CSEN 202 – Introduction to Computer Programming

Lecture 2:
Data Types

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What you already know

- The origin of Java as a programming language
- The path from the source to the executable in Java
- A minimum Java program and its structure
- Further, you know. . .

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- . . . The structure of comments
  - Normal comment: `/* ... */`
  - Single line comment: `// ...`
  - Javadoc comment: `/** ... */`

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  - Normal comment: `/* ... */`
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  - Syntax error
  - Logical error
  - Runtime error

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  - Normal comment: `/* ... */`
  - Single line comment: `// ...`
  - Javadoc comment: `/** ... */`
- . . . The classification of errors
  - Syntax error
  - Logical error
  - Runtime error
- The format of identifiers
  - Starts with letter, can include letters, digits, '$', '_'
  - Is case sensitive
  - Must not be a reserved word

Just for the record

Reserved words in Java:

abstract, **assert**, **boolean**, **break**, **byte**, **case**, **catch**, **char**, **class**, **const**[1], **continue**, **default**, **double**, **do**, **else**, **enum**, **extends**, **false**, **final**, **finally**, **float**, **for**, **goto**[1], **if**, **implements**, **import**, **instanceof**, **int**, **interface**, **long**, **native**, **new**, **null**, **package**, **private**, **protected**, **public**, **return**, **short**, **static**, **strictfp**, **super**, **switch**, **synchronized**, **this**, **throw**, **throws**, **transient**, **true**, **try**, **void**, **volatile**, **while**

[1] not used anymore, but still reserved

Today's lecture

- Primitive datatypes and their aspects
- Special values
- Literals and assignments
- Strings
- Composite expressions

Summary

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- How a piece of data in the memory is to be interpreted
- How data can be stored in the memory
- What values can be assigned to a memory location (variable)
- What operations are possible on a piece of data

Properties of a value

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The overall properties of a piece of data in a storage location are recorded as the datatype or simply type.

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Datatype

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- To understand datatypes it makes sense to understand the underlying representation

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Example (declaring an integer variable)

type

```
int studentSemesterCount;
```

variable name

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Example (declaring and initializing a floating-point variable)

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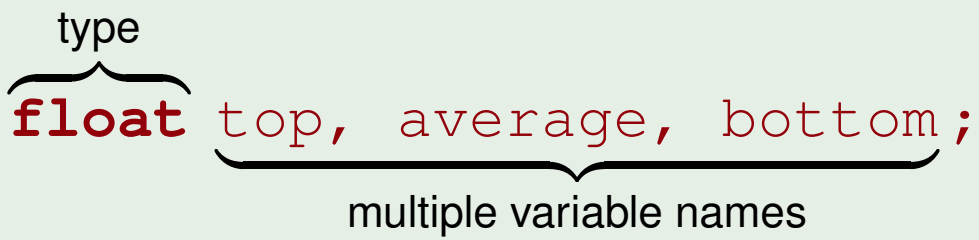
Example (declaring multiple floats)



Identifiers as variable names

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In variable declarations, observe the following naming conventions:

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- for consecutive words, capitalize first letter
- Examples: `studentSemesterCount`, `gradePointAverage`, `total`, ...

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- **`short`**: a 16-bit signed two's complement integer. ($-32,768$ to $32,767$)
- **`int`**: a 32-bit signed two's complement integer. ($-2,147,483,648$ to $2,147,483,647$)
- **`long`**: a 64-bit signed two's complement integer. ($-9,223,372,036,854,775,808$ to $9,223,372,036,854,775,807$)

Primitive types

Floating-point types

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Floating-point types

- **`float`**: a single-precision 32-bit IEEE 754 floating point. ($\pm 3.4 \times 10^{38}$ with 7 significant bits)
  This data type should never be used for precise values, such as currency! (Why?)

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Floating-point types

- **`float`**: a single-precision 32-bit IEEE 754 floating point.
  ($\pm 3.4 \times 10^{38}$ with 7 significant bits)
  This data type should never be used for precise values, such as currency! (Why?)
- **`double`**: a double-precision 64-bit IEEE 754 floating point.
  Generally the default choice for decimal values.
  ($\pm 1.7 \times 10^{308}$ with 15 significant bits)
  Never use for precise values, same reason.

Primitive types

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- **`boolean`**: **`true`** or **`false`**. The “size” (representation) isn’t something that’s precisely defined. . .

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- **`char`**: a single 16-bit Unicode character.

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- `double average = 54.597;`
  Declares a double-precision floating point number (52-bit mantissa, 11-bit exponent) with the initial value 54.597

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- `double average = 54.597;`
  Declares a double-precision floating point number (52-bit mantissa, 11-bit exponent) with the initial value 54.597
- `boolean flag = true;`
  Declares a boolean variable with an initial value of `true`

Character values

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- Special characters

Escape Sequence	Unicode	Character
\b	'\u0008'	Backspace
\n	'\u000a'	Line feed
\t	'\u0009'	Horizontal Tabulation
\'	'\u0027'	Single quote
\"	'\u0022'	Double quote
\\	'\u0055'	Backslash

Boolean values

- The reserved words **`true`** and **`false`** are the only legal values for variables of type **`boolean`**!

```
boolean understood = true;
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- A **`boolean`** variable stores one bit worth of information, however the internal representation is not defined.

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- Signed binary, octal, or hexadecimal numbers

```
/*A hexadecimal prefixed with 0x */
int i = -0x1FA29;
/*An octal prefixed with 0 */
short s = 0177;
/*A binary prefixed with 0b */
long l = 0b1001010010111101;
```

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long l = 0b1001010010111101;
```

- An integer numeral is by default of type **int**. Literals of type **long** are suffixed with "L"

```
long l = 23L;
```

Integer values

If an integer literal is small enough to fit into a **`byte`** or a **`short`**, it will be automatically converted. The same is true for **`long`** literals and **`int`**, **`byte`**, and **`short`**.

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- `byte b = 0x7F; /*7 bits, OK */`
- `short s = 0x7FFF; /*15 bits, OK */`
- `long i = 0x12345678L; /*29 bits, OK */`

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- `byte b = 0x7F; /*7 bits, OK */`
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- `byte b2 = 0xFF; /*Error: 255 > 127 */`

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- `short s = 0x7FFF; /*15 bits, OK */`
- `long i = 0x12345678L; /*29 bits, OK */`
- `byte b2 = 0xFF; /*Error: 255 > 127 */`
- `int b2 = 0xFFFFFFFFFFFFFFFF; /*number too large*/`

Integer values

Note:

Integer values

Note:

- If a literal is too big for its target variable, you must explicitly convert it using a type cast. The number is converted by truncating the extra bits, which is probably not what you want.

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/*0x100 = 256 */
byte b = (byte) 0x100;
/*b now equals 0! */
```

Integer values

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/*0x100 = 256 */
byte b = (byte) 0x100;
/*b now equals 0! */
```

- An **int** literal can always be assigned to a **long** variable—its value will be the same as if it was assigned to **int** variable.

Floating point values

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float f = 3.141592654f;
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- To type a literal as **float**, it must be suffixed with "f"
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float f = 3.141592654f;
```
- floating point values can be given in base-10 scientific notation
```
double d = 1.234e2; /*equals 123.4 */
float f = 1.234e-3f; /*equals 0.001234 */
```

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- floating point values can be given in base-10 scientific notation
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double d = 1.234e2; /*equals 123.4 */
float f = 1.234e-3f; /*equals 0.001234 */
```
- Again: these types are not meant for precise arithmetics!

Floating point values

- You can assign a **float** to a **double**, but not vice versa!

```
double d = 3.141592654f; /*OK */
float f = 3.141592654; /*type mismatch! */
```

Floating point values

- You can assign a **float** to a **double**, but not vice versa!

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double d = 3.141592654f; /*OK */
float f = 3.141592654; /*type mismatch! */
```

- When an integer literal is assigned to a floating-point type, it is automatically "promoted" to floating-point, even if that means a loss of precision.

```
float f = 2; /*OK, f = 2.0 */
float f2 = 1234512345L; /*OK, f2 = 1.23451238E9 */
```

Initialization

Always initialize your variables!

Default values for uninitialized variables

Data Type	Default Value
`byte`	`0`
`short`	`0`
`int`	`0`
`long`	`0L`
`float`	`0.0f`
`double`	`0.0d`
`char`	`'\u0000'`
`boolean`	`false`

Note that not all variables are automatically initialized!

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- By convention, names of constants are all uppercase using underscore to separate words.

```
final boolean ALL_UNDER_CONTROL = true;
```

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  (ignore the `"␣"` for now)

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- A string literal is surrounded by double quotes.
  ```
  String hamlet = "to␣be␣or␣not␣to␣be";
  ```
  (ignore the `"␣"` for now)
- Once a string has been created, we can use the dot operator to invoke its methods:
  ```
  l = hamlet.length ();
  ```

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  - **`char`** `charAt (`**`int`** `index)`: returns the character at the specified index

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  - `char charAt (int index)`: returns the character at the specified index
  - `String toLowerCase ()`: Converts all of the characters in this String to lower case.

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  - `char charAt (int index)`: returns the character at the specified index
  - `String toLowerCase ()`: Converts all of the characters in this String to lower case.
  - `String replace(char oldChar, char newChar)`: Returns a new string resulting from replacing all occurrences of `oldChar` in this string by `newChar`.

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  - `%` — Modulus (remainder)
- There are also unary `+` and `-` operators (*i. e.*, with just one operand)
- The operators can be applied to any of the integer or floating-point types.

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- Parentheses ((. . .)) overrule precedence

Comparisons

- Comparisons are applied to two expressions of compatible type and always yield a **`boolean`** result.

```
a < b
a <= b
a == b /*equals */
a > b
a >= b
a != b /*not equal to */
```

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a == b /*equals */
a > b
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a != b /*not equal to */
```

- Assignment operator `a = b;`

Do not confuse `a = b` with `a == b`!

Examples

```
double a;
int i;
boolean b;

a = 3.1415 + 42;
i = 4 - 9;
i = i + 1;
a = i * 2 + 3;
a = i * (2+3);
b = i > 0;
```

Examples

```
double a;
int i;
boolean b;

a = 3.1415 + 42;      // a = 45.1415
i = 4 - 9;
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Examples

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a = i * (2+3);        // a = -20
b = i > 0;
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i = i + 1;            // i = -4
a = i * 2 + 3;        // a = -5
a = i * (2+3);        // a = -20
b = i > 0;            // b = false
```

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- They are known from last semester:
  - Logical AND (A AND B) yields true only if both A and B evaluate to true. In Java: `A && B` or `A & B`.
  - Logical OR (A OR B) yields true if either A or B, or both yield true. In Java: `A || B` or `A | B`
  - Logical XOR (A XOR B) yields true if and only if exactly one of its operands is true. In Java `A^B`
  - Logical Negation inverts its operand. In Java `!A`

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  - Logical Negation inverts its operand. In Java `!A`
- `A && B` and `A || B`: evaluate the second operand only if required.
- `A & B` and `A | B`: Both operands have to be evaluated.