Chapter 4

Core APIs

Creating and Manipulating Strings

Concatenating

3 rules of +

- If both operands are numeric → addition
- If either operand is a String → concatenation
- The expression is evaluated left to right

```
1 + 2;          // 3
"a" + "b";      // ab
"a" + "b" + 3;  // ab3
1 + 2 + "c";    // 3c
"c" + 1 + 2;    // c12
"c" + null;     // cnull
```

Important String Methods (String is immutable)

1/ Determining the length

public int length()

2/ Getting a single character

public char charAt(int index)

→ throws exception if index is out of range

3/ Finding an index

public int indexOf(int ch) → can pass a char

(int ch, int fromIndex)

(String str)

(String str, int fromIndex)

→ returns the 1st index matching the desired value

→ returns -1 if it can't find the match

4/ Getting a substring

public String substring(int beginIndex)

(int beginIndex, int endIndex)

→ begin = end : empty string

→ begin > end or end is out of range : exception

5/ Adjusting case

public String toLowerCase()

public String toUpperCase()

6/ Checking for equality

public boolean equals(Object obj)

publir boolean equalsIgnoreCase(String str)

7/ Searching for substrings

public boolean startsWith(String prefix)

public boolean endsWith(String suffix)

public boolean contains(CharSequence charSeq)

8/ Replacing values

public String replace(char oldChar, char newChar)

(CharSequence target,

CharSequence replacement)

9/ Removing whitespace

whitespace = space + \t (tab) + \n (newline)

public String strip() → supports Unicode
public String stripLeading()
public String stripTrailing()
public String trim()

10/ Working with indentation

public String indent(int numberSpaces)
public String stripIndent()

\r\n becomes \n

Method	Indent change	Normalizes existing line breaks	Adds line break at end if missing
`indent(n)` where n > 0	Adds n spaces to beginning of each line	Yes	Yes
`indent(n)` where n == 0	No change	Yes	Yes
`indent(n)` where n < 0	Removes up to n spaces from each line where the same number of characters is removed from each non-blank line	Yes	Yes
`stripIndent()`	Removes all leading incidental whitespace	Yes	No

Scanned with CamScanner

```
10: var block = """
11:             a \n
12:             b \n
13:             c""";
14: var concat = " a\n"
15:            + "  b\n"
16:            + " c";
17: System.out.println(block.length());                    // 6
18: System.out.println(concat.length());                   // 9
19: System.out.println(block.indent(1).length());          // 10
20: System.out.println(concat.indent(-1).length());        // 7
21: System.out.println(concat.indent(-4).length());        // 6
22: System.out.println(concat.stripIndent().length());     // 6
```

Scanned with CamScanner

11/ Translating escapes

public String translateEscapes()

```
var str = "1\\t2";
System.out.println(str);                    // 1\t2
System.out.println(str.translateEscapes()); // 1   2
```

12/ Checking for empty or blank Strings

public boolean isEmpty()

public boolean isBlank()

13/ Formatting values

public static String format(String format, Object args...)
(Locale loc, String format,
Object args...)

public String formatted(Object args...)

```
var name = "Kate";
var orderId = 5;

// All print: Hello Kate, order 5 is ready
System.out.println("Hello "+name+", order "+orderId+" is ready");
System.out.println(String.format("Hello %s, order %d is ready",
    name, orderId));
System.out.println("Hello %s, order %d is ready"
    .formatted(name, orderId));
```

Scanned with CamScanner

Symbol	Description
%s	Applies to any type, commonly String values
%d	Applies to integer values like int and long
%f %0.1f	Applies to floating-point values like float and double (default: 6 digits
%n ↳ rounding	Inserts a line break using the system-dependent line separator past the .)

The following example uses all four symbols from Table 4.2:

```
var name = "James";
var score = 90.25;
var total = 100;
System.out.println("%s:%n   Score: %f out of %d"
   .formatted(name, score, total));
```

This prints the following:

```
James:
   Score: 90.250000 out of 100
```

Scanned with CamScanner

```
var pi = 3.14159265359;
System.out.format("[%f]",pi);       // [3.141593]
System.out.format("[%12.8f]",pi);   // [  3.14159265]
System.out.format("[%012f]",pi);    // [00003.141593]
System.out.format("[%12.2f]",pi);   // [        3.14]
System.out.format("[%.3f]",pi);     // [3.142]
```

Scanned with CamScanner

Using the StringBuilder

```
String alpha = "";
for (char current = 'a'; current <= 'z'; current++)
  alpha += current;
```

Loop 1: alpha → `""`

Loop 2: alpha

`""` → eligible for garbage collection

`"a"` → new object, since String is immutable

Mutability & Chaining

```
StringBuilder a = new StringBuilder("abc");
StringBuilder b = a.append("de");
b = b.append("f").append("g");
```

Both a & b are "abcdefg"

Creating a StringBuilder

```
new StringBuilder();  // empty
new StringBuilder("abc");  // "abc"
new StringBuilder(10);  // 10 slots for char.
```

Important StringBuilder Methods

1/ Common methods: substring(), indexOf(), length(), charAt()

↙

returns a String

rather than a StringBuilder

2/ Appending values

public StringBuilder append(String str)
(int val)
(char val)...

```
new StringBuilder().append(1)
                   .append('c')
                   .append("-")
                   .append(true);
// 1c-true
```

3/ Inserting data (lots of method signatures for different types)

public StringBuilder insert(int offset, String str)

↙ insert the param to this index

4/ Deleting contents

public StringBuilder delete(int startIndex, int endIndex)

public StringBuilder deleteCharAt(int index)

past the end → OK, delete to the end

5/ Replacing portions

public StringBuilder replace(int startIndex, int endIndex, String newString)

deletes characters, then inserts

6/ Reversing

public StringBuilder reverse()

Understanding Equality

```
var x = "Hello World";
var y = " Hello World".trim();
System.out.println(x.equals(y)); // true
```

StringBuilder doesn't implement equals()

→ calling equals() will check reference equality (same as ==)

The String Pool

A location in the JVM, containing literal values & constants that appear in our program

```
var x = "Hello World";
var y = "Hello World";
System.out.println(x == y); // true
```

only 1 literal in memory

```
var x = "Hello World";
var z = " Hello World".trim();
System.out.println(x == z); // false
```

computed at runtime → new obj

```
var singleString = "hello world";
var concat = "hello ";
concat += "world";
System.out.println(singleString == concat); // false
```

new str.

intern() method will use an object in the string pool if one is present. Otherwise, Java will add this literal to the string pool.

```
var name = "Hello World";
var name2 = new String("Hello World").intern();
System.out.println(name == name2); // true
```

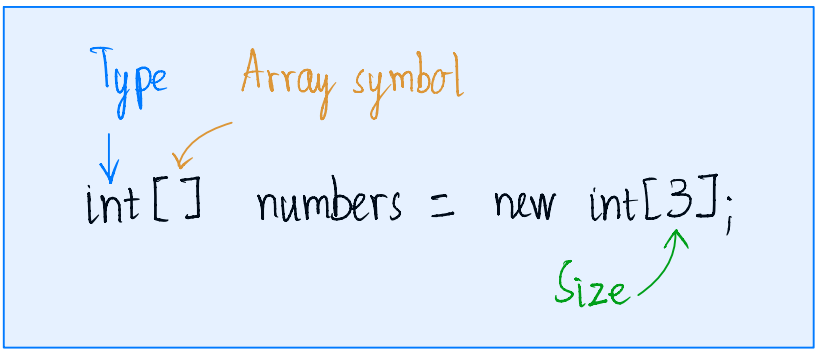
```
var first = "rat" + 1;
var second = "r" + "a" + "t" + "1";
var third = "r" + "a" + "t" + new String("1");
```

Both first & second values are compile-time constants
→ share the same string pool reference

third does not point to a reference in the string pool

Understanding Arrays

Creating an Array of Primitives



All elements are set to the default value for that type

```
int[] moreNumbers = new int[] {42, 55, 99};
```

```
int[] moreNumbers = {42, 55, 99};
```

```
int [] arr1;
int []arr2;
```

```
int arr3[];
int arr4 [];
```

Creating an Array with Reference Variables

```
String[] bugs = {"cricket", "beetle", "ladybug"};
```

```
3: String[] strings = { "stringValue" };
4: Object[] objects = strings;
5: String[] againStrings = (String[]) objects;
6: againStrings[0] = new StringBuilder();  // DOES NOT COMPILE
7: objects[0] = new StringBuilder();       // Careful!
```

> String[]

Scanned with CamScanner

throws an ArrayStoreException

at runtime (since "objects" still refers to String[])

Sorting

```
import java.util.*;
```

or `import java.util.Arrays;`

→ `Arrays.sort(<array>);` // Sort ascending

String sorts in alphabetic order: number < upper < lower

Ex: {"10", "9", "100"} → 10 100 9

Searching

Scenario	Result
Target element found in sorted array	Index of match
Target element not found in sorted array	Negative value showing one smaller than the negative of the index, where a match needs to be inserted to preserve sorted order
Unsorted array	A surprise; this result is undefined

unpredictable
not error

Let's try these rules with an example:

```
3: int[] numbers = {2,4,6,8};
4: System.out.println(Arrays.binarySearch(numbers, 2)); // 0
5: System.out.println(Arrays.binarySearch(numbers, 4)); // 1
6: System.out.println(Arrays.binarySearch(numbers, 1)); // -1
7: System.out.println(Arrays.binarySearch(numbers, 3)); // -2
8: System.out.println(Arrays.binarySearch(numbers, 9)); // -5
```

Comparing

compare()

Arrays.compare(arr1, arr2);

< 0 : arr1 < arr2

= 0 : arr1 = arr2

> 0 : arr1 > arr2

* arr1 & arr2 must be the same array type

- `null` is smaller than any other value.
- For numbers, normal numeric order applies.
- For strings, one is smaller if it is a prefix of another.
- For strings/characters, numbers are smaller than letters.
- For strings/characters, uppercase is smaller than lowercase.

Table 4.4 shows examples of these rules in action.

TABLE 4.4 `Arrays.compare()` examples

First array	Second array	Result	Reason
`new int[] {1, 2}`	`new int[] {1}`	Positive number	The first element is the same, but the first array is longer.
`new int[] {1, 2}`	`new int[] {1, 2}`	Zero	Exact match
`new String[] {"a"}`	`new String[] {"aa"}`	Negative number	The first element is a substring of the second.
`new String[] {"a"}`	`new String[] {"A"}`	Positive number	Uppercase is smaller than lowercase.
`new String[] {"a"}`	`new String[] {null}`	Positive number	`null` is smaller than a letter.

mismatch()

Arrays.mismatch(arr1, arr2);

arr1 = arr2 : -1

arr1 ≠ arr2 : the 1st index where they differ

Using Methods with Varargs

```
public static void main(String... args)
```

Working with Multidimensional Arrays

```
int[][] vars1;
int vars2 [][];
int[] vars3[];
int[] vars4 [], space [][] // 2D & 3D
```

```
String[][] rectangle = new String[3][2];
int[][] differentSizes = {{1,4}, {3}, {9,8,7}};
```

```
int[][] args = new int[4][];
args[0] = new int[5];
arg[1] = new int[3];
```

It is legal to leave out the size for later dimensions, the first one is required

Calculating with Math APIs

Minimum & Maximum

```
public static <type> min (<type> a, <type> b)
```

<type> can be
- double
- float
- int
- long

The same for max() method

Rounding Numbers

```
public static long round(double num)
public static int round(float num)
```

>/ .5 → round up ↑

< .5 → round down ↓

Ceiling & Floor

```
public static double ceil(double num)
```

* whole number → returns the same value
* has any fractional value → rounds up to the next whole number

Ex: `double c = Math.ceil(3.14); // 4.0`

```
public static double floor(double num)
```

discards any fractional value

Ex: `double f = Math.floor(3.14); // 3.0`

Exponents

```
public static double pow(double number,
                         double exponent)
```

Ex: `double squared = Math.pow(5, 2); // 25.0`

Random Numbers

```
public static double random()
```

$0.0 \leq result < 1.0$

Working with Dates & Times

```
import java.time.*;
```

Creating Dates & Times

```
LocalDate.now(); // just date (no time & no timezone)
LocalTime.now(); // just time (no date & no timezone)
LocalDateTime.now(); // date & time but no timezone
ZonedDateTime.now(); // date, time, & timezone
```

```
public static LocalDate of(int year, int month,
                           int dayOfMonth)
                of(int year, Month month,
                           int dayOfMonth)
```

```
var date1 = LocalDate.of(2022,
                         Month.JANUARY, 20);
var date2 = LocalDate.of(2022, 1, 20);
```

```
public static LocalTime of(int hour, int minute)
                          (int hour, int minute, int second)
                          (int hour, int minute, int second,
                                                 int nanos)
```

```
public static LocalDateTime of(int year, int month,
    int dayOfMonth, int hour, int minute, int second, int nanos)
```

can use Month instead

can ignore

```
                of(LocalDate date, LocalTime time)
```

```
public static ZonedDateTime of(int year, int month, int dom,
                               int hour, int minute, int second, int nanos,
                               ZoneId zone)
```

no Month enum

```
of(LocalDate date,
   LocalTime time,
   ZoneId zone)

of(LocalDateTime dateTime,
   ZoneId zone)
```

```
var zone = ZoneId.of("US/Eastern");
var zoned1 = ZonedDateTime.of(2022, 1, 20,
                              6, 15, 30, 200, zone);
```

The date & time classes have private constructors along with static methods that return instances

```
var d = new LocalDate(); // Error
var d = LocalDate.of(2022, 1, 32);
// DateTimeException
```

Manipulating Dates & Times

The date & time classes are immutable

	Can call on LocalDate?	Can call on LocalTime?	Can call on LocalDateTime or ZonedDateTime?
plusYears() minusYears()	Yes	No	Yes
plusMonths() minusMonths()	Yes	No	Yes
plusWeeks() minusWeeks()	Yes	No	Yes
plusDays() minusDays()	Yes	No	Yes
plusHours() minusHours()	No	Yes	Yes
plusMinutes() minusMinutes()	No	Yes	Yes
plusSeconds() minusSeconds()	No	Yes	Yes
plusNanos() minusNanos()	No	Yes	Yes

Working with Periods

```
Period.ofYears(1); // every 1 year
Period.ofMonths(3); // every 3 months
Period.ofWeeks(3); // every 3 weeks
Period.ofDays(2); // every 2 days
Period.of(1, 0, 7); // every year & 7 days
```

```
var wrong = Period.ofYears(1).ofWeeks(1);
```

only the last method is used

⇐

```
var wrong = Period.ofYears(1);
wrong = Period.ofWeeks(1);
```

```
System.out.println(Period.of(1, 2, 3)); // P1Y2M3D
System.out.println(Period.ofMonths(3)); // P3M
```

```
3:  var date = LocalDate.of(2022, 1, 20);
4:  var time = LocalTime.of(6, 15);
5:  var dateTime = LocalDateTime.of(date, time);
6:  var period = Period.ofMonths(1);
7:  System.out.println(date.plus(period));     // 2022-02-20
8:  System.out.println(dateTime.plus(period)); // 2022-02-20T06:15
9:  System.out.println(time.plus(period));     // Exception
```

Working with Durations

```
Duration.ofDays(1); // PT24H
Duration.ofHours(1); // PT1H
Duration.ofMinutes(1); // PT1M
Duration.ofSeconds(10); // PT10S
Duration.ofMillis(1); // PT0.001S
Duration.ofNanos(1); // PT0.000000001S
```

```
Duration.of(1, ChronoUnit.DAYS);
```

implementation of TemporalUnit

- HOURS
- MINUTES
- SECONDS
- MILLIS
- NANOS
- HALF_DAYS ...

```
var one = LocalTime.of(5, 15);
var two = LocalTime.of(6, 30);
var date = LocalDate.of(2016, 1, 20);
ChronoUnit.HOURS.between(one, two); // 1
ChronoUnit.MINUTES.between(one, two); // 75
ChronoUnit.MINUTES.between(one, date); // DateTimeExc.
```

```
LocalTime time = LocalTime.of(3, 12, 45);
System.out.println(time); // 03:12:45
LocalTime truncated = time.truncatedTo(
                ChronoUnit.MINUTES);
System.out.println(truncated); // 03:12
```

	Can use with `Period`?	Can use with `Duration`?
`LocalDate`	Yes	No
`LocalDateTime`	Yes	Yes
`LocalTime`	No	Yes
`ZonedDateTime`	Yes	Yes

Working with Instants

The Instant class represents a specific moment in time in the GMT time zone

———— || ————

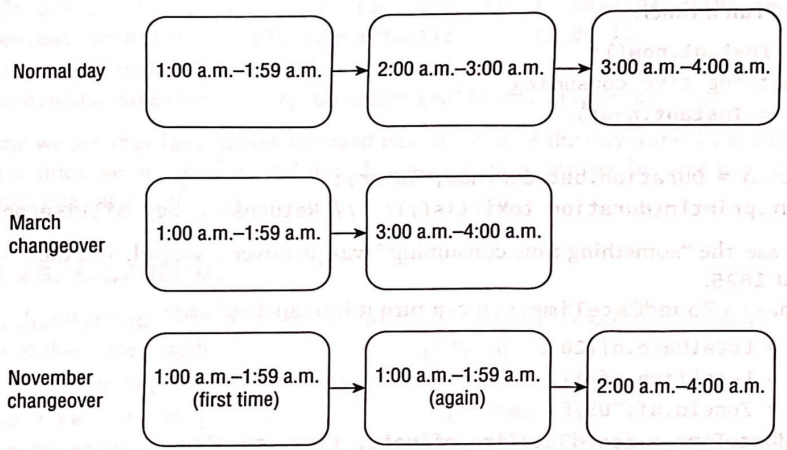
```
var now = Instant.now();
// do something time consuming
var later = Instant.now();
var duration = Duration.between(now, later);
System.out.println(duration.toMillis());
```

```
var date = LocalDate.of(2022, 5, 25);
var time = LocalTime.of(11, 55, 00);
var zone = ZoneId.of("US/Eastern");
var zonedDateTime = ZonedDateTime.of(date, time, zone);
var instant = zonedDateTime.toInstant(); // 2022-05-25T15:55:00Z
System.out.println(zonedDateTime); // 2022-05-25T11:55-04:00[US/Eastern]
System.out.println(instant); // 202-05-25T15:55:00Z
```

gets rid of the timezone & turns it into an Instant of time in GMT

CANNOT convert a LocalDateTime to an Instant (not contain a timezone)

Accounting for Daylight Saving Time




```
var date = LocalDate.of(2022, Month.MARCH, 13);
var time = LocalTime.of(1, 30);
var zone = ZoneId.of("US/Eastern");
var dateTime = ZonedDateTime.of(date, time, zone);
System.out.println(dateTime);  // 2022-03-13T01:30-05:00[US/Eastern]
System.out.println(dateTime.getHour());    // 1
System.out.println(dateTime.getOffset()); // -05:00

dateTime = dateTime.plusHours(1);
System.out.println(dateTime);  // 2022-03-13T03:30-04:00[US/Eastern]
System.out.println(dateTime.getHour());    // 3
System.out.println(dateTime.getOffset()); // -04:00
```

```
var date = LocalDate.of(2022, Month.NOVEMBER, 6);
var time = LocalTime.of(1, 30);
var zone = ZoneId.of("US/Eastern");
var dateTime = ZonedDateTime.of(date, time, zone);
System.out.println(dateTime); // 2022-11-06T01:30-04:00[US/Eastern]

dateTime = dateTime.plusHours(1);
System.out.println(dateTime); // 2022-11-06T01:30-05:00[US/Eastern]

dateTime = dateTime.plusHours(1);
System.out.println(dateTime); // 2022-11-06T02:30-05:00[US/Eastern]
```

```
var date = LocalDate.of(2022, Month.MARCH, 13);
var time = LocalTime.of(2, 30);
var zone = ZoneId.of("US/Eastern");
var dateTime = ZonedDateTime.of(date, time, zone);
System.out.println(dateTime);    // 2022-03-13T03:30-04:00[US/Eastern]
```

Review Questions

1/ ~~A C~~ F (can't store int → String)

2/ C E F (declare size for 1st dim)

3/ A C D ✓ (Java can adjust for DST)

4/ A C D ✓

5/ B ✓

6/ ~~E~~ C (widening primitive conversion)

7/ ~~B~~ E A (earlier → <)

8/ A ~~B~~ ~~E~~ F (length() is method)

9/ A C F ✓ (arrays don't override equals())

10/ ~~B~~ A (same as #6)

11/ E ✓

12/ A D E ✓

13/ B ✓ (immutable vs. mutable)

14/ A F ✓

15/ C E ✓

16/ B ~~D~~ ~~E~~ A G ("base" is 2-line)

17/ A G ✓

18/ C ~~E~~ F (from Str. pool ≠ from building)

19/ B D A (P > L)

20/ A D ✓

21/ A C ✓

22/ A ✓ (using Month enum → getMonth() return name)

59,1%