COMP 250

INTRODUC   TER SCIENCE

Week 2-1: Primitive Dat   rings

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- **Primitive data types**

- `char`

- `String`

- **type conversion**

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PRIMITIVE TYPES

A **primitive** type is

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- predefined by the

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- named by a reser

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Java supports 8 primitive data types.

byte

short

int

long

Integer values

float

double

Real Numbers

boolean   true **or** false

char   One character

https://docs.oracle.com/javase/tutorial/java/nutsandbolts/datatypes.html

How many values can you represent with:

- 1 bit?

- 2 bits?

- 3 bits?

- And what about n bits?

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$$2^n$$

And how many bits do you need to represent:

- 2 different values?

- 4 different val

- 5 different values?

- And what about x different v

$$\lceil \log_2 x \rceil$$

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

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

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What is the relationship between m and N ?

Recall that,

$$\sum_{i=0}^{N-1} x^i = 1 \text{https://eduassistpro.github.io/} \frac{x^N - 1}{x - 1}$$

That is, if $x = 2$,

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

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

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

$$= 2^N - 1$$

$$< 2^N$$

Thus,

$$m < 2^N$$

To s̶ ̶e take the log (base 2) of both sides and obtain the following equation:

$$\boxed{N > \log_2 m}$$

Lower bound

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, $(\ldots 0000000 10011)_2$

Then,

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

Taking the log (base 2) of both sides,

$$\log_2 m \geq N - 1 \qquad \Rightarrow \qquad \boxed{N \leq (\log_2 m) + 1}$$

Upper Bound

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We proved that,

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

Thus, N must be equal to the largest inte

n or equal to $(\log_2 m) + 1$. We write,

$$N = floor\big((\log_2 m) + 1\big) = \lfloor (\log_2 m) + 1 \rfloor$$

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

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)

  - $-2^{31} = -21474836$ (~~IN_VALUE~~)

- What happens if:

```
int x = 2147483647;

System.out.println(x+1);
```

```
int y = -2147483648;

System.out.println(y-1);
```

```
Output:-2147483648
```

```
Output 2147483647
```

Let's pretend that we only have 8 bits.

7 bits are used to store the number, and the leftmost bit for the sign.

0 means positive and

0111 1111

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 leftmost bit for the sign.
0 means positive and

$$0111\,1111$$

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

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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 distingu

  If you write .0 after an integer, it w   dered 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.

```
double x =                    bad style!
```

- If the mathematical operators are used with an 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

CHAR DATA TYPE

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

- We can declare and in   e `char` as follows:

```
char lette
```

- Character literals appears in <u>single quotes</u>

- Character literals can only contain a single character

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

- Examples:

  - `\n` represents the Assignment Project Exam Help

  - `\"` or `\'` represent quotation mar https://eduassistpro.github.io/

  - `\t` represents a tab.

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

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

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

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- **Unicode** is an internati   uses Unicode to represent

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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 →

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- It is a superset of ASCII: the nu   map to the same
characters both in ASCII and U

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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 = (
```

- 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]

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

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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` positio

received as input is not a lower case lette   lish alphabet, then the
method returns the character itself with n   ons.

For example:

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

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

```
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double y = 4.
int n = (int)       Add WeChat edu_assist_pro
double m = (double) x;
```

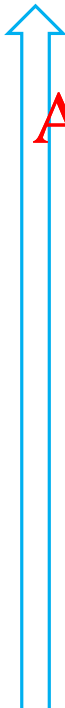- What are the values of `x, y, n,` and `m`?
  - ➢ `x = 3, y = 4.56, n = 4, m = 3.0`

PRIMITIVE TYPE CONVERSION – INT ↔ DOUBLE

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

- When going from `double` to `in`

PRIMITIVE TYPE CONVERSION – IN GENERAL

type	*number of bits*
double	64
int	
char	16
short	16
byte	8

wider

narrower

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

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

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

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


d = 5.3 * i;  // n")
```

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


d = 5.3 * i;  // (              n")


i = (int)d;  // narrowing (by
float f = (float) d; // nar              y casting)
```

EXAMPLES

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


d = 5.3 * i;  //                         n")


i = (int)d;  // narrowing (by
float f = (float) d; // nar              y casting)
```

- 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.

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

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

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

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```
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.

- `String` is a **Class** and a string literal is an **Object**.
  (more on classes and objects)

- 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

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You can find it here:
https://docs.oracle.com/java
se/7/docs/api/java/lang/Stri
ng.html

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

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- `equals` is case sensitive, use `equals` 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).

```
String course           Assignment Project Exam Help
String course
boolean a = c          https://eduassistpro.github.io/    );
boolean b = course.equals          e(course2);
```

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- **The value of** `a` **is** `false`

- **The value of** `b` **is** `true`

BE CAREFUL!

- If you try to use ~~compare Strings~~ you program will
compile and run.
It is **not** doing what ~~you want it to do~~.

- **Always use** `equals` **or** `equalsIgnoreCase` **if you want to**
compare strings.

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 return ter in the `String s`

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  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.

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

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```
String s = "Another string";

System.ou
```

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What prints?

➢ 14

```
String s

System.ou                        2));
```

What prints?

➢ o

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```
String s
System.ou                          https://eduassistpro.github.io/ 0)=='a');
```

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What prints?

➢ `false`

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

Example – method		Return type	Return value
s.equals("review")		boolean	false
s.equalsIgnoreCase("review")		boolean	true
s.length()	none	int	6
s.charAt(2)	int	char	'v'
s.toLowerCase()	none	String	"review"
s.toUpperCase()	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    https://eduassistpro.github.io/
```

➤ To convert from a `String` to an in

```
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");
```

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 passwor~~d~~ ~~and~~ ~~pri~~nt `false` otherwise.

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

Coming Soon

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In the next   g about arrays

and refer https://eduassistpro.github.io/

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