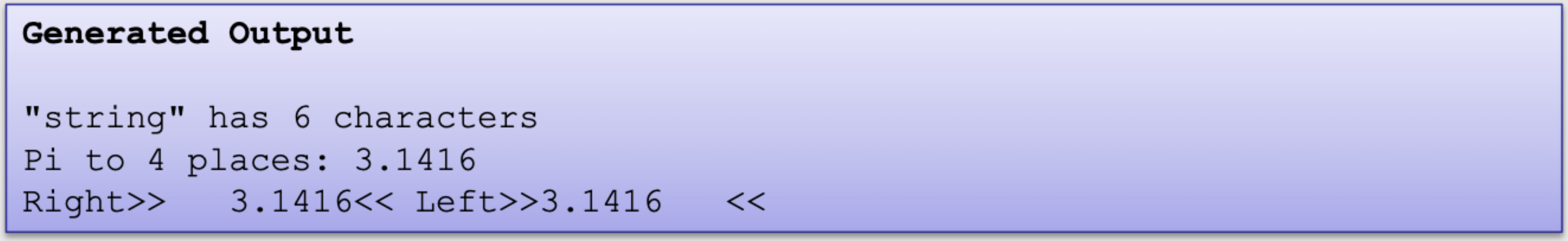
d	format an integer (no fractional part)
s	format a string (no fractional part)
c	format a character (no fractional part)
f	format a float or double
e	format a float or double in exponential notation
g	like either %f or %e, Java chooses
%	output a percent sign (no argument)
n	end the line (no argument)

- Good format for money: $%.2f

Formatted Output Example

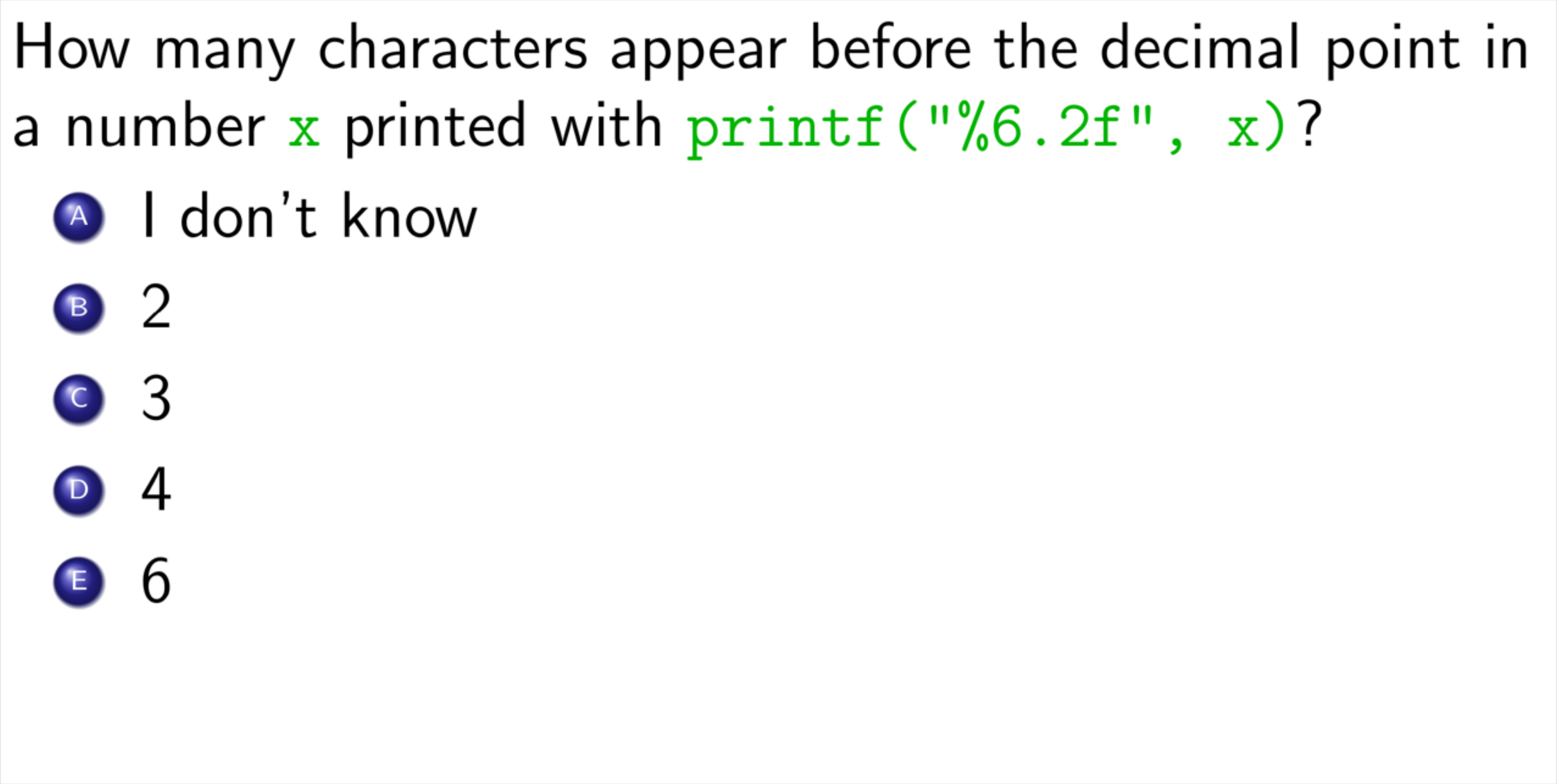


```
public class PrintExample
{
    public static void main(String [] args)
    {
        String s = "string";
        double pi = 3.1415926535;
        System.out.printf("\"%s\" has %d characters %n", s, s.length());
        System.out.printf("pi to 4 places: %.4f%n", pi);
        System.out.printf("Right>>%9.4f<<", pi);
        System.out.printf(" Left >>%-9.4f<<%n", pi);
    }
}
```



Generated Output

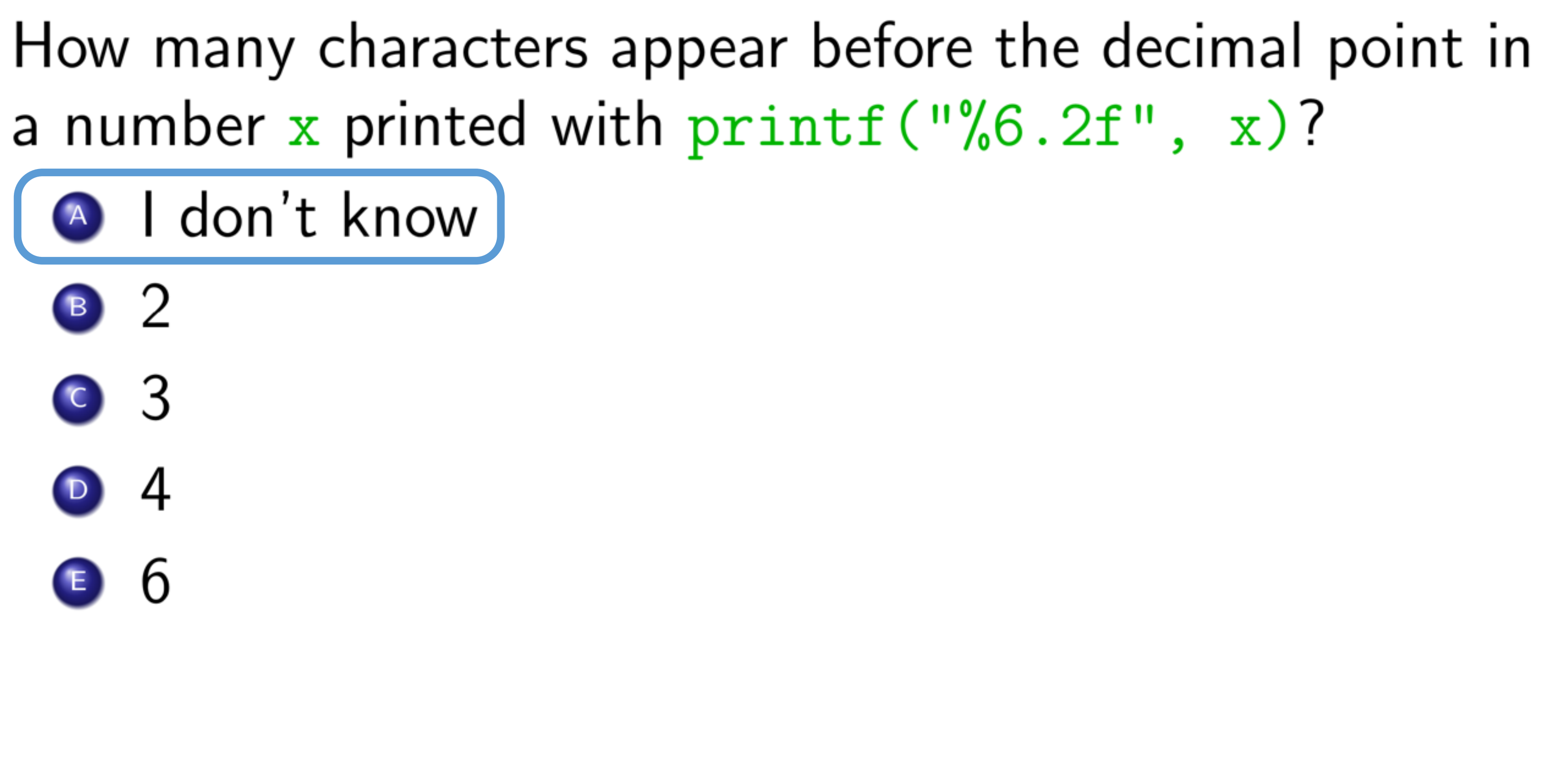
```
"string" has 6 characters
Pi to 4 places: 3.1416
Right>>   3.1416<< Left>>3.1416   <<
```



How many characters appear before the decimal point in a number `x` printed with `printf("%6.2f", x)`?

- A. I don't know
- B. 2
- C. 3
- D. 4
- E. 6

Quick Poll



How many characters appear before the decimal point in a number `x` printed with `printf("%6.2f", x)`?

[✓ A I don't know]

B 2

C 3

D 4

E 6

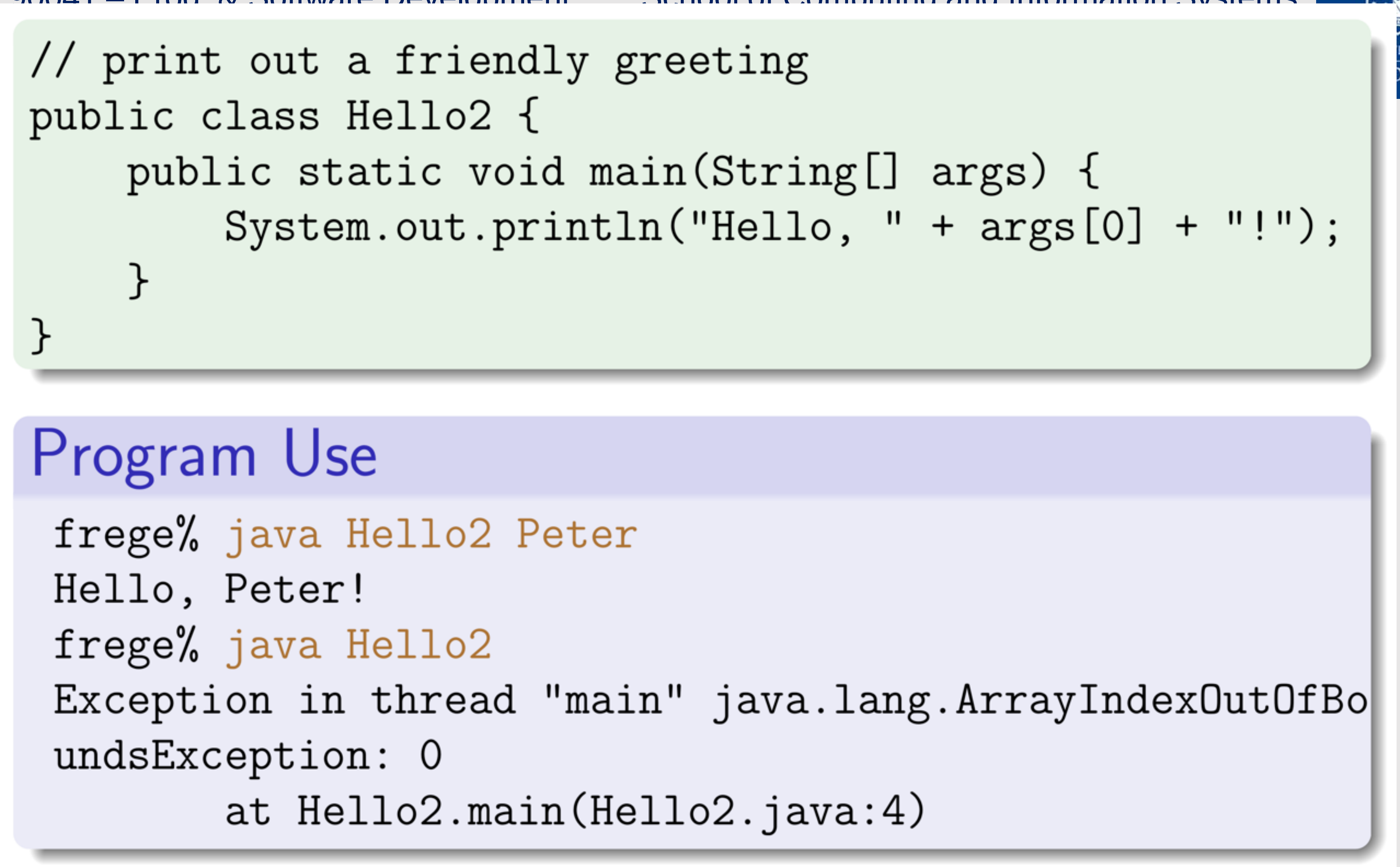
Quick Poll

- Operations for primitive data types & type conversions
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

Outline

- When your program is run, it can be given arguments on the command line
  - E.g., javac Hello.java ("Hello.java" is an argument for javac)
- Allows the user to give information to the program
- For the boilerplate we've been using, the command line arguments can be referred to as
  - First argument: args[0]
  - Second argument: args[1], etc..
- Each of these arguments is a string

Handling Command Line Inputs



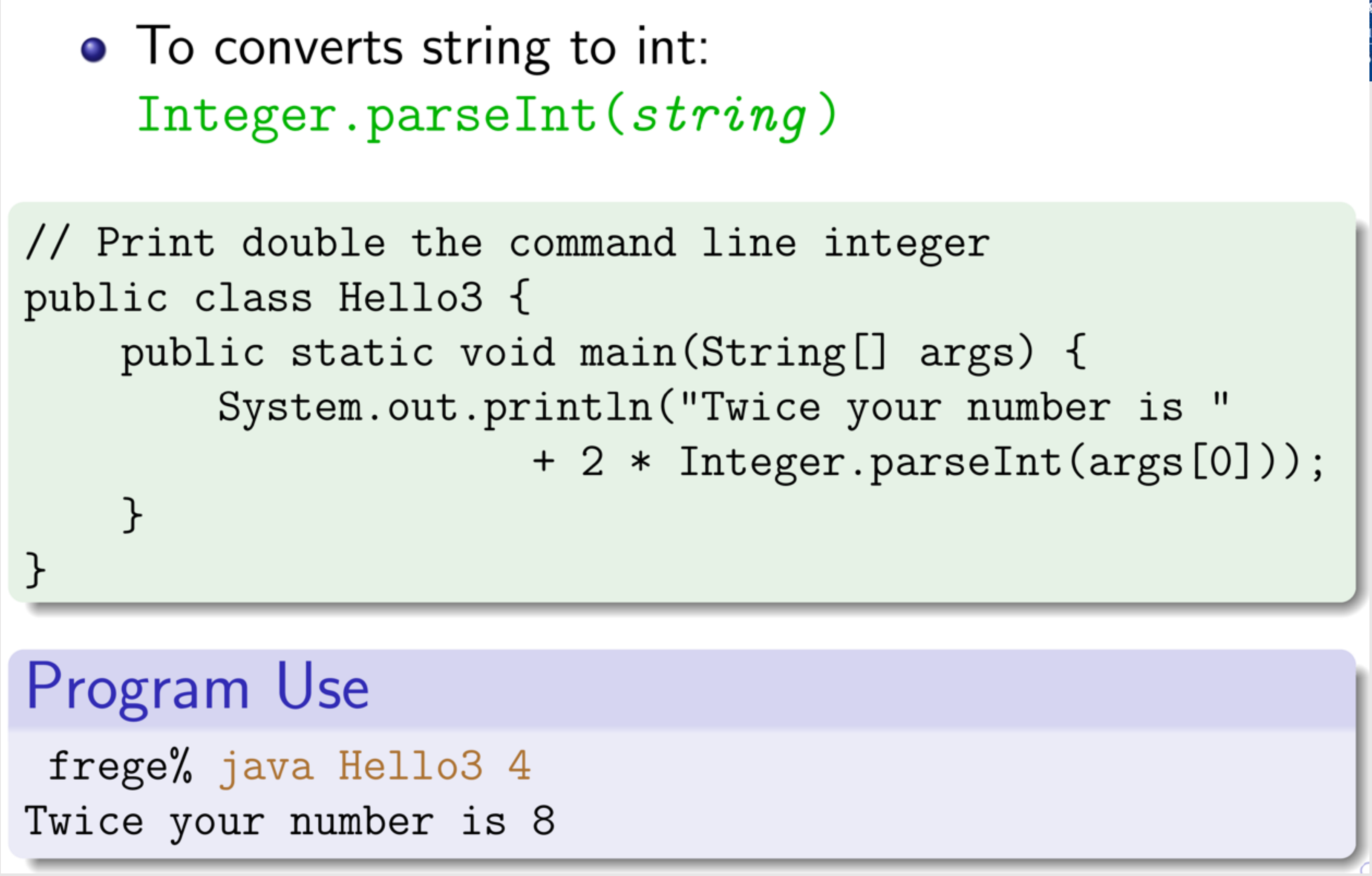
```
// print out a friendly greeting
public class Hello2 {
    public static void main(String[] args) {
        System.out.println("Hello, " + args[0] + "!");
    }
}
```

Program Use

```
frege% java Hello2 Peter
Hello, Peter!
frege% java Hello2
Exception in thread "main" java.lang.ArrayIndexOutOfBo
undsException: 0
       at Hello2.main(Hello2.java:4)
```

Command Line Input Example

Handling Command Line Inputs



- To converts string to int:
  `Integer.parseInt(`*string*`)`

```
// Print double the command line integer
public class Hello3 {
    public static void main(String[] args) {
        System.out.println("Twice your number is "
                        + 2 * Integer.parseInt(args[0]));
    }
}
```

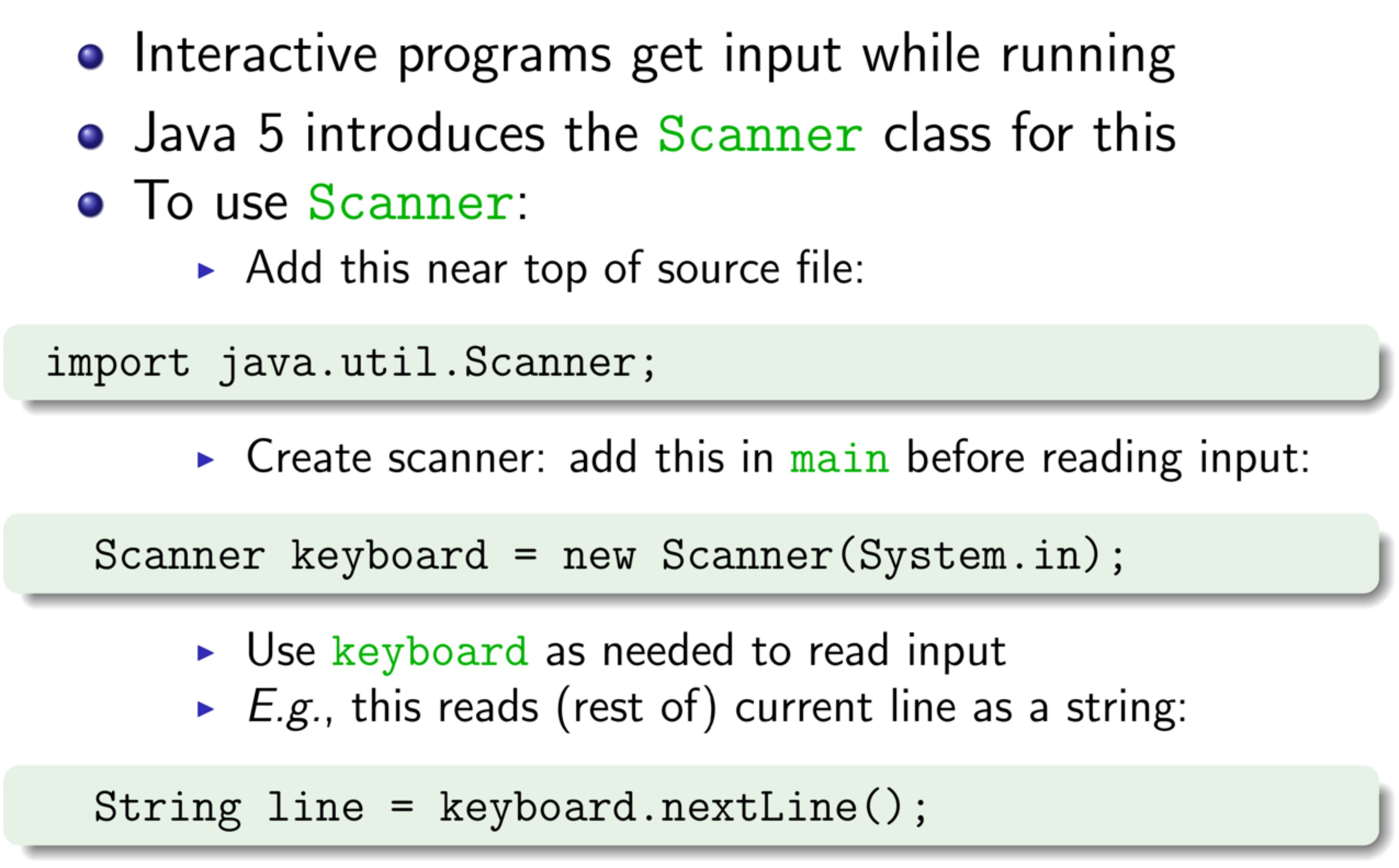
Program Use

```
 frege% java Hello3 4
Twice your number is 8
```

- Operations for primitive data types & type conversions
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

Outline

Reading Console Input



- Interactive programs get input while running
- Java 5 introduces the Scanner class for this
- To use Scanner:
  - Add this near top of source file:

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

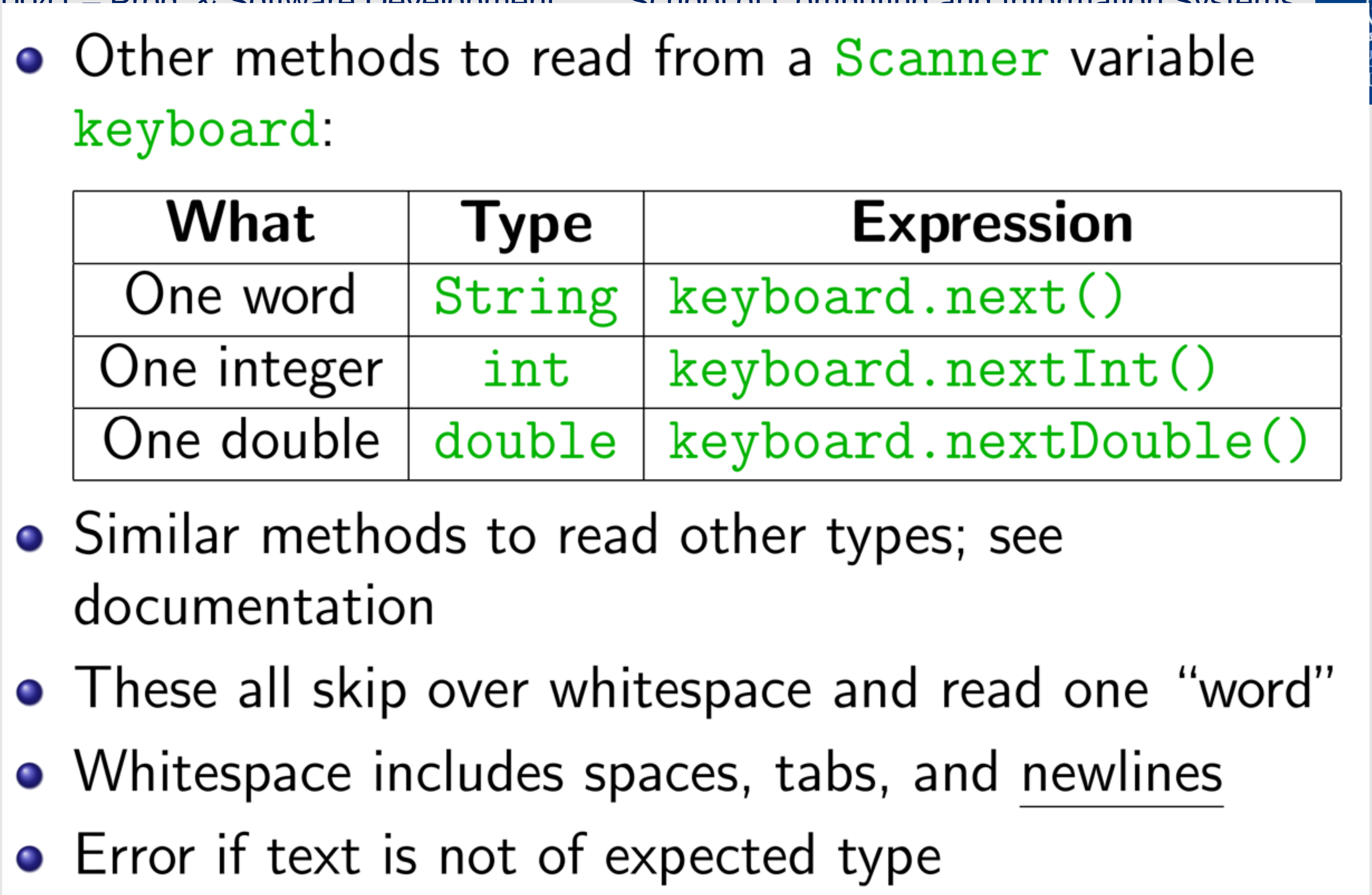
  - Create scanner: add this in main before reading input:

```
  Scanner keyboard = new Scanner(System.in);
```

  - Use keyboard as needed to read input
  - *E.g.*, this reads (rest of) current line as a string:

```
  String line = keyboard.nextLine();
```

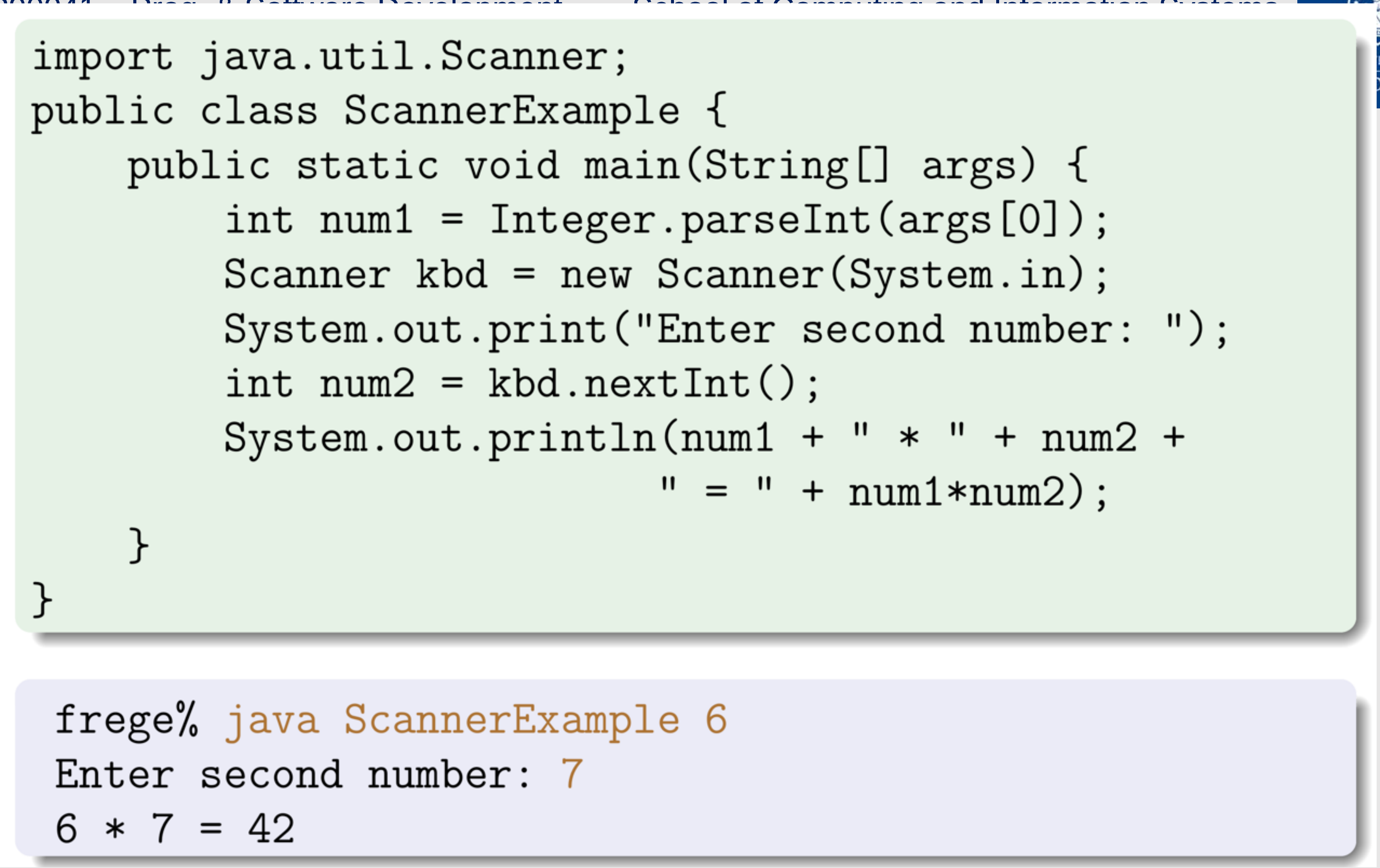
Reading Console Input



- Other methods to read from a `Scanner` variable `keyboard`:

What	Type	Expression
One word	`String`	`keyboard.next()`
One integer	`int`	`keyboard.nextInt()`
One double	`double`	`keyboard.nextDouble()`

- Similar methods to read other types; see documentation
- These all skip over whitespace and read one “word”
- Whitespace includes spaces, tabs, and <u>newlines</u>
- Error if text is not of expected type

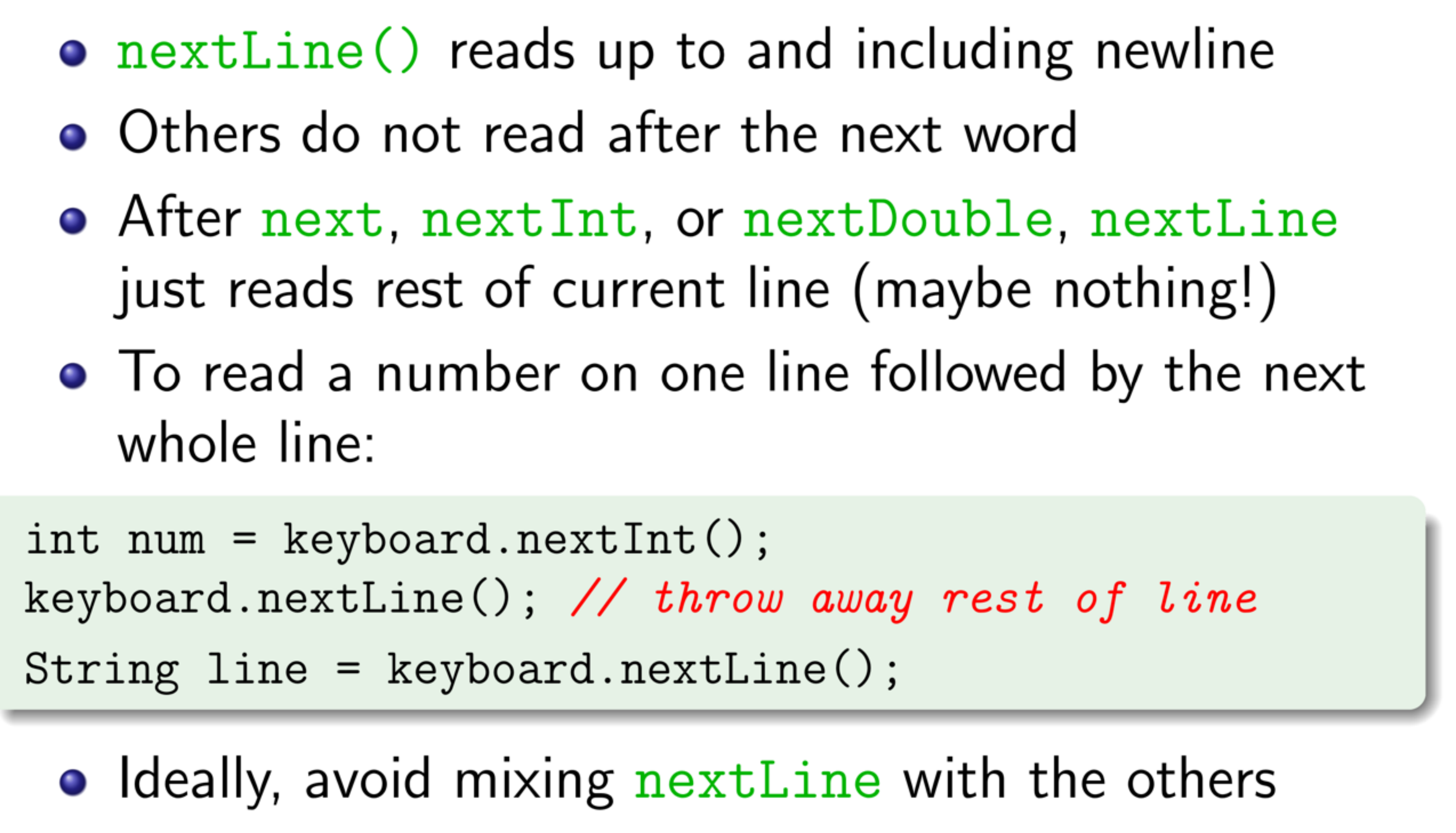


```java
import java.util.Scanner;
public class ScannerExample {
    public static void main(String[] args) {
        int num1 = Integer.parseInt(args[0]);
        Scanner kbd = new Scanner(System.in);
        System.out.print("Enter second number: ");
        int num2 = kbd.nextInt();
        System.out.println(num1 + " * " + num2 +
                           " = " + num1*num2);
    }
}
```

```
frege% java ScannerExample 6
Enter second number: 7
6 * 7 = 42
```

Command Line and Scanner Example

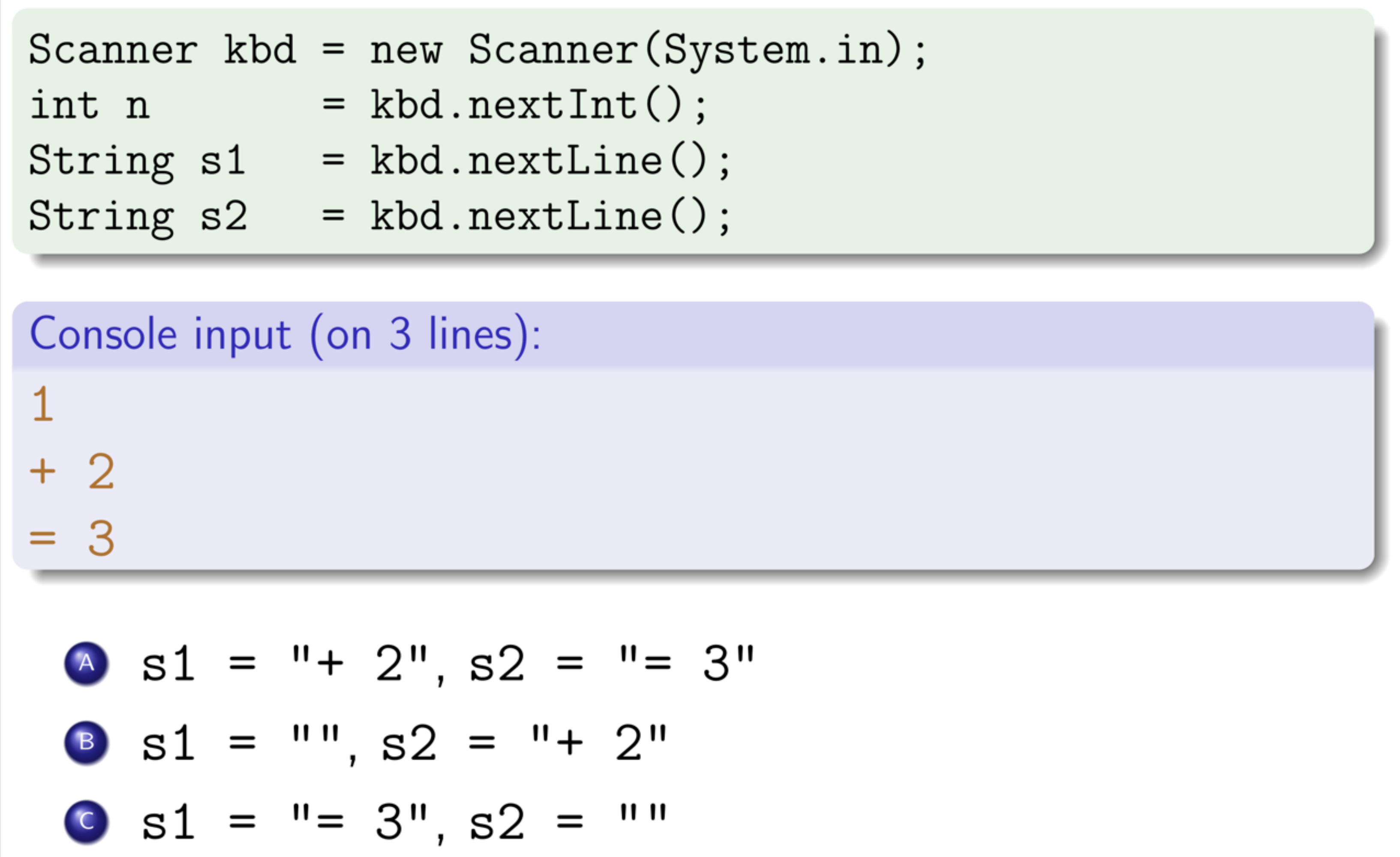
Pitfall: Mixing with nextLine



- `nextLine()` reads up to and including newline
- Others do not read after the next word
- After `next`, `nextInt`, or `nextDouble`, `nextLine` just reads rest of current line (maybe nothing!)
- To read a number on one line followed by the next whole line:

```
int num = keyboard.nextInt();
keyboard.nextLine(); // throw away rest of line
String line = keyboard.nextLine();
```

- Ideally, avoid mixing `nextLine` with the others



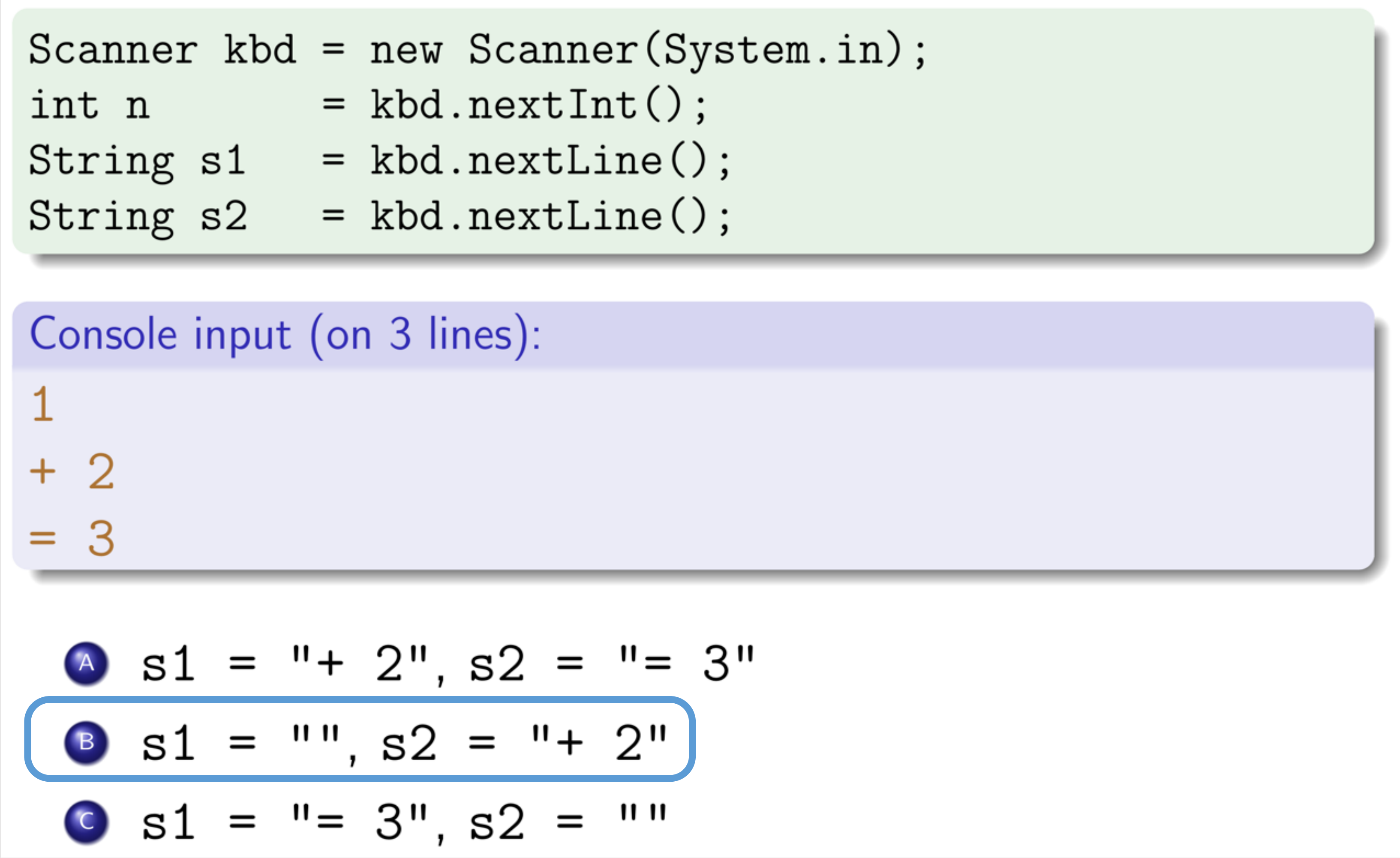
```
Scanner kbd = new Scanner(System.in);
int n       = kbd.nextInt();
String s1   = kbd.nextLine();
String s2   = kbd.nextLine();
```

Console input (on 3 lines):

```
1
+ 2
= 3
```

- A: s1 = "+ 2", s2 = "= 3"
- B: s1 = "", s2 = "+ 2"
- C: s1 = "= 3", s2 = ""

Quick Poll: What are s1 and s2 after



```
Scanner kbd = new Scanner(System.in);
int n       = kbd.nextInt();
String s1   = kbd.nextLine();
String s2   = kbd.nextLine();
```

Console input (on 3 lines):

```
1
+ 2
= 3
```

A s1 = "+ 2", s2 = "= 3"

[✓ B s1 = "", s2 = "+ 2"]

C s1 = "= 3", s2 = ""

Quick Poll: What are s1 and s2 after

- Operations for primitive data types & type conversions
  - How to use different operators
  - How to identify/specify the precedence of the operators in an expression/a statement
  - How to convert between data types
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

Summary