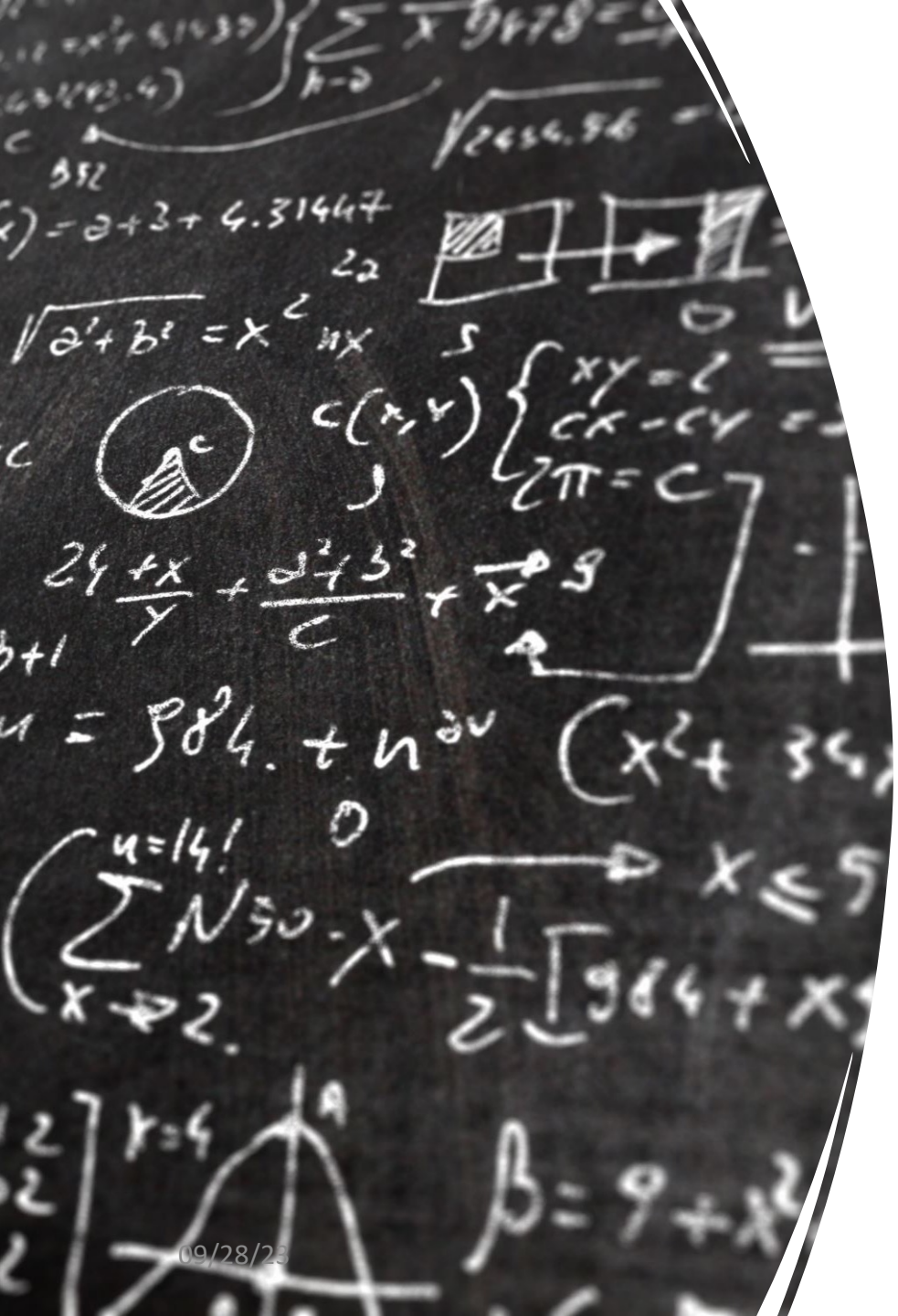


CS 113 – Computer Science I

Lecture 08 – Recursion, Strings, Arrays

Thursday 09/28/2023

Announcements

- HW02:
  - Due tonight
- HW03 – releasing tonight
  - Due Monday 10/02
- **Read & Follow Instructions**
  - Don’t just skim the labs & homework

Agenda

Recursion

Comparing strings

- In Java, you cannot directly compare strings using ==

- Instead, use **compareTo**
  - Javadocs: https://docs.oracle.com/javase/7/docs/api/java/lang/String.html

compareTo

```
public int compareTo(String anotherString)
```

Compares two strings lexicographically. The comparison is based on the Unicode value of each character in the strings. The character sequence represented by this `String` object is compared lexicographically to the character sequence represented by the argument string. The result is a negative integer if this `String` object lexicographically precedes the argument string. The result is a positive integer if this `String` object lexicographically follows the argument string. The result is zero if the strings are equal; `compareTo` returns `0` exactly when the `equals(Object)` method would return `true`.

This is the definition of lexicographic ordering. If two strings are different, then either they have different characters at some index that is a valid index for both strings, or their lengths are different, or both. If they have different characters at one or more index positions, let *k* be the smallest such index; then the string whose character at position *k* has the smaller value, as determined by using the < operator, lexicographically precedes the other string. In this case, `compareTo` returns the difference of the two character values at position `k` in the two string -- that is, the value:

```
this.charAt(k)-anotherString.charAt(k)
```

If there is no index position at which they differ, then the shorter string lexicographically precedes the longer string. In this case, `compareTo` returns the difference of the lengths of the strings -- that is, the value:

```
this.length()-anotherString.length()
```

Specified by:

`compareTo` in interface `Comparable<String>`

Parameters:

`anotherString` - the `String` to be compared.

Returns:

the value `0` if the argument string is equal to this string; a value less than `0` if this string is lexicographically less than the string argument; and a value greater than `0` if this string is lexicographically greater than the string argument.

```
public int compareTo(String anotherString)
```

Parameters:

`anotherString` - the `String` to be compared.

Returns:

- the value 0 if the argument string is equal to this string;
- a value less than 0 if this string is lexicographically less than the string argument;
- and a value greater than 0 if this string is lexicographically greater than the string argument.

Comparing strings

- In Java, you cannot directly compare strings: use **compareTo**

```
String a = “apple”;
String b = “banana”;
if (a.compareTo(b) == 0) {
   System.out.println(“a and b match!”);
}
if (a.compareTo(b) != 0) {
 System.out.println(“a and b DO NOT match!”);
}
```

Lexicographic Values/Order

- Strings are **ordered lexicographically**
  - Generally, the same order as alphabetical order, with some caveats
  - The characters of a string each correspond to a number

ASCII

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH (start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX (start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX (end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT (end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ (enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK (acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL (bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS (backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB (horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF (NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT (vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF (NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR (carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO (shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI (shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE (data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1 (device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2 (device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3 (device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4 (device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK (negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN (synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB (end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN (cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM (end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB (substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC (escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS (file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS (group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS (record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US (unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

Source: www.LookupTables.com

https://www.asciitable.com/

StringCompare.java

```
String first = "a";
String second = "A";
int asciia = (int) first.charAt(0);
int asciib = (int) second.charAt(0);
System.out.println("ASCII Code for "+first+" is " + asciia);
System.out.println("ASCII Code for "+second+" is " + asciib);

if (first.compareTo(second) == 0) {
   System.out.println(first+" is equal to "+second);
}
else if (first.compareTo(second) < 0) {
   System.out.println(first+" is less than "+second);
}
else if (first.compareTo(second) > 0) {
   System.out.println(first+" is greater than "+second);
}
```

```
$ java StringCompare
ASCII Code for a is 97
ASCII Code for A is 65
a is greater than A
```

Exercise: IsPrimary

Write a program that asks the user for a color and prints whether the color is primary or not.

- The primary colors are “red”, “green”, “blue”
- All other inputs are non-primary

```
$ java IsPrimary
Enter a color: green
green is not primary

$ java IsPrimary
Enter a color: blue
blue is primary
```

Top down design

1. Identify features of the program
    1. List them out!
2. Identify verbs and nouns in feature list
    1. Verbs: functions
    2. Nouns: objects/variables
3. Sketch major steps – how features should fit together
    1. Algorithm!
4. Write program skeleton
    1. Include method **stubs** (placeholders for our functions)
    2. method **stub:** empty function with parameters and return type
5. Implement and test method stubs one at a time

Smart way to wash dishes

Punt the problem to someone else

But we want to wash one dish so we can say we washed a dish

Recursion

a function that calls itself

“Simple” way to solve “similar” problems

Creating a recursive algorithms

Rule that “does work” then ”calls itself” on a smaller version of the problem

Base case that handles the smallest problem

Prevents “infinite recursion”

Recursion Example – Contains letter

Write a method called “containsLetter” that determines if a String contains a given character

Question: What are the parameters?

1. The String to be looking in
2. The character to look for

Question: What is the return type?

Recursion Example – Contains letter

How can we break this problem down into smaller problems?

contains(“l”, “apple”) =

contains(“l”, “a”) OR

contains(“l”, “p”) OR

contains(“l”, “p”) OR

contains(“l”, “l”) OR

contains(“l”, “e”) OR

Recursion Visualization – Contains letter

contains(“l”, “apple”) =

contains(“l”, “apple”)

contains(“l”, “pple”)

contains(“l”, “ple”)

contains(“l”, “le”)

return true

Recursion Example – IndexOf letter

Write a method called IndexOf.

Arguments: String (haystack), Character (needle)

Return: the index of the character in the String, if the chatacter isnt there, return:

-1.

Recursion Example – printVowels

Write a recursive function that prints just the vowels in a String

Recursion limitations

- Limited number of times we can recurse
  - Stackoverflow – too many frames
- Potentially memory inefficient
  - If we copy data in subproblems – we'll worry about this in a few weeks
- Performance: might duplicate unnecessary work
  - We'll define performance later in the semester

Style

- How we format our programs is **very** important
  - Like rules of etiquette around eating and keep a clean appearance
  - Like punctuation rules, it helps make text more readable
- Variable names should be descriptive
- Indentation is **very** important
  - Every statement inside a pair of braces must be indented
- Braces should be placed consistently

Arrays

Strings revisited

Arrays

Arrays

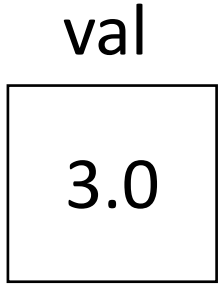
Idea: Store multiple values into a single variable

Values are sequential

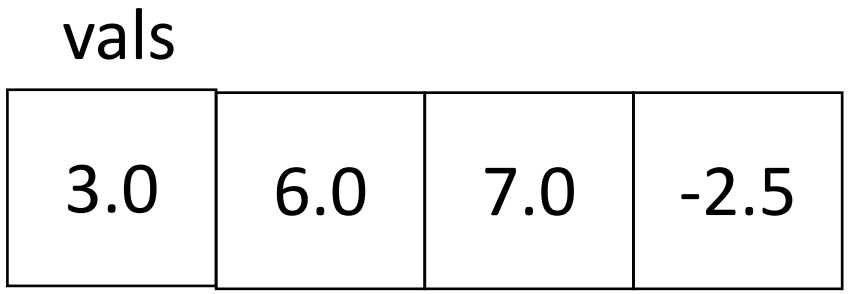
Analogous to a list

Arrays

```
double val = 3.0;
```




```
double[] vals = {3.0, 6.0, 7.0, -2.5};
```



Arrays

Three ways to initialize an array

1. With an initial value
```
int[] numbers = {1, 2, 5};
```

2. With allocated space, but uninitialized
```
int[] numbers = new int[3];
```

3. With an empty array reference
```
int[] numbers = null;
```

Array Indexing

Access individual elements of an array with indexing

array[index]

We use *zero*-based indexing

first element is **0**

last element is **length-1**

Accessing indices out of range results in a **runtime error**!

Exercise: print backwards

Write a program, Backwards.java, that asks the user for 3 integers and then prints the list of numbers in reverse order

Strings

Strings are implemented as *arrays of characters*

Get the length of a string with length()

```
String greeting = “hola”;
int len = greeting.length(); // what is the length?
char c = greeting[2]; // what character is in index 2?
```

char: New built-in type, denoted with single quote, e.g. ‘a’ or ‘{‘

Strings as an array of characters

String str = “hello world”

- How many characters in this String?

  10

- How do we access the first character?

  str.charAt(0)

- How do access the 5th character?

  str.charAt(4)

Exercise: GetCharacters.java

Write a program, GetCharacters.java, that asks the user for a word and then prints the first, last and middle character.

```
Enter a word: hola!
FirstIndex: 0 FirstCharacter: h
MiddleIndex: 2 MiddleCharacter: l
LastIndex: 5 LastCharacter: !
```

Command line arguments

```
public static void main(String[] args)
```

Command line arguments are an *array of String*

Exercise: Write a program called commandLineArgs.java that

1) prints out 3 command line arguments that are passed in.
2) Compute the sum of three command line arguments (assuming they are integers)

Recursion Example – printList

Write a recursive function that prints the contents of an array