Programming 1

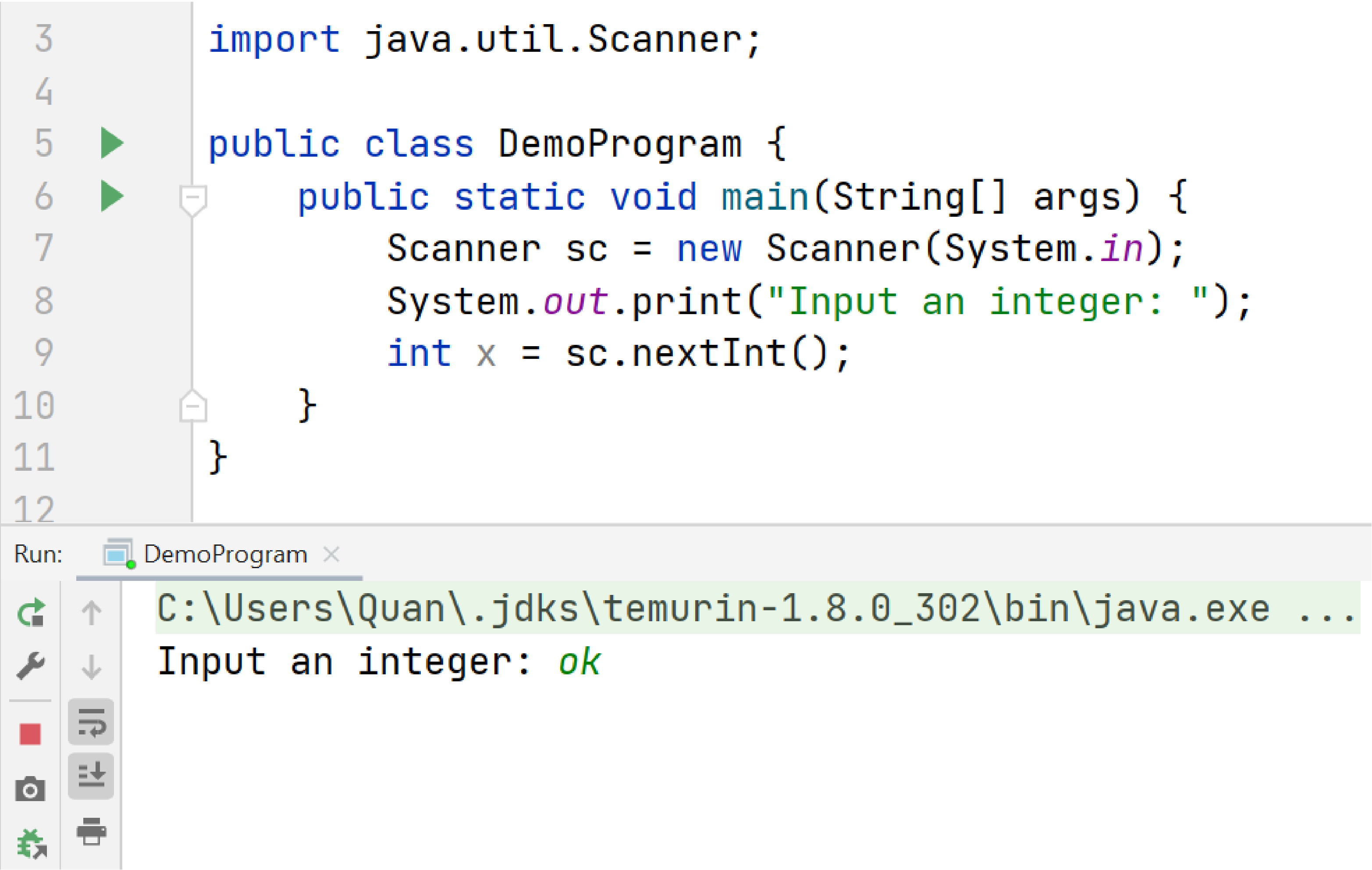
Lecture 7 – Exception, Recursion, Overloading, Scopes

Faculty of Information Technology
Hanoi University

Up next…

Exception handling

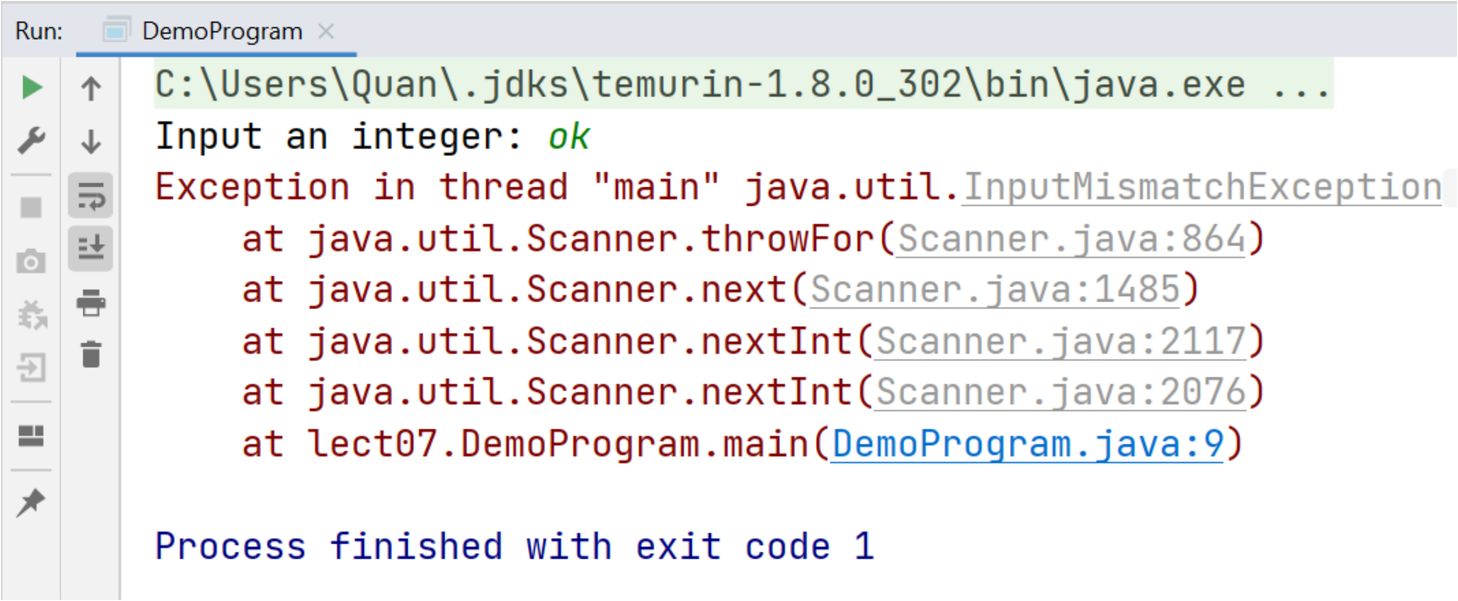
Guess what would happen?



```java
import java.util.Scanner;

public class DemoProgram {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        System.out.print("Input an integer: ");
        int x = sc.nextInt();
    }
}
```

```
C:\Users\Quan\.jdks\temurin-1.8.0_302\bin\java.exe ...
Input an integer: ok
```

Errors



```
C:\Users\Quan\.jdks\temurin-1.8.0_302\bin\java.exe ...
Input an integer: ok
Exception in thread "main" java.util.InputMismatchException
	at java.util.Scanner.throwFor(Scanner.java:864)
	at java.util.Scanner.next(Scanner.java:1485)
	at java.util.Scanner.nextInt(Scanner.java:2117)
	at java.util.Scanner.nextInt(Scanner.java:2076)
	at lect07.DemoProgram.main(DemoProgram.java:9)

Process finished with exit code 1
```

- A computer program gives an error when it cannot continue execution
- **Causes:** bad logic in code, wrong input, something not found, and other unforeseeable things.

Errors

- How to deal with errors?
  - – Terminate program
  - – Try an alternative solution
- Which is better?
  - A. Program terminates immediately when error happens.
  - B. Program keeps running when error happens. Only the affected task is unable to finish.

Error handling in older languages

- For non-critical errors: display a message and continue execution.
  - e.g. warnings, notices…
- For critical (fatal) errors: display a message and terminate program.
  - e.g. array out of bound, division by zero…
- No option to resume program after fatal error.

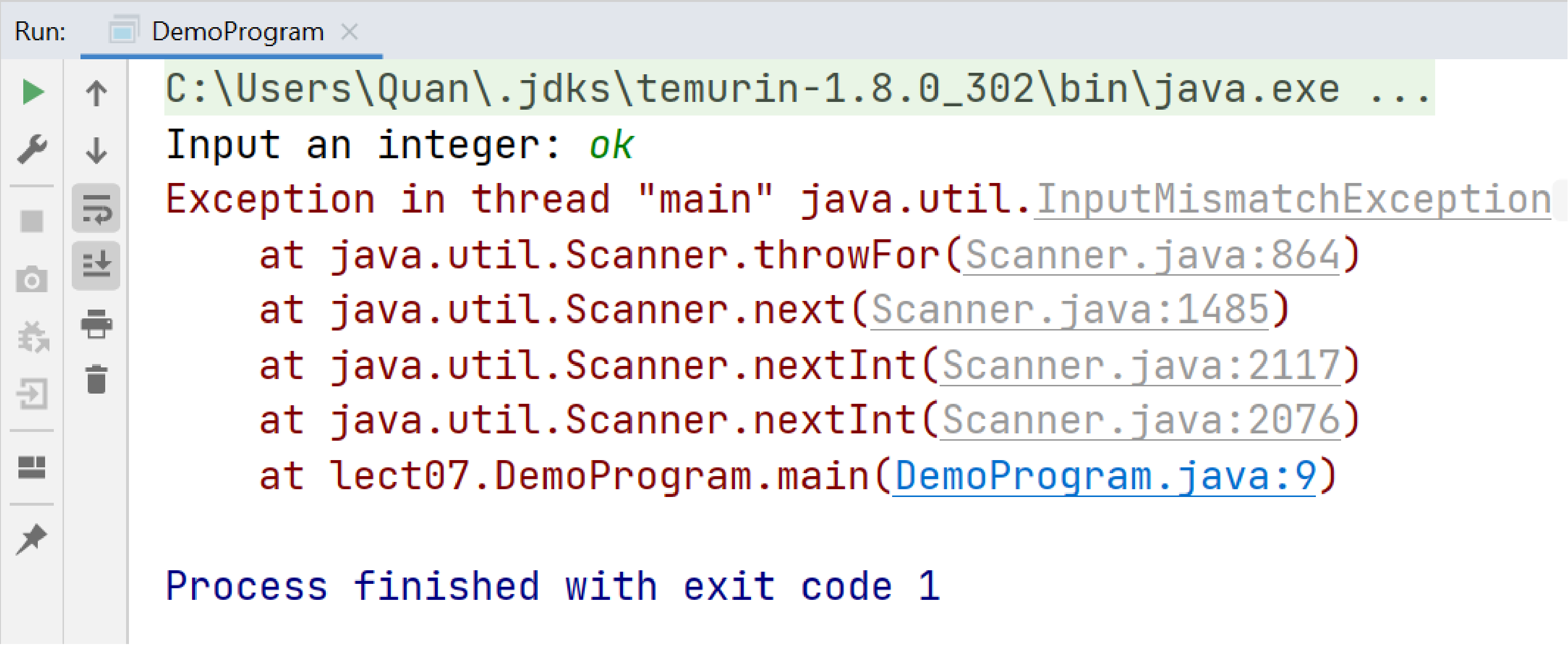
Errors in Java

- An error in Java is called an **Exception**
- Exception handling provides a flexible mechanism for reporting and dealing with errors.
  - It’s possible to analyze error information programmatically
  - It’s possible to resume program after an error
  - It’s possible to produce errors in your code and invent new types of errors

Error handling process in Java

- In case of an unexpected situation, throw a suitable Exception.
  - e.g. invalid data, unable to read file, lost connection…
- Detect `Exception` with **`try…catch`**.
- Write code to deal with the Exception.
  - a.k.a. perform alternative actions.
- Program should never terminate unexpectedly!

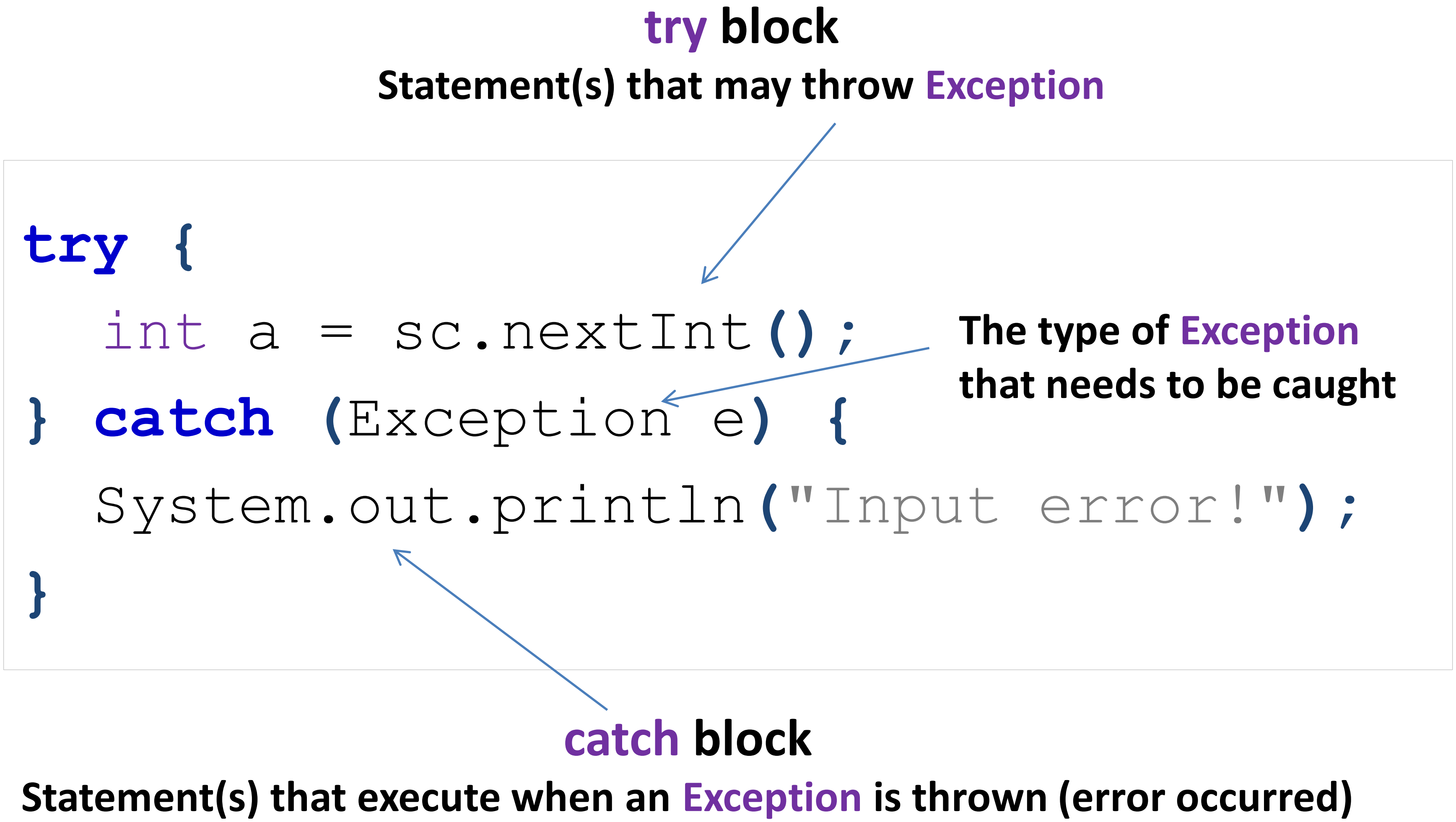
Dealing with Exception



```
C:\Users\Quan\.jdks\temurin-1.8.0_302\bin\java.exe ...
Input an integer: ok
Exception in thread "main" java.util.InputMismatchException
	at java.util.Scanner.throwFor(Scanner.java:864)
	at java.util.Scanner.next(Scanner.java:1485)
	at java.util.Scanner.nextInt(Scanner.java:2117)
	at java.util.Scanner.nextInt(Scanner.java:2076)
	at lect07.DemoProgram.main(DemoProgram.java:9)

Process finished with exit code 1
```

How do I catch an Exception?

try-catch syntax



try block

Statement(s) that may throw Exception

```
try {
   int a = sc.nextInt();
} catch (Exception e) {
  System.out.println("Input error!");
}
```

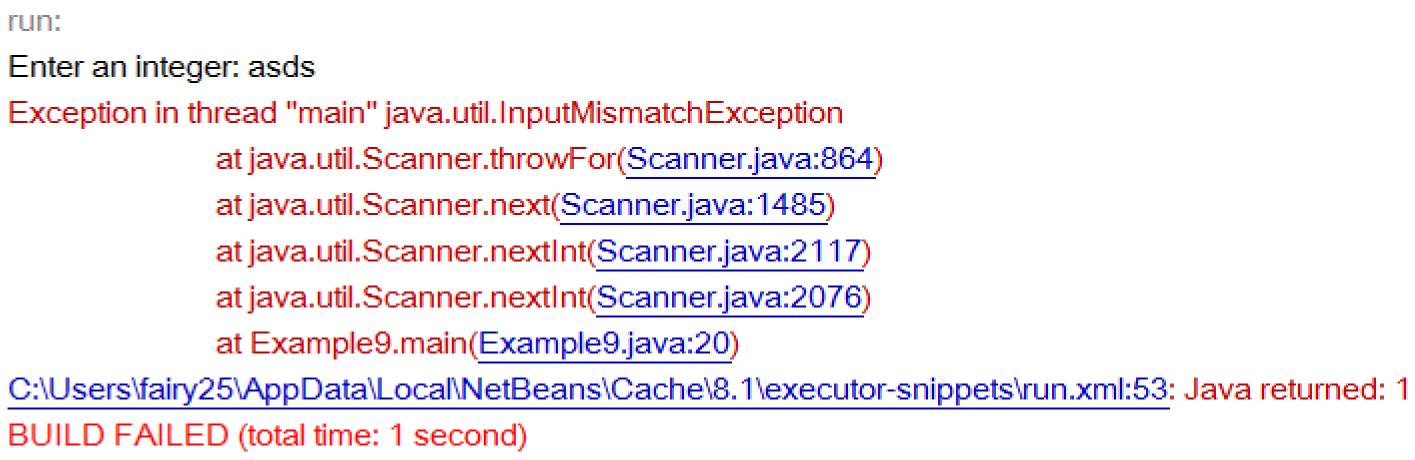
The type of Exception that needs to be caught

catch block

Statement(s) that execute when an Exception is thrown (error occurred)

Exception w/out try…catch

```java
int n;
System.out.print("Enter an integer: ");
n = sc.nextInt();
```

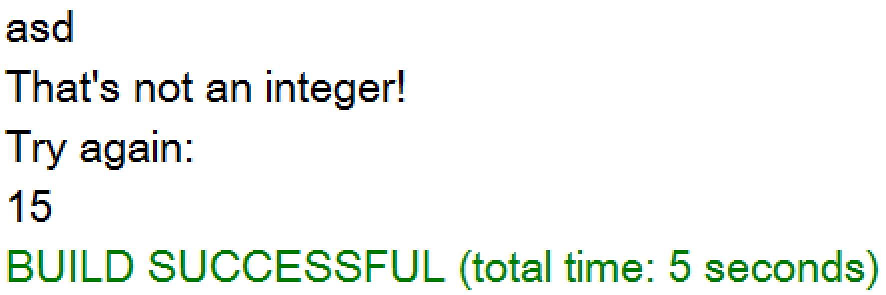


```
run:
Enter an integer: asds
Exception in thread "main" java.util.InputMismatchException
	at java.util.Scanner.throwFor(Scanner.java:864)
	at java.util.Scanner.next(Scanner.java:1485)
	at java.util.Scanner.nextInt(Scanner.java:2117)
	at java.util.Scanner.nextInt(Scanner.java:2076)
	at Example9.main(Example9.java:20)
C:\Users\fairy25\AppData\Local\NetBeans\Cache\8.1\executor-snippets\run.xml:53: Java returned: 1
BUILD FAILED (total time: 1 second)
```

try-catch example

```
try {
    int a = sc.nextInt();
} catch (InputMismatchException e) {
    System.out.println("That's not an integer!");
    System.out.println("Try again: ");
    sc.nextLine(); // clear newline char
    int a = sc.nextInt();
}
```

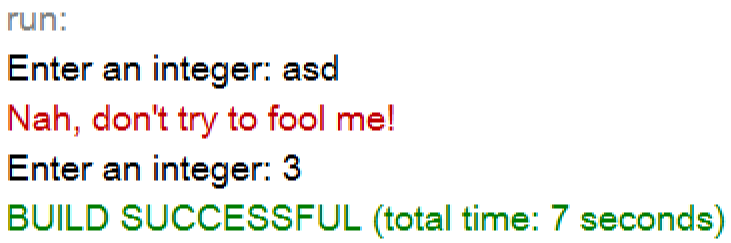
Output:



```
asd
That's not an integer!
Try again:
15
BUILD SUCCESSFUL (total time: 5 seconds)
```

Exception with try…catch

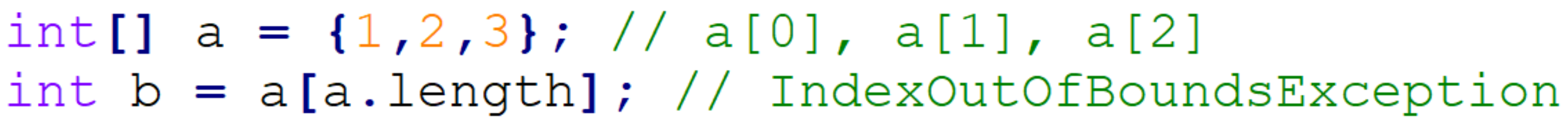
```java
int n;
boolean gotIt = false;
while (!gotIt) {
    try {
        System.out.print("Enter an integer: ");
        n = sc.nextInt();
        gotIt = true;
    } catch (Exception e) {
        System.err.print("Nah, don't try to fool me!");
        sc.nextLine(); // try commenting out this line
    }
}
```



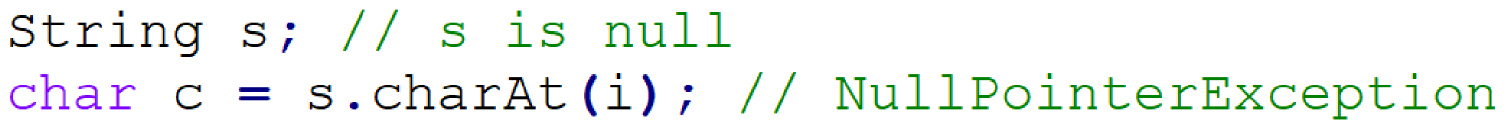
```
run:
Enter an integer: asd
Nah, don't try to fool me!
Enter an integer: 3
BUILD SUCCESSFUL (total time: 7 seconds)
```

More about Java Exceptions

- An event that occurs when something *unexpected* happens



```
int[] a = {1,2,3}; // a[0], a[1], a[2]
int b = a[a.length]; // IndexOutOfBoundsException
```



```
String s; // s is null
char c = s.charAt(i); // NullPointerException
```

Why use an Exception?

- To tell the code using your method that something went wrong

How do exceptions “happen”?

- Java doesn’t know what to do, so it
  - Creates an Exception object
  - Includes some useful information
  - “throws” the Exception

Using Exception

- Exception is a special data type (just like String) which represents errors in Java (and many other languages).

```
Exception e = new Exception("404 Not Found!");
System.out.println(e.getMessage());
throw e; // intentionally raise an error
```

- However, Exception is meant to be “thrown”.

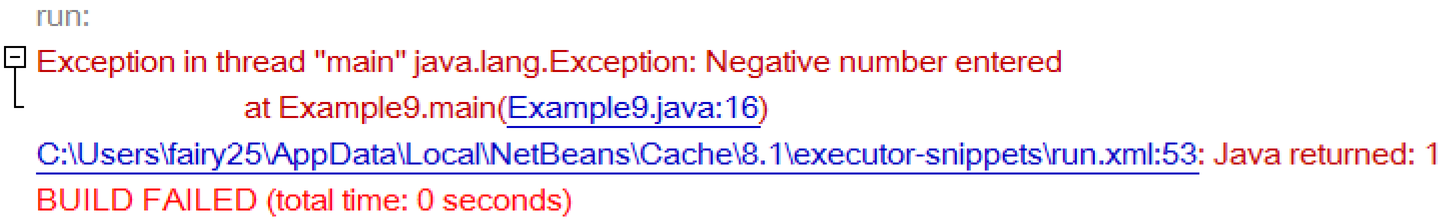
Using Exception

- It is used to indicate errors.
- It is used when there's some problem. E.g.
  - Data error
  - Inappropriate action from user
  - Something is not found or missing (data, library)
- Exceptions are meant to be handled, so that a program can response to problematic situations.
  - a.k.a. Even when some data is missing, the app keeps running smoothly (with some "Plan B" when an Exception is caught).

```
int n = sc.nextInt();
if (n < 0) {
    throw new Exception("Negative number entered");
}
```

Using `Exception`

- It is `Throwable` (we can `thow` it)
- An uncaught Exception stops the program.
  - a.k.a. A caught one does not.



```
run:
Exception in thread "main" java.lang.Exception: Negative number entered
                    at Example9.main(Example9.java:16)
C:\Users\fairy25\AppData\Local\NetBeans\Cache\8.1\executor-snippets\run.xml:53: Java returned: 1
BUILD FAILED (total time: 0 seconds)
```

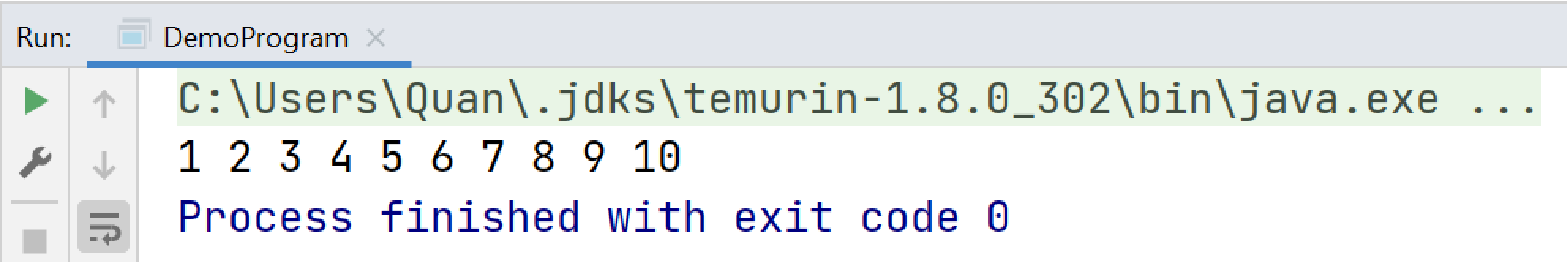
Up next…

Recursion

Calling a method recursively

- **Recursion:** calling a method from inside itself.
- Example: for loop using recursion

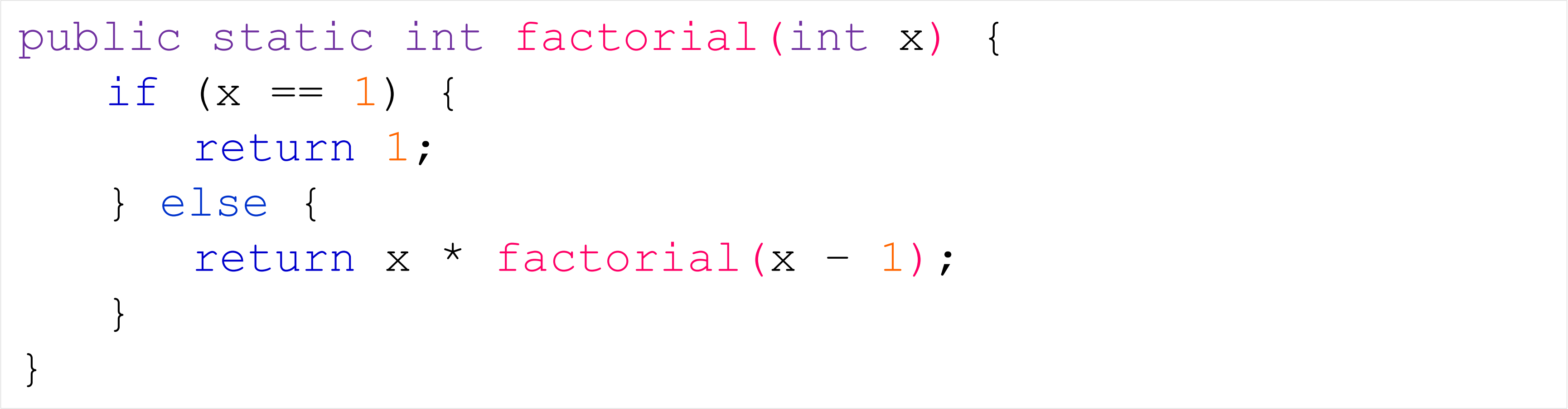
```java
public static void repeat(int start, int stop) {
    System.out.print(start + " ");
    if (start < stop) repeat(start + 1, stop);
}

public static void main(String[] args) {
    repeat(1, 10);
}
```



```
C:\Users\Quan\.jdks\temurin-1.8.0_302\bin\java.exe ...
1 2 3 4 5 6 7 8 9 10
Process finished with exit code 0
```

Calling a method recursively

- Recursion example: calculating ***x!***



```
public static int factorial(int x) {
    if (x == 1) {
        return 1;
    } else {
        return x * factorial(x - 1);
    }
}
```

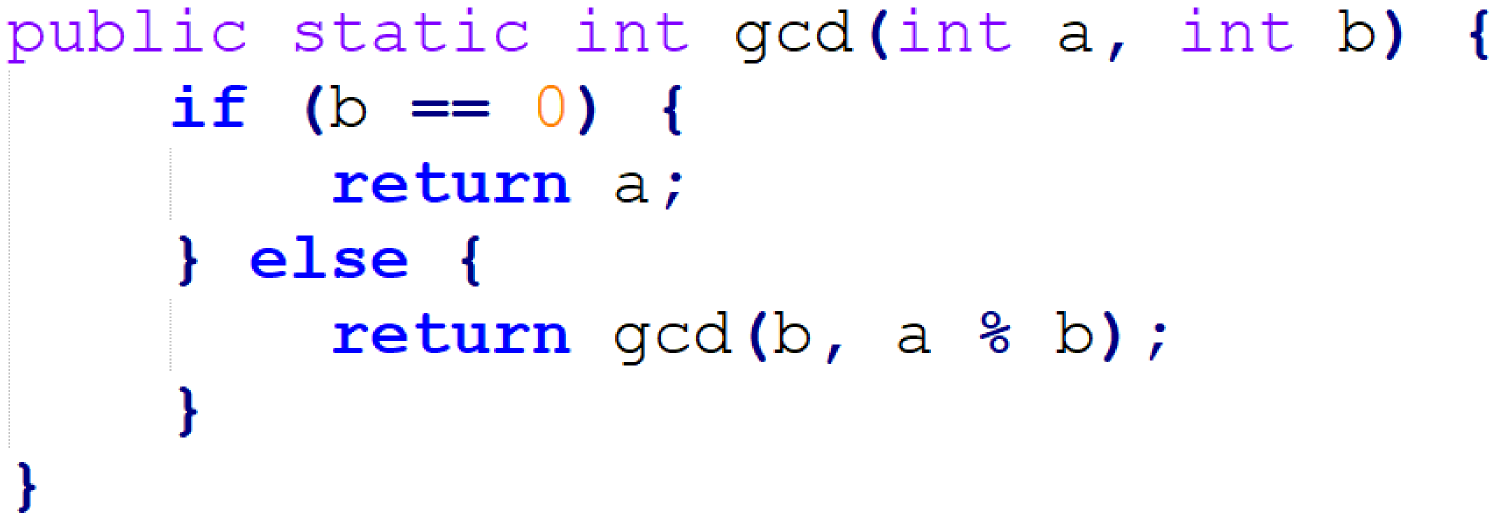
Calling a method recursively

- Consider: `factorial(5)`

Method call	Return expression	Value (bottom up)
`factorial(5)`	`5 * factorial(4)`	`120`
`factorial(4)`	`4 * factorial(3)`	`24`
`factorial(3)`	`3 * factorial(2)`	`6`
`factorial(2)`	`2 * factorial(1)`	`2`
`factorial(1)`	`1`	`1`

Recursion example: GCD

$$gcd(a, 0) = \mathrm{a}$$
$$gcd(a, b) = gcd(b, a \bmod b)$$



```
public static int gcd(int a, int b) {
    if (b == 0) {
        return a;
    } else {
        return gcd(b, a % b);
    }
}
```

Up next…

Method overloading

Method overloads

- **Definition:** Two or more methods by the same name but different parameters.

```
public class Math {
    public static long abs(long x) {
        if (x < 0) return -x;
        return x;
    }

    public static float abs(float x) {
        if (x < 0) return -x;
        return x;
    }
}
```

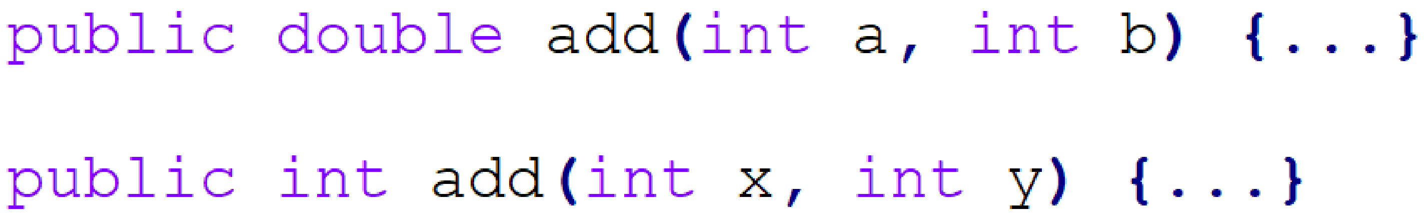
How overloading works

- When we call a method, the compiler must determine which of the methods to use through a process called binding.
  - Binding is matching a method’s signature to how it is called.
  - A method’s signature consists of its name and the data types of its parameters.
- Signature of the methods in the previous example:
  - `abs(long)`
  - `abs(float)`

How overloading works

- We cannot have methods with the same name and same list of parameters, EVEN IF THEY HAVE A DIFFERENT return type.

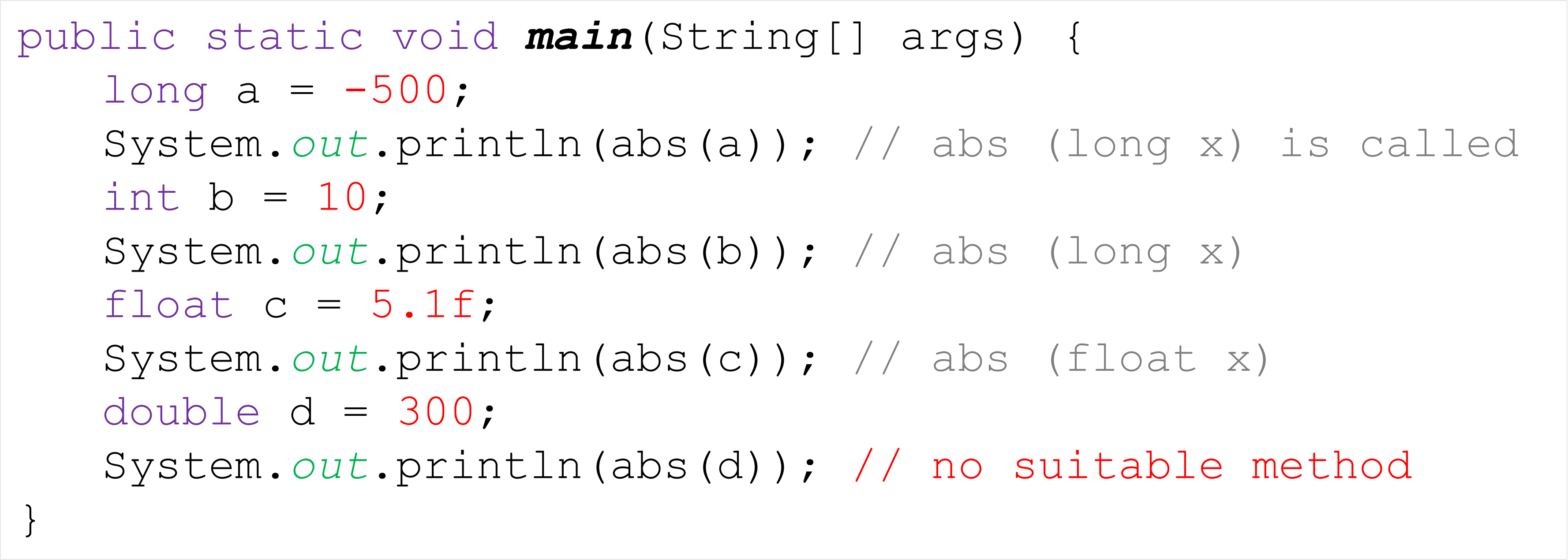
- Example of invalid overloading methods:



```
public double add(int a, int b) {...}

public int add(int x, int y) {...}
```

Calling method overloads

- A suitable overload is automatically selected.
- Automatic type conversion is applied.
  - E.g. an overload with long parameter is selected for int input
  - E.g. no suitable overload is found because double cannot be automatically converted to long or float



```java
public static void main(String[] args) {
    long a = -500;
    System.out.println(abs(a)); // abs (long x) is called
    int b = 10;
    System.out.println(abs(b)); // abs (long x)
    float c = 5.1f;
    System.out.println(abs(c)); // abs (float x)
    double d = 300;
    System.out.println(abs(d)); // no suitable method
}
```

Constructor overloading

- One of the more useful uses of method overloading is to overload constructors.
- More options when creating new objects.
- We can have many constructors which
  - Create empty objects
  - Create partial objects
  - Or, create complete objects

Packages

- All of the Java classes are organized into packages.
  - A package is a group of related classes.
- A class has a path that shows which package it belongs to:
  - `java.lang.String, java.lang.Math, java.util.Scanner…`
- Classes in `java.lang` package are available for use without importing. Others need importing.
  - **`import`** `java.util.Scanner;`
- All classes in a package can be imported using wildcard:
  - **`import`** `java.util.*;`

Up next…

Variable scopes

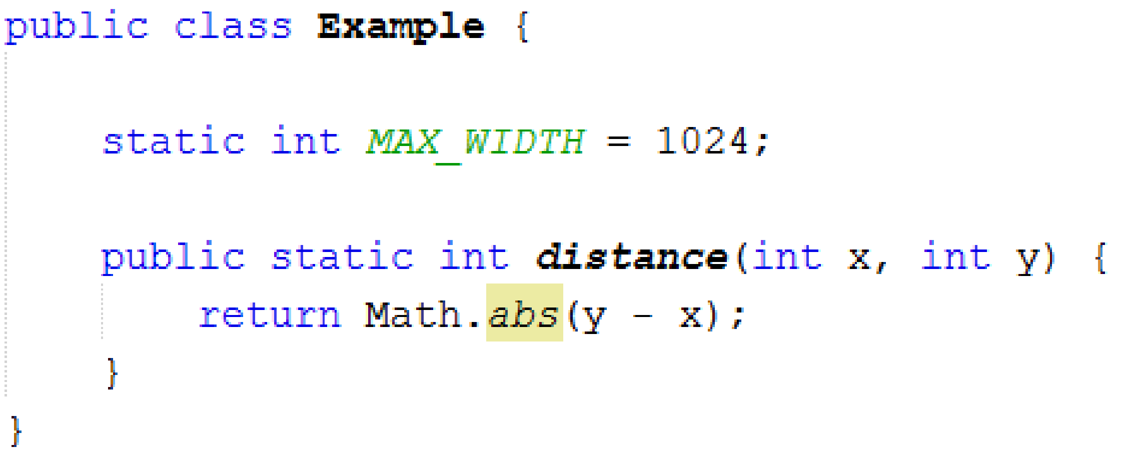
Variable scopes

- **Definition:** The scope of a variable is the part of the program that can refer to that variable by name.
- Three levels of Java variable scopes:
  - Class (global) scope
    - Declared outside of methods
  - Method scope
    - Declared inside a method, but not inside a block
  - Block scope
    - E.g. if…else, for, while, do, switch, try…catch

The global scope

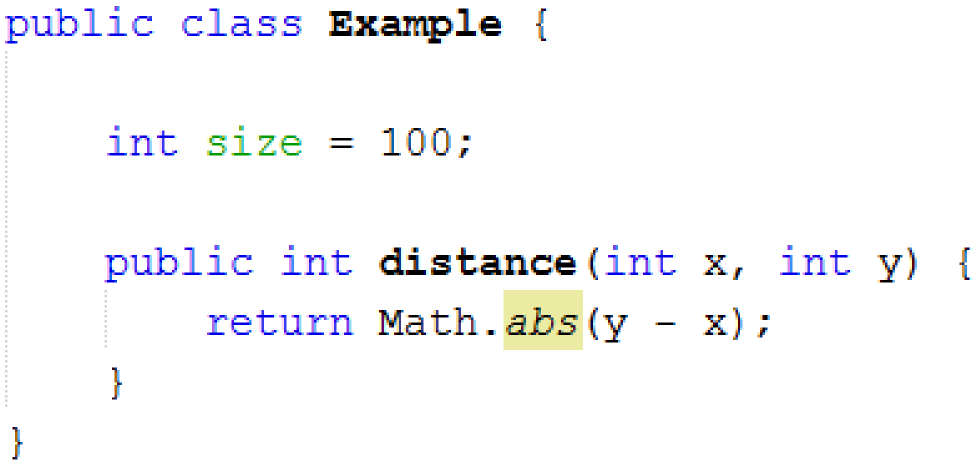
- A class member refers to one of the following:
  - A `static` method
  - A `static` variable
    (declared within the class and outside of methods)
- Class member vs. instance member:
  - A `static` member belongs to the class.
  - A `non-static` member does not belong to the class, but to an instance of that class.

Class members (static)



```
public class Example {

    static int MAX_WIDTH = 1024;

    public static int distance(int x, int y) {
        return Math.abs(y - x);
    }
}
```

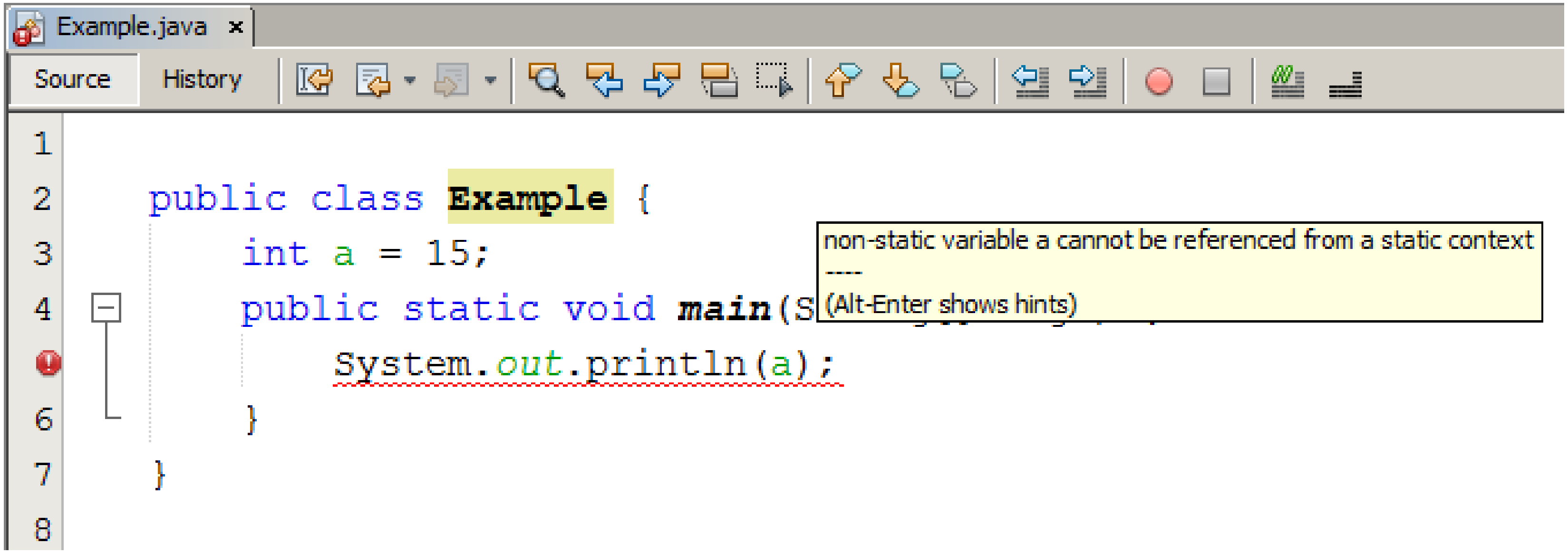
Instance members (non-static)



```
public class Example {

    int size = 100;

    public int distance(int x, int y) {
        return Math.abs(y - x);
    }
}
```

The global scope

- The **main** method is static.
- non-static members (variables, methods) cannot be accessed from the **main** method or any other static method.



```
public class Example {
    int a = 15;
    public static void main(S
        System.out.println(a);
    }
}
```

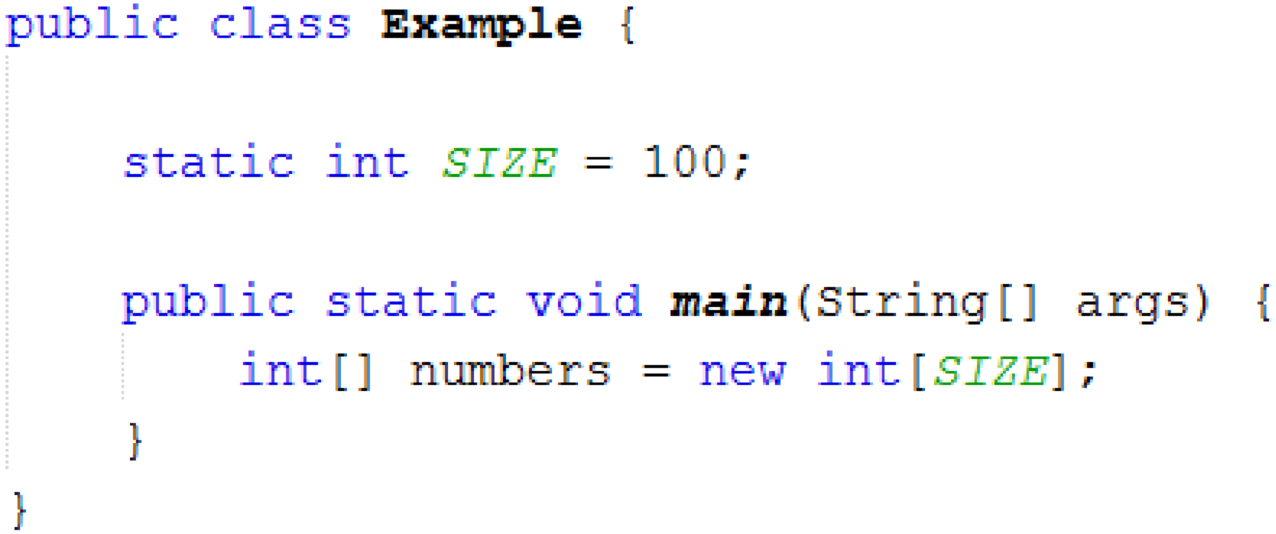
non-static variable a cannot be referenced from a static context
----
(Alt-Enter shows hints)

The global scope

- A global variable is declared inside class and outside any method.
- `non-static` variables can only be accessed in `non-static` methods.
- `static` variables can be accessed anywhere in `static` and `non-static` methods.
  - We use `static` global variables in this course.

The global scope

- Example use of a global variable:



```
public class Example {

    static int SIZE = 100;

    public static void main(String[] args) {
        int[] numbers = new int[SIZE];
    }
}
```

The global scope

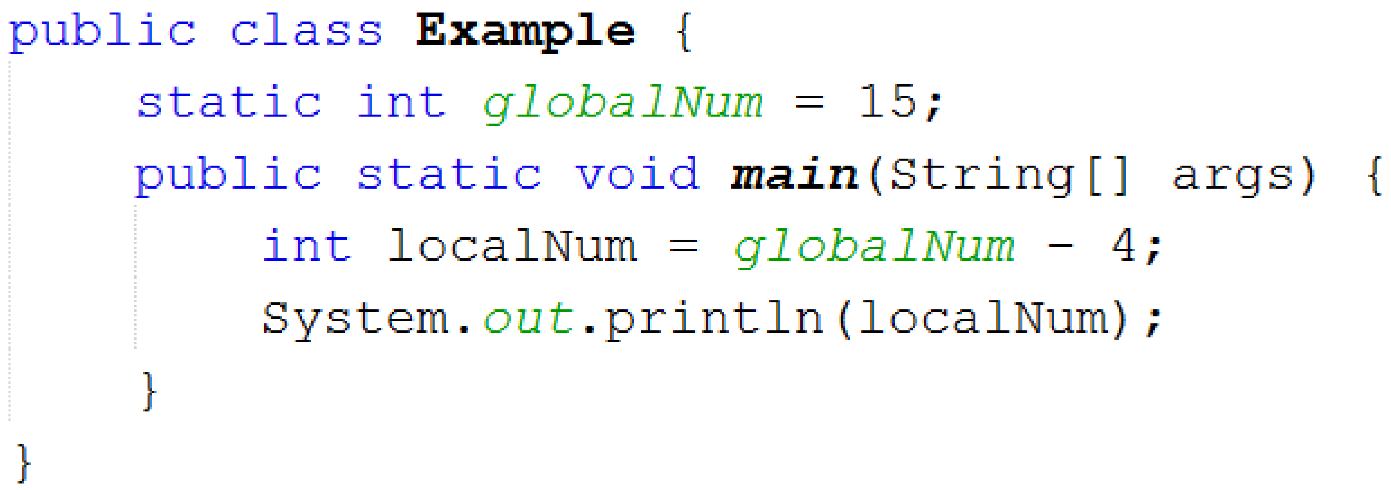
- Another example use of global variables: (which can be accessed by all methods in a class)

```
public static int a = 5; // a global variable
public static void firstMethod() {
    int b = a + 3;
}
public static void secondMethod() {
    System.out.println(a); // ok
}
```

- A global variable and a method are both class members. They are on the same level (like siblings).

The local scope

- **Definition:** Local variables, or method-level variables, are declared inside a method and outside any block.



```
public class Example {
    static int globalNum = 15;
    public static void main(String[] args) {
        int localNum = globalNum - 4;
        System.out.println(localNum);
    }
}
```

The local scope

- Variables declared inside a method are local to the method.
- These variables can't be accessed outside the method (a.k.a in other methods).

```java
public static void firstMethod() {
    int a = 5;
}
public static void secondMethod() {
    System.out.println(a); // error: cannot find symbol
}
```

The block scope

- **Definition:** A variable declared inside pair of brackets **{** and **}** (a block) has scope within the brackets only.
- This scope applies to:
  - `if…else` statements
  - Loops
  - `try…catch` statements
  - `switch`
  - Generic code blocks.

The block scope

- Example: **if…else** statements

```
if (pw.length() >= 8) {
    int score = 1;
} else {
    int score = 0;
}
System.out.println(score); // error: cannot find symbol
```

- Example: **for** loop

```
for (int i = 0; i < 5; i++) {
    System.out.println("i = " + i);
}
System.out.println("Now, i = " + i); // error
```

The block scope

- Example: **while** loop

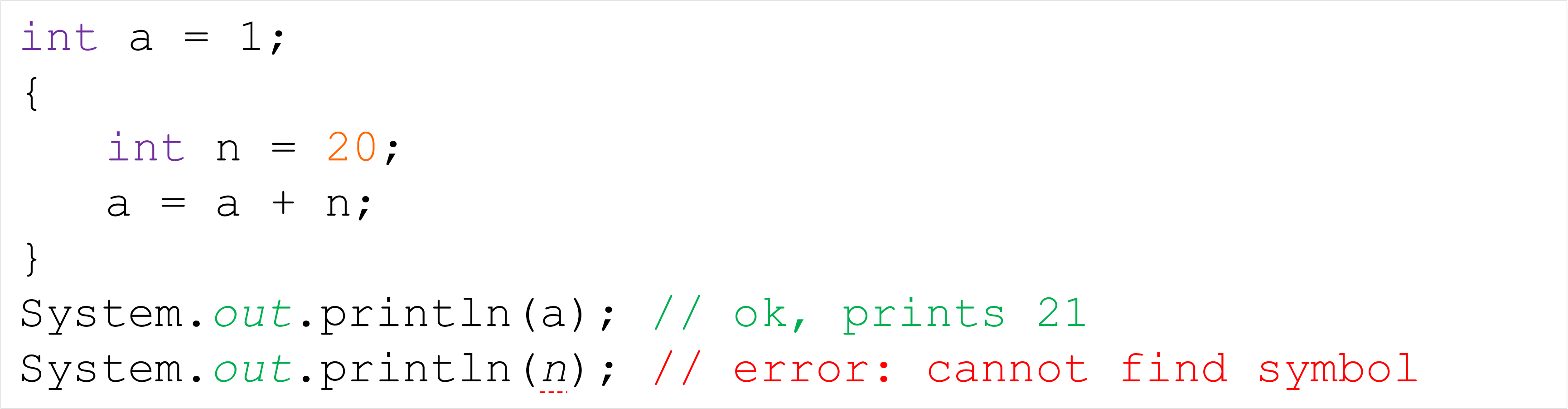
```
int i = 0;
while (i < 10) {
    int j = 2;
    i = i + j;
}
System.out.println(j); // error: cannot find symbol
```

- Example: **switch** statement

```
int option = 1;
switch (option) {
    case 1:
        int a = 123;
}
System.out.println(a); // error
```

The block scope

- Example: generic code block



```
int a = 1;
{
    int n = 20;
    a = a + n;
}
System.out.println(a); // ok, prints 21
System.out.println(n); // error: cannot find symbol
```