

COMP 250

INTRODUCTORY SCIENCE

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Week 2-1: Primitive Datatypes

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WHAT ARE WE GOING TO DO IN THIS VIDEO?



- Primitive data types
- char
- String
- type conversion

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PRIMITIVE TYPES

A **primitive** type is

- predefined by the
- named by a reser

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Java supports 8 primitive data types.

THE 8 TYPES SUPPORTED

byte

short

int

long

float

double

boolean

char

Integer values

Real Numbers

true or false

One character

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HOW MANY VALUES?

How many values can you represent with:

- 1 bit?
- 2 bits?
- 3 bits?
- And what about n bits?

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$$2^n$$

HOW MANY BITS?

And how many bits do you need to represent:

- 2 different values?

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- 4 different val

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- 5 different values?

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- And what about x different v

$$\lceil \log_2 x \rceil$$

➤ So, how many bits do you need to store a boolean?

— HOW MANY BITS N DO WE NEED TO REPRESENT A POSITIVE INTEGER m ? —

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$N-1$

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$i=0$

What is the relationship between m and N ?

GEOMETRIC SERIES

Recall that,

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$$\sum_{i=0}^{N-1} x^i = \frac{x^N - 1}{x - 1}$$

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That is, if $x = 2$,

$$\sum_{i=0}^{N-1} 2^i = 2^N - 1$$

HOW MANY BITS N DO WE NEED TO REPRESENT A POSITIVE INTEGER m ? —

$$m = \sum_{i=0}^{N-1} b_i \cdot 2^i$$

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$$m < 2^N$$

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$$\leq \sum_{i=0}^{N-1} 1 \cdot 2^i$$

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To solve, we take the log (base 2) of both sides and obtain the following equation:

$$= 2^N - 1$$

$$< 2^N$$

$$N > \log_2 m$$

Lower bound

HOW MANY BITS N DO WE NEED TO REPRESENT A POSITIVE INTEGER m ? —

Now, let's assume that $N - 1$ is the index i of the leftmost bit b_i such that $b_i = 1$.

e.g. We ignore leftmost 0's of the binary representation of m , $(100000010011)_2$

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Then,

$$m = \sum_{i=0}^{N-1} b_i 2^i = 1 \cdot 2^{N-1} + \sum_{i=0}^{N-2} b_i 2^i \geq 2^{N-1}$$

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Taking the log (base 2) of both sides,

$$\log_2 m \geq N - 1$$

\Rightarrow

$$N \leq (\log_2 m) + 1$$

Upper Bound

HOW MANY BITS N DO WE NEED TO REPRESENT A POSITIVE INTEGER m ? —

We proved that,

$$\log_2 m < N \leq (\log_2 m) + 1$$

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Thus, N must be equal to the largest integer n or equal to $(\log_2 m) + 1$.

We write,

$$N = \text{floor}((\log_2 m) + 1) = \lfloor (\log_2 m) + 1 \rfloor$$

where *floor* means "round down to the nearest integer".

WHY DIFFERENT TYPES?

It turns out that the difference between the types storing integer values and real numbers is the number of bits reserved for those values. For more info: COMP 273

Description	Keyword	Size	Values
Very Small Integer			$[-128, 127]$
Small Integer	short		$[-2^{15}, 2^{15} - 1]$
Integer	int		$[-2^{31}, 2^{31} - 1]$
Big Integer	long	64-bits	$[-2^{63}, 2^{63} - 1]$
Low Precision Reals	float	32-bits	-
High Precision Reals	double	64-bits	-
True/False	boolean	1-bit	[true, false]
One character	char	16-bits	-

OVERFLOW AND UNDERFLOW

- Variables of type `int` store values between $2^{31} - 1$ and -2^{31} .

- $2^{31} - 1 = 2147483647$ (Integer.MAX_VALUE)
- $-2^{31} = -2147483648$ (Integer.MIN_VALUE)

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- What happens if: Add WeChat edu_assist_pro

```
int x = 2147483647;  
System.out.println(x+1);
```

Output:-2147483648

```
int y = -2147483648;  
System.out.println(y-1);
```

Output 2147483647

STORING INTEGER AND OVERFLOW

Let's pretend that we only have 8 bits.

7 bits are used to store the number and the left most bit for the sign.

0 means positive and

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What happens if we add 1?

STORING INTEGER AND OVERFLOW

Let's pretend that we only have 8 bits.

7 bits are used to store the number and the left most bit for the sign.

0 means positive and

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What happens if we add 1?

$$1000\ 0000 = -128$$

Note that negative numbers are stored a little bit differently. For more info see: https://en.wikipedia.org/wiki/Two's_complement

EXAMPLES

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EXAMPLES

Therac-25, radiation machine

- overflow during safety checks
- metal target would not moved into place.
- result: beams 100 times higher than intended were fired into patients.
- 6 known cases causing the death of 4 patients.

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FLOATING POINT

- In java the default floating point type is `double`.
- All standard arithmetic operations can be done on floating point.
- NOTE: Java distinguishes between `int` and `double`. If you write `.0` after an integer, it will be considered to be a `double`.

```
int x = 3.0;
```



```
int x = 3;
```



```
double x = 3.0;
```



BE CAREFUL!



- Java automatically converts one type to the other (e.g. int to double) if need be AND if no loss of information would occur.

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```
double x =
```

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- If the mathematical operators are used with one operand of type double, then java will convert the other operands to double and it will output a values of type double. BUT, if all the operands are integers, the output of the operator will also be an integer!!

```
int x = 1.0/2;    // compiler error!  
double y = 1/4;  // no compiler error, but is it correct?
```

CHAR

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CHAR DATA TYPE

We have seen `char` as one of the primitive data types that we have in Java.

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- We can declare and initialize `char` as follows:

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```
char letter
```

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- Character literals appears in single quotes
- Character literals can only contain a single character

ESCAPE SEQUENCES

- **Escape sequence:** a sequence of characters that represents a special character.

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- **Examples:**

- `\n` represents the <https://eduassistpro.github.io/>
- `\"` or `\'` represent quotation marks
- `\t` represents a tab.

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- **Escape sequences are legal characters because they represent a single character**

```
char nl = '\n';
```

UNICODE

- A character set is an ordered list of character, where each character corresponds to a unique number.

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- **Unicode** is an international standard that uses Unicode to represent characters.

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- Variables of type char have 16 bits reserved in the memory to store a value.
- Each character is represented by an integer.
Note: not every integer represent a character!

ASCII VS UNICODE

- ASCII: 7 bits. → It can represent 128 characters.

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- UNICODE: 16 bits → <https://eduassistpro.github.io/>
 - It is a superset of ASCII: the nu map to the same characters both in ASCII and U

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ASCII TABLE

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CHARACTER ARITHMETIC

- Since every character is practically an integer, we can perform arithmetic operations on variables of type char.

```
char first = 'a';  
char second = (
```

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- What is the value of second?

- 'b'

- Note the typecasting!

`first` is automatically converted into an integer, and `first + 1` evaluates to 98.

Then the typecasting converts the `int` into a `char`, and stores 'b' in `second`.

97	61	a
98	62	b
99	63	c
100	64	d
101	65	e
102	66	f
103	67	g
104	68	h
105	69	i
106	6A	j
107	6B	k
108	6C	l
109	6D	m
110	6E	n
111	6F	o
112	70	p
113	71	q
114	72	r
115	73	s
116	74	t
117	75	u
118	76	v
119	77	w
120	78	x
121	79	y
122	7A	z
123	7B	{
124	7C	
125	7D	}
126	7E	~
127	7F	[DEL]

COMPARING CHARS

```
char letter = 'g';
if(letter == 'a') {
    System.out.println("First letter of the alphabet");
} else if (letter == 'a') {
    System.out.println("Updaet");
} else if (letter > 'a' && letter < 'z') {
    System.out.println("Another lett alphabet");
} else {
    System.out.println("Not a lower case letter of the alphabet");
}
```

What prints?

➤ Another letter of the alphabet

TRY IT! - charRightShift

Write a method called `charRightShift` which takes a character and an integer `n` as inputs, and returns a character. If the character received as input is a lower case letter of the English alphabet, the method returns the letter of the alphabet which is `n` positions to the right. If the character received as input is not a lower case letter of the English alphabet, then the method returns the character itself with no change.

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For example:

- `charRightShift('g', 2)` returns `'i'`,
- `charRightShift('#', 2)` returns `'#'`
- `charRightShift('z', 27)` returns `'a'`

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TYPECASTING

- We can convert back and forth between variables of different types using **typecasting**. (or casting, for short)

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```
in https://eduassistpro.github.io/  
double y = 4.56;  
int n = (int) y;  
double m = (double) n;
```

- What are the values of x, y, n, and m?

➤ x = 3, y = 4.56, n = 4, m = 3.0

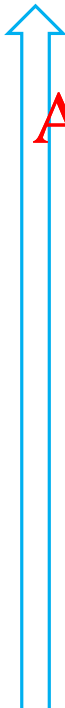

PRIMITIVE TYPE CONVERSION – INT ↔ DOUBLE

- When going from `int` to `double` an explicit cast is NOT necessary.

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- When going from `double` to `int` get a compile-time error if you don't have an explicit cast.

PRIMITIVE TYPE CONVERSION – IN GENERAL

	<i>type</i>	<i>number of bits</i>	
 wider	double	64	 narrower
	int	32	
	char	16	
	short	16	
	byte	8	

*Here, wider usually
(but not always)
means more bytes.*

NOTE: *char is "special"...see the following slides.*

EXAMPLES

```
int i = 3;  
double d = 4.2;  
d = i; // widening (implicit casting)
```

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EXAMPLES

```
int i = 3;  
double d = 4.2;  
d = i; // widening (implicit casting)
```

```
d = 5.3 * i; // narrowing (explicit casting)
```

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EXAMPLES

```
int i = 3;
double d = 4.2;
d = i; // widening (implicit casting)
d = 5.3 * i; // narrowing (explicit casting)
i = (int)d; // narrowing (explicit casting)
float f = (float) d; // narrowing (explicit casting)
```

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EXAMPLES

```
int i = 3;
double d = 4.2;
d = i; // widening (implicit casting)
d = 5.3 * i; // narrowing (explicit casting)
i = (int)d; // narrowing (explicit casting)
float f = (float) d; // narrowing (explicit casting)
```

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- For primitive types, both widening and narrowing change the bit representation. (See COMP 273.)
- For narrowing conversions, you get a compiler error if you don't cast.

EXAMPLES WITH CHAR

```
char c = 'q';  
int x = c
```

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// widening

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EXAMPLES WITH CHAR

```
char c = 'q';
```

```
int x = c // widening
```

```
c = (char) x; //
```

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EXAMPLES WITH CHAR

```
char c = 'q';
```

```
int x = c // widening
```

```
c = (char) x; //
```

```
short y = 12;
```

```
c = y; // compile time error!! (need explicit casting)
```

```
y = c; // compile time error!! Narrowing → need explicit casting
```

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STRING

- Recall that a `String` is sequence of characters.

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- `String` is a **Class** and a string literal is an **Object**.
(more on classes and <https://eduassistpro.github.io/> weeks)

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- We cannot use on Strings the same o use on primitive data types.
- There's a **set of methods** provided to manipulate characters and they can be called **on** values of type `String`.

DOCUMENTATION

You can find it here:

<https://docs.oracle.com/javase/7/docs/api/java/lang/String.html>

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COMPARING STRINGS

- To compare two strings you can use one of the following methods

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- `equals` is case sensitive, use `equalsIgnoreCase` if you don't want to distinguish between upper and lower case.
- Note that there's no keyword `static`!
This means that the methods need to be called on a specific value/variable of type `String` and not on the name of the class (like, for instance, the method `abs` from the `Math` library).

EXAMPLES

String course1 = "CMP010";
String course2 = "CMP010";
boolean a = course1.equals(course2);
boolean b = course1.equals(course2);

- The value of a is false
- The value of b is true

BE CAREFUL!



- If you try to use `String` you program will compile and run.
It is **not** doing what <https://eduassistpro.github.io/>
[Add WeChat edu_assist_pro](#)
- Always use `equals` or `equalsIgnoreCase` if you want to compare strings.

OTHER METHODS

Let `s` be a variable of type `String`. Then some useful methods include:

- `s.length()`

It takes no inputs and returns the number of characters in the `String s`.

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- `s.charAt(i)`

It takes an integer as input and returns the character in the `String s` which has index equal to `i`. The index determines the position of the character in the `String`. Note that the first character is in position 0.

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If in the `String s` there's no character with index `i`, then we will get a run-time error. (`StringIndexOutOfBoundsException`)

EXAMPLE

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```
String s = "Another string";
```

```
System.out.println(s);
```

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What prints?

➤ 14

EXAMPLE

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```
String s
```

```
System.out.println("2)");
```

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What prints?



EXAMPLE

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```
String s
```

```
System.out
```

```
    .println(https://eduassistpro.github.io/  
            s.charAt(0) == 'a' );
```

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What prints?

➤ false

REVIEW – METHODS FROM THE STRING CLASS

```
String s = "Review";
```

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Example – method		Return type	Return value
<code>s.equals("review")</code>		boolean	false
<code>s.equalsIgnoreCase("review")</code>		boolean	true
<code>s.length()</code>	none	int	6
<code>s.charAt(2)</code>	int	char	'v'
<code>s.toLowerCase()</code>	none	String	"review"
<code>s.toUpperCase()</code>	none	String	"REVIEW"

CONVERTING TYPES WITH STRINGS

You cannot use a cast when converting from a String.

- To convert from `int/double` to a String, just concatenate the number with the empty String `""`.

```
String s = "54";
```

- To convert from a String to an `int`,

```
int x = Integer.parseInt("54");  
String s = "5";  
int y = Integer.parseInt(s);
```

- To convert from a String to a double, use:

```
double z = Double.parseDouble("5.4");
```

TRY IT!

1. Write a method that takes a `String` as input and prints `true` if the `String` received is equal to a password (you, the programmer, can choose the password) `print false` otherwise.

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2. Write a method that takes a `String` and `int i` as input. The method should return `true` if the character at index `i` is a vowel, `false` otherwise.

An orange paint roller with a red handle, positioned horizontally. The roller is covered in orange paint, which is dripping down the left side. The text "Coming Soon" is written in white on the orange surface of the roller.

Coming Soon

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In the next <https://eduassistpro.github.io/> g about arrays
and refer

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