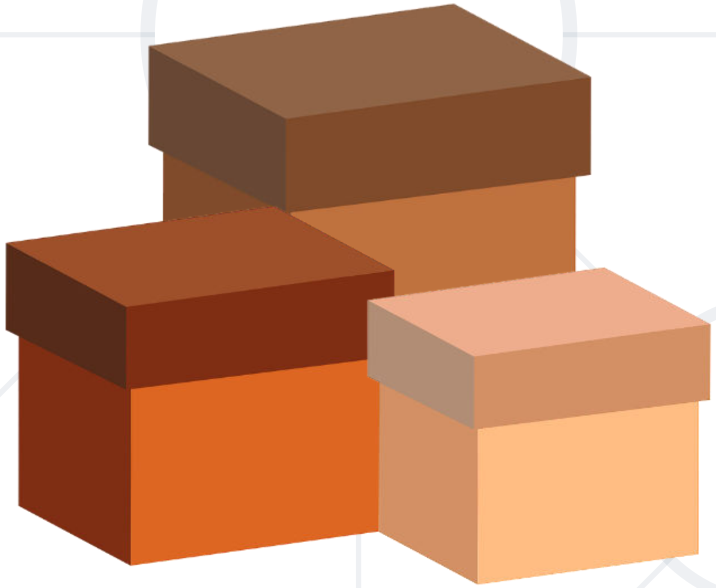
Data Types and Variables

Numeral Types, Text Types and Type Conversion



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Have a Question?

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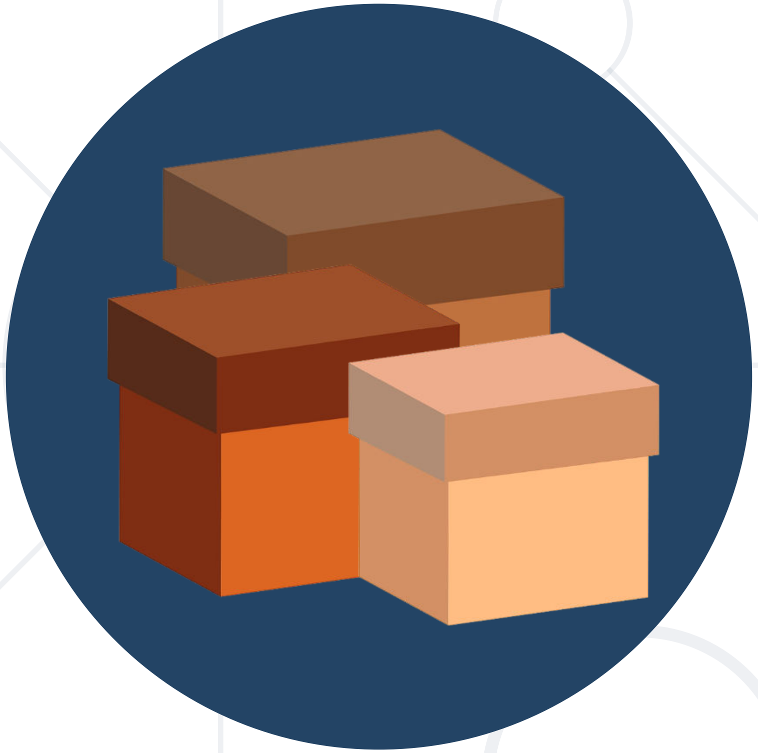
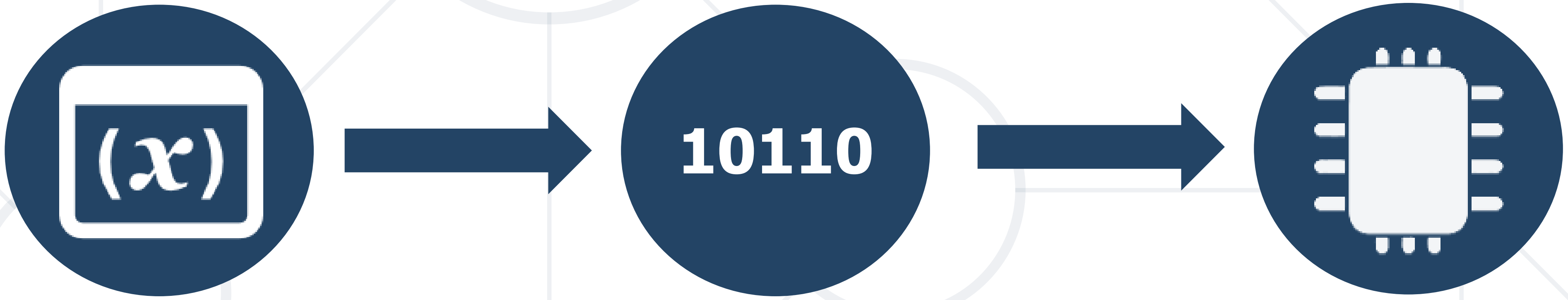
#tech-java



Data Types

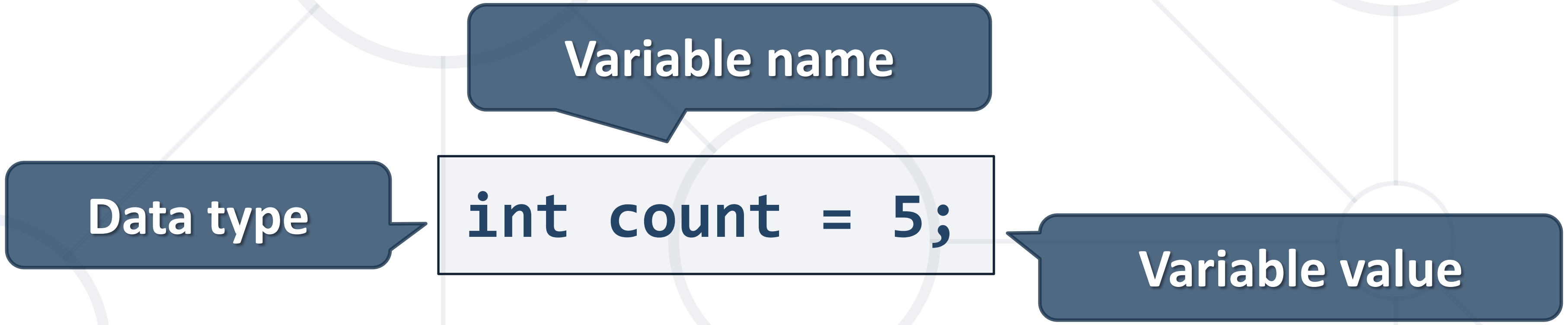
How Computing Works?

- Computers are machines that process data
  - Instructions and data are stored in the computer memory



Variables

- Variables have name, data type and value
  - Assignment is done by the operator "="
  - Example of variable definition and assignment



```
int count = 5;
```

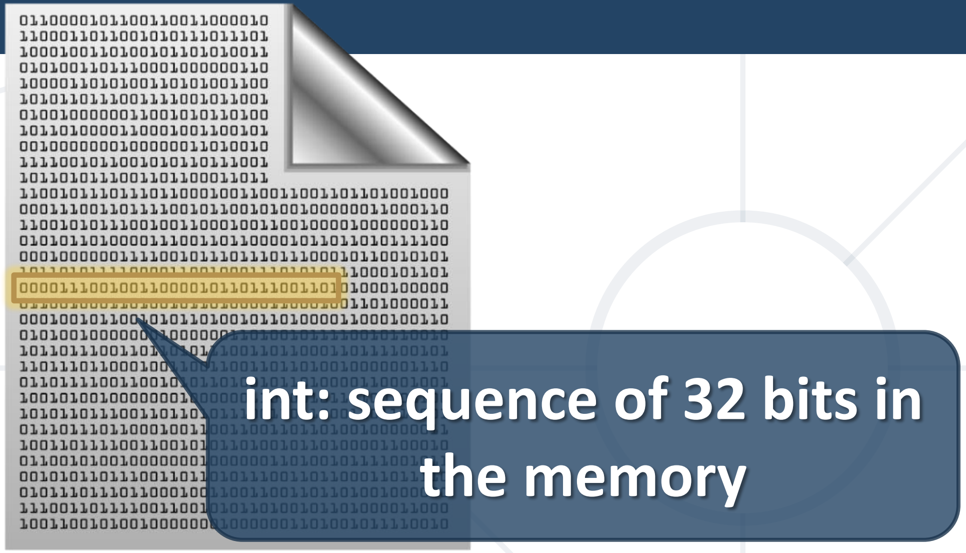
- When processed, data is stored back into variables

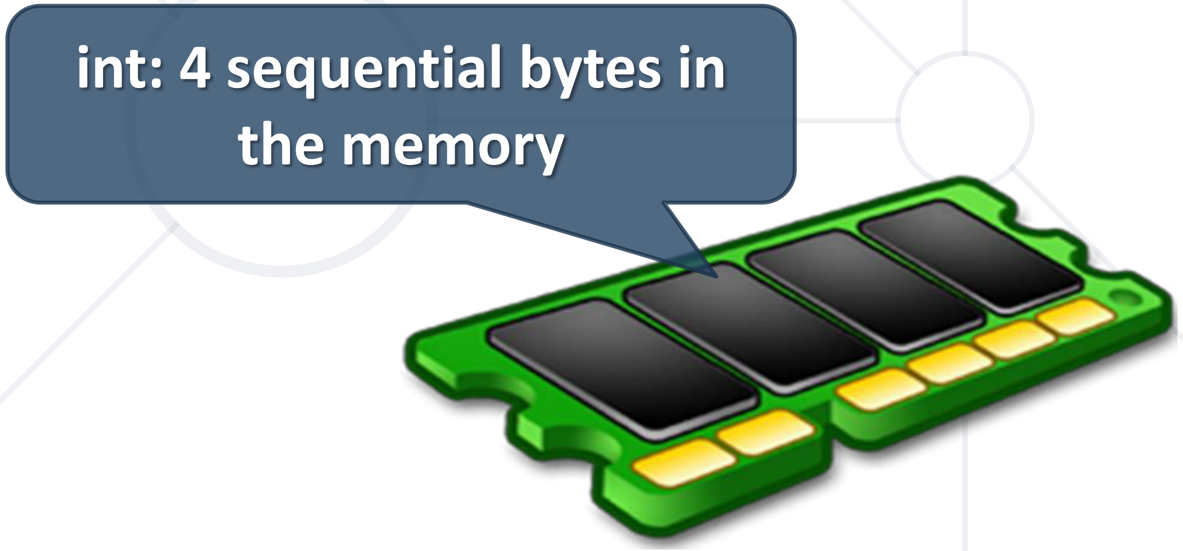
What Is a Data Type?

- A **data type**:
  - Is a **domain of values** of similar characteristics
  - Defines the type of information stored in the computer memory (in a **variable**)
- Examples:
  - Positive integers: **1**, **2**, **3**, …
  - Alphabetical characters: **a**, **b**, **c**, …
  - Days of week: **Monday**, **Tuesday**, …

Data Type Characteristics

- A data type has:
  - Name (Java keyword)
  - Size (how much memory is used)
  - Default value
- Example:
  - Integer numbers
  - Name: `int`
  - Size: `32 bits` (4 bytes)
  - Default value: `0`





Naming Variables

- Always refer to the naming **conventions** of a programming language for Java use **`camelCase`**
- Preferred form: **[Noun]** or [**Adjective**] + **[Noun]**
- Should explain the purpose of the variable (Always ask yourself "**What this variable contains?**")

✓
```
firstName, report, config, usersList, fontSize
```

🚫
```
foo, bar, p, p1, populate, LastName, last_name
```

Variable Scope and Lifetime

- **Scope** == where you can access a variable (global, local)
- **Lifetime** == how long a variable stays in memory

Accessible in the `main()`

```java
String outer = "I'm inside the Main()";
for (int i = 0; i < 10; i++)  {
   String inner = "I'm inside the loop";
}
System.out.println(outer);
// System.out.println(inner); Error
```

Accessible only in the loop

Variable Span

- Variable span is how long before a variable is called
- Always declare a variable
  as late as possible (e.g. shorter span)

```
static void main(String[] args) {
  String outer = "I'm inside the main()";
  for (int i = 0; i < 10; i++)
    String inner = "I'm inside the loop";
  System.out.println(outer);
  //System.out.println(inner); Error
}
```

"outer"
variable span

Keep Variable Span Short

- Shorter span simplifies the code
  - Improves its readability and maintainability

```
for (int i = 0; i < 10; i++) {
   String inner = "I'm inside the loop";
}
String outer = "I'm inside the main()";
System.out.println(outer);
// System.out.println(inner); Error
```

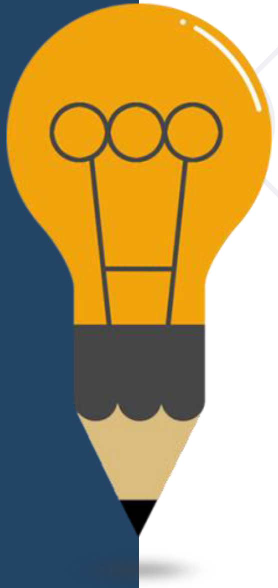
"outer" variable span – reduced

int

Integer Types

Integer types

Type	Default Value	Min Value	Max Value	Size
byte	0	-128 (-2^7)	127 (2^7-1)	8 bit
short	0	-32768 (-2^{15})	32767 (2^{15} - 1)	16 bit
int	0	-2147483648 (-2^{31})	2147483647 (2^{31} – 1)	32 bit
long	0	-9223372036854775808 (-2^{63})	9223372036854775807 (2^{63}-1)	64 bit



Centuries – Example

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- Depending on the unit of measure we can use different data types:

```
byte centuries = 20;
short years = 2000;
int days = 730484;
long hours = 17531616;
System.out.printf(
"%d centuries = %d years = %d days = %d hours.",
                                    centuries, years, days, hours)
//20 centuries = 2000 years = 730484 days = 17531616 hours.
```

Beware of Integer Overflow!

- Integers have range (minimal and maximal value)
- Integers could overflow → this leads to incorrect values

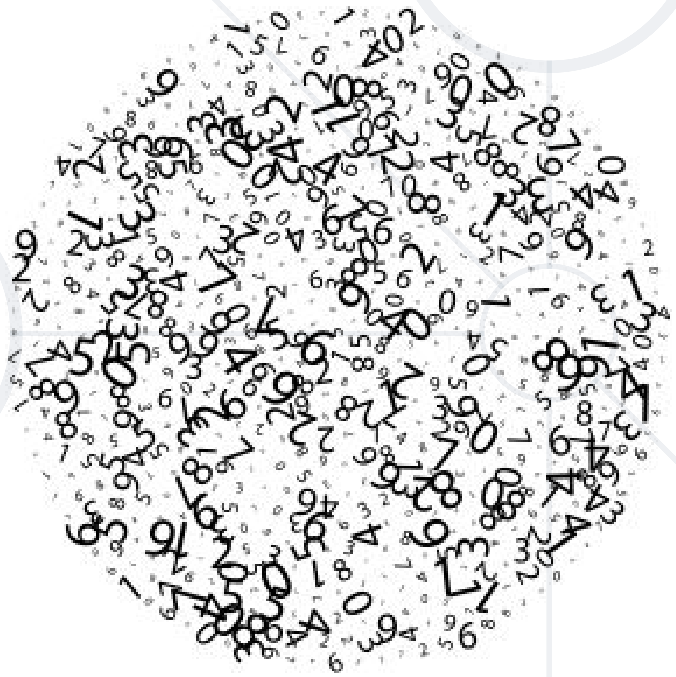
```java
byte counter = 0;
for (int i = 0; i < 130; i++) {
  counter++;
  System.out.println(counter);
}
```

```
1
2
…
127
-128
-127
```

Integer Literals

- Examples of integer literals:
  - The '0x' and '0X' prefixes mean a hexadecimal value
    - E.g. 0xFE, 0xA8F1, 0xFFFFFFFF
  - The 'l' and 'L' suffixes mean a long
    - E.g. 9876543L, 0L

```java
int hexa = 0xFFFFFFFF; //-1
long number = 1L; //1
```



Problem: Convert Meters to Kilometres

- Write a program that converts meters to kilometers formatted to the second decimal point
- Examples: `1852` → `1.85`   `798` → `0.80`

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

int meters = Integer.parseInt(scanner.nextLine());
double kilometers = meters / 1000.0;
System.out.printf("%.2f", kilometers);
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

float

Real Number Types

What are Floating-Point Types?

- Floating-point types:
  - Represent real numbers, e.g. `1.25`, `-0.38`
  - Have range and precision depending on the memory used
  - Sometimes behave abnormally in the calculations
  - May hold very small and very big values like `0.00000000000001` and `10000000000000000000000000000000000.0`

Floating-Point Numbers

- Floating-point types are:
  - `float` (±1.5 × 10^{-45} to ±3.4 × 10^{38})
    - 32-bits, precision of 7 digits
  - `double` (±5.0 × 10^{-324} to ±1.7 × 10^{308})
    - 64-bits, precision of 15-16 digits
- The default value of floating-point types:
  - Is `0.0F` for the `float` type
  - Is `0.0D` for the `double` type

PI Precision – Example

- Difference in precision when using **float** and **double**:

```
float floatPI = 3.141592653589793238f;
double doublePI = 3.141592653589793238;
System.out.println("Float PI is: " + floatPI);
System.out.println("Double PI is: " + doublePI);
```

```
3. 1415927
```

```
3. 141592653589793
```

- NOTE: The "**f**" suffix in the first statement!
  - Real numbers are by default interpreted as **double**
  - One should explicitly convert them to **float**

Problem: Pound to Dollars

- Write a program that converts British pounds to US dollars formatted to 3th decimal point
- 1 British Pound = 1.31 Dollars

```
80 → 104.800        39 → 51.090
```

```
double num = Double.parseDouble(scanner.nextLine());
double result = num * 1.31;
System.out.printf("%.3f", result);
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

Scientific Notation

- Floating-point numbers can use scientific notation, e.g.
  - `1e+34`, `1E34`, `20e-3`, `1e-12`, `-6.02e28`

```java
double d = 10000000000000000000000000000000000.0;
System.out.println(d); // 1.0E34
double d2 = 20e-3;
System.out.println(d2); // 0.02
double d3 = Double.MAX_VALUE;
System.out.println(d3); //1.7976931348623157E308
```

Floating-Point Division

- Integral division and floating-point division are different:

```
System.out.println(10 / 4);     // 2 (integral division)
System.out.println(10 / 4.0);   // 2.5 (real division)
System.out.println(10 / 0.0);   // Infinity
System.out.println(-10 / 0.0);  // -Infinity
System.out.println(0 / 0.0);    // NaN (not a number)
System.out.println(8 % 2.5);    // 0.5 (3 * 2.5 + 0.5 = 8)
System.out.println(10 / 0);     // ArithmeticException
```

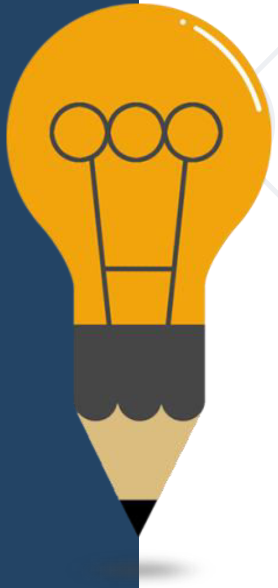
Floating-Point Calculations – Abnormalities

- Sometimes floating-point numbers work incorrectly!
- Read more about **IEE 754**

```
double a = 1.0f;
double b = 0.33f;
double sum = 1.33d;
System.out.printf("a+b=%f sum=%f equal=%b",
                        a+b, sum, (a + b == sum));
// a+b=1.33000001311302 sum=1.33 equal = false
double num = 0;
for (int i = 0; i < 10000; i++) num += 0.0001;
  System.out.println(num); // 0.99999999999999062
```

BigDecimal

- Built-in Java Class
- Provides arithmetic operations
- Allows calculations with very high precision
- Used for financial calculations



```java
BigDecimal number = new BigDecimal(0);
number = number.add(BigDecimal.valueOf(2.5));
number = number.subtract(BigDecimal.valueOf(1.5));
number = number.multiply(BigDecimal.valueOf(2));
number = number.divide(BigDecimal.valueOf(2));
```

Problem: Exact Sum of Real Numbers

- Write program to enter **n** numbers and print their exact sum:

```
2
1000000000000000000
5
```

→

```
1000000000000000005
```

```
2
0.00000000003
333333333333.3
```

→

```
333333333333.30000000003
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

Solution: Exact Sum of Real Numbers

```
int n = Integer.parseInt(sc.nextLine());
BigDecimal sum = new BigDecimal(0);
for (int i = 0; i < n; i++) {
   BigDecimal number = new BigDecimal(sc.nextLine());
   sum = sum.add(number);
}
System.out.println(sum);
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

Live Exercises

Integer and Real Numbers

Type Conversion

Type Conversion

- Variables hold values of certain type
- Type can be **changed** (**converted**) to another type
  - **Implicit** type conversion (**lossless**): variable of bigger type (e.g. **`double`**) takes smaller value (e.g. **`float`**)

```
float heightInMeters = 1.74f;
double maxHeight = heightInMeters;
```

Implicit conversion

  - **Explicit** type conversion (lossy) – when precision can be lost:

```
double size = 3.14;
int intSize = (int) size;
```

Explicit conversion

Problem: Centuries to Minutes

- Write program to enter an integer number of centuries and convert it to years, days, hours and minutes

```
1
```

```
1 centuries = 100 years = 36524 days =
876576 hours = 52594560 minutes
```

```
5
```

```
5 centuries = 500 years = 182621 days
= 4382904 hours = 262974240 minutes
```

The output is on one row

Check your solution here: https://judge.softuni.bg/Contests/1227/

Solution: Centuries to Minutes

```
int centuries = Integer.parseInt(sc.nextLine());
int years = centuries * 100;
int days = (int) (years * 365.2422);
int hours = 24 * days;
int minutes = 60 * hours;
System.out.printf(
"%d centuries = %d years = %d days = %d hours = %d minutes",
                              centuries, years, days, hours, minutes);
```

Tropical year has 365.2422 days

(int) converts double to int

Check your solution here: https://judge.softuni.bg/Contests/1227/

Boolean Type

Boolean Type

- Boolean variables (**boolean**) hold **true** or **false**:

```
int a = 1;
int b = 2;
boolean greaterAB = (a > b);
System.out.println(greaterAB);  // False
boolean equalA1 = (a == 1);
System.out.println(equalA1);    // True
```

Problem: Special Numbers

- A number is special when its sum of digits is 5, 7 or 11
  - For all numbers **1…n** print the number and if it is special

```
20
```

```
1 -> false
2 -> false
3 -> false
4 -> false
5 -> true
6 -> false
7 -> true
8 -> false
9 -> false
10 -> false
11 -> false
12 -> false
13 -> false
14 -> true
15 -> false
16 -> true
17 -> false
18 -> false
19 -> false
20 -> false
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

Solution: Special Numbers

```java
int n = Integer.parseInt(sc.nextLine());
for (int num = 1; num <= n; num++) {
  int sumOfDigits = 0;
  int digits = num;
  while (digits > 0) {
    sumOfDigits += digits % 10;
    digits = digits / 10;
  }
  // TODO: check whether the sum is special
}
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

'A'

Character Type

The Character Data Type

- The character data type
  - Represents symbolic information
  - Is declared by the **`char`** keyword
  - Gives each symbol a corresponding integer code
  - Has a **`'\0'`** default value
  - Takes 16 bits of memory (from **`U+0000`** to **`U+FFFF`**)
  - Holds a single Unicode character (or part of character)

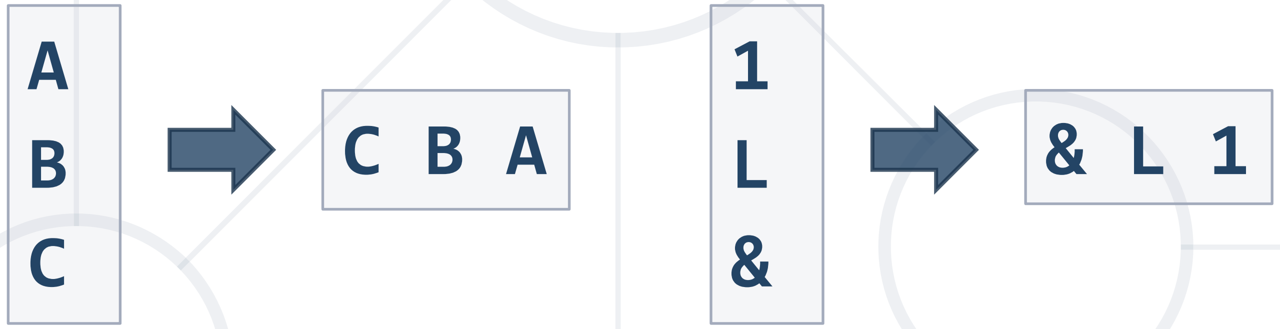
Characters and Codes

- Each **character** has an unique **Unicode** value (**`int`**):

```java
char ch = 'a';
System.out.printf("The code of '%c' is: %d%n", ch, (int) ch);
ch = 'b';
System.out.printf("The code of '%c' is: %d%n", ch, (int) ch);
ch = 'A';
System.out.printf("The code of '%c' is: %d%n", ch, (int) ch);
ch = 'щ';  // Cyrillic letter 'sht'
System.out.printf("The code of '%c' is: %d%n", ch, (int) ch);
```

Problem: Reversed Chars

- Write a program that takes 3 lines of characters and prints them in reversed order with a space between them
- Examples:



```
A
B
C
```

```
C B A
```

```
1
L
&
```

```
& L 1
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

Solution: Reversed Chars

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

char firstChar = scanner.nextLine().charAt(0);
char secondChar = scanner.nextLine().charAt(0);
char thirdChar = scanner.nextLine().charAt(0);

System.out.printf("%c %c %c",
        thirdChar, secondChar, firstChar);
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

Escaping Characters

- Escaping sequences are:
  - Represent a special character like `'`, `"` or `\n` (new line)
  - Represent system characters (like the [TAB] character `\t`)
- Commonly used escaping sequences are:
  - `\'` → for single quote `\"` → for double quote
  - `\\` → for backslash `\n` → for new line
  - `\uXXXX` → for denoting any other Unicode symbol

Character Literals – Example

```
char symbol = 'a'; // An ordinary character
symbol = '\u006F'; // Unicode character code in a
                   // hexadecimal format (letter 'o')
symbol = '\u8449'; // 葉 (Leaf in Traditional Chinese)
symbol = '\''; // Assigning the single quote character
symbol = '\\'; // Assigning the backslash character
symbol = '\n'; // Assigning new line character
symbol = '\t'; // Assigning TAB character
symbol = "a";  // Incorrect: use single quotes!
```

"ABC"

String

Sequence of letters

The String Data Type

- The string data type
  - Represents a sequence of characters
  - Is declared by the `String` keyword
  - Has a default value `null` (no value)
- Strings are enclosed in quotes:

```
String s = "Hello, JAVA";
```

- Strings can be concatenated
  - Using the + operator

Formatting Strings

- Strings are enclosed in quotes `""`:

```
String file = "C:\\Windows\\win.ini";
```

The backslash \ is **escaped by \\**

- Format strings insert variable values by pattern:

```
String firstName = "Svetlin";
String lastName = "Nakov";
String fullName = String.format(
                      "%s %s", firstName, lastName);
```

Saying Hello – Examples

- Combining the names of a person to obtain the full name:

```
String firstName = "Ivan";
String lastName = "Ivanov";
String fullName = String.format(
                          "%s %s", firstName, lastName);
System.out.printf("Your full name is %s.", fullName);
```

- We can concatenate strings and numbers by the **+** operator:

```
int age = 21;
System.out.println("Hello, I am " + age + " years old");
```

Problem: Concat Names

- Read first and last name and delimiter
- Print the first and last name joined by the delimiter

```
John
Smith
->
```

```
John->Smith
```

```
Linda
Terry
=>
```

```
Linda=>Terry
```

```
Jan
White
<->
```

```
Jan<->White
```

```
Lee
Lewis
---
```

```
Lee---Lewis
```

Check your solution here: https://judge.softuni.bg/Contests/1227/

Solution: Concat Names

```java
String firstName = sc.nextLine();
String lastName = sc.nextLine();
String delimiter = sc.nextLine();

String result = firstName + delimiter + lastName;
System.out.println(result);
```

```
Jan<->White
```

Live Exercises

Data Types

Summary

- **Variables** – store data
- Numeral types:
  - Represent **numbers**
  - Have **specific ranges** for every type
- String and text types:
  - Represent **text**
  - **Sequences of Unicode characters**
- Type conversion: **implicit** and **explicit**

Questions?

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