eC Academy

Realize Your Dreams

AP Computer Science A Review

Week 2: Basic Programming

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SECTION 1

Package and Classes

Package and Classes

- A typical Java program has user-defined classes whose objects interact with those from Java class libraries. In Java, related classes are grouped into packages, many of which are provided with the compiler. For example, the package **java.util** contains the collections classes. Note that you can put your own classes into a package-this facilitates their use in other programs.
- The package **java.lang**, which contains many commonly used classes, is automatically provided to all Java programs. To use any other package in a program, an import statement must be used. To import all of the classes in a package called `packagename`, use the form

Package

```
import packagename.*;
```

Note that the package name is all lowercase letters. To import a single class called ClassName from the package, use

```
import packagename.ClassName;
```

Java has a hierarchy of packages and sub-packages. Sub-packages are selected using multiple dots:

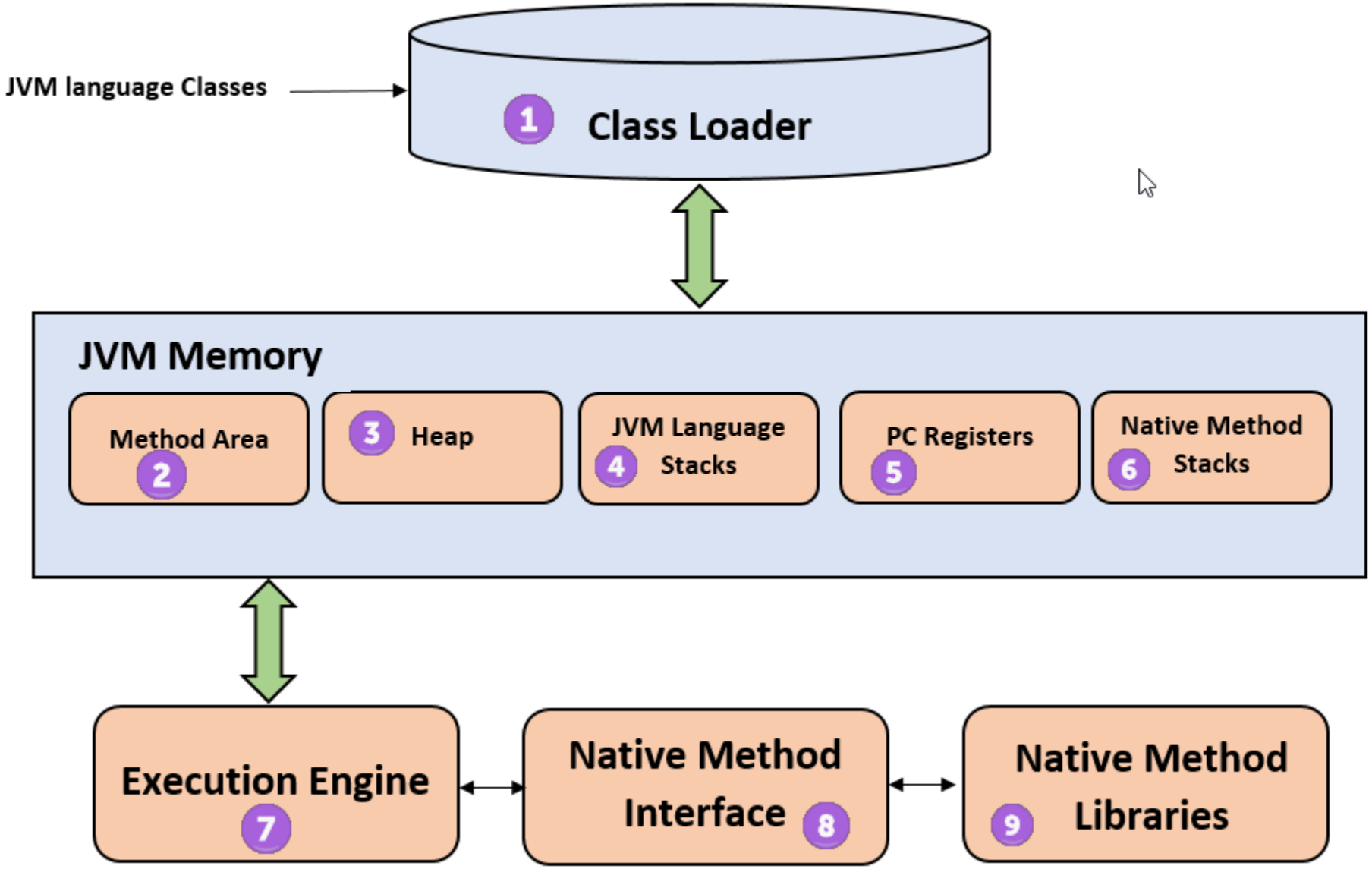
Classes

```
import packagename.subpackagename.ClassName;
```

For example,

```
import java.util.ArrayList;
```

- The import statement allows the programmer to use the objects and methods defined in the designated package. You will not be expected to write any `import` statements.
- Java program must have at least one class, the one that contains the `main method`. The Java files that comprise your program are called `source files`.
- A `compiler` converts source code into machine-readable form called `bytecode`.


JVM language Classes
1
Class Loader
JVM Memory
Method Area
2
3
Heap
JVM Language
4
Stacks
PC Registers
5
Native Method
6
Stacks
Execution Engine
7
Native Method
Interface
8
Native Method
9
Libraries

```
import package1.*;
import package2.subpackage.ClassName;
/* Program FirstProg.java
Start with a comment, giving the program name and a brief
description of what the program does.
*/
public class FirstProg{ //note that the file name is FirstProg.java
    public static type1 method1 (parameter list) {
        < code for method 1 >
    }
    public static type2 method2 (parameter list) {
        < code for method 2 >
    }
    public static void main(String[] args) {
        < your code >
    }
}
```

NOTE:

1. All Java methods must be contained in a class.
2. The words class, public, static, and void are reserved words, also called keywords. (This means they have specific uses in Java and may not be used as identifiers.)
3. The keyword public signals that the class or method is usable outside of the class, whereas private data members or methods (see Chapter 3) are not.
4. The keyword static is used for methods that will not access any objects of a class, such as the methods in the FirstProg class in the example above. This is typically true for all methods in a source file that contains no instance variables (see Chapter 3). Most methods in Java do operate on objects and are not static. The main method, however, must always be static.
5. The program shown above is a Java application.
6. There are three different types of comment delimiters in Java:
    - /* ... */, which is the one used in the program shown, to enclose a block of comments. The block can extend over one or more lines.
    - //, which generates a comment on one line.
    - /** ... */, which generates Javadoc comments. These are used to create API documentation of Java library software.

SECTION 2

Data Types

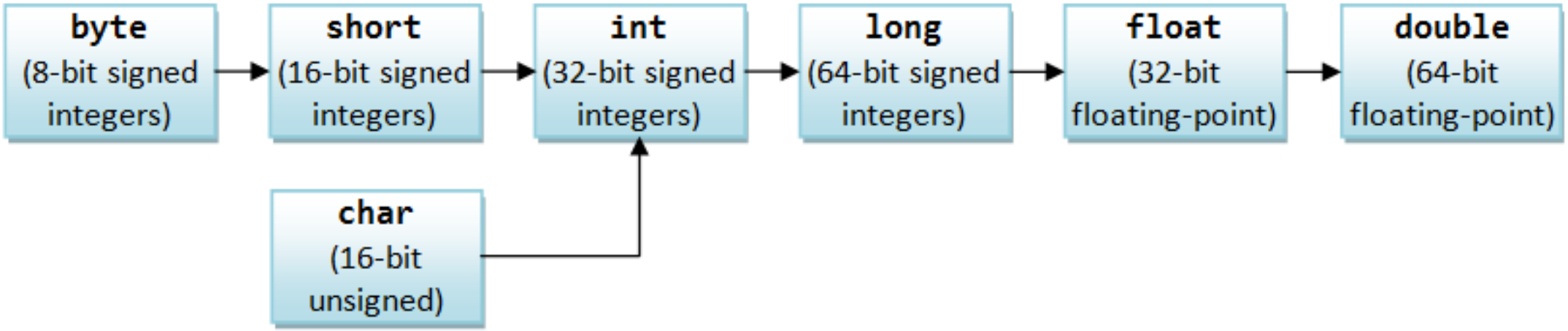
Java Primitive Types

Integer.MIN_VALUE
Integer.MAX_VALUE

Type	Size	Range	Default
boolean	1 bit	true or false	false
byte	8 bits	[-128, 127]	0
short	16 bits	[-32,768, 32,767]	0
char	16 bits	['\u0000', '\uffff'] or [0, 65535]	'\u0000'
int	32 bits	[-2,147,483,648 to 2,147,483,647]	0
long	64 bits	$[-2^{63}, 2^{63}-1]$	0
float	32 bits	32-bit IEEE 754 floating-point	0.0
double	64 bits	64-bit IEEE 754 floating-point	0.0

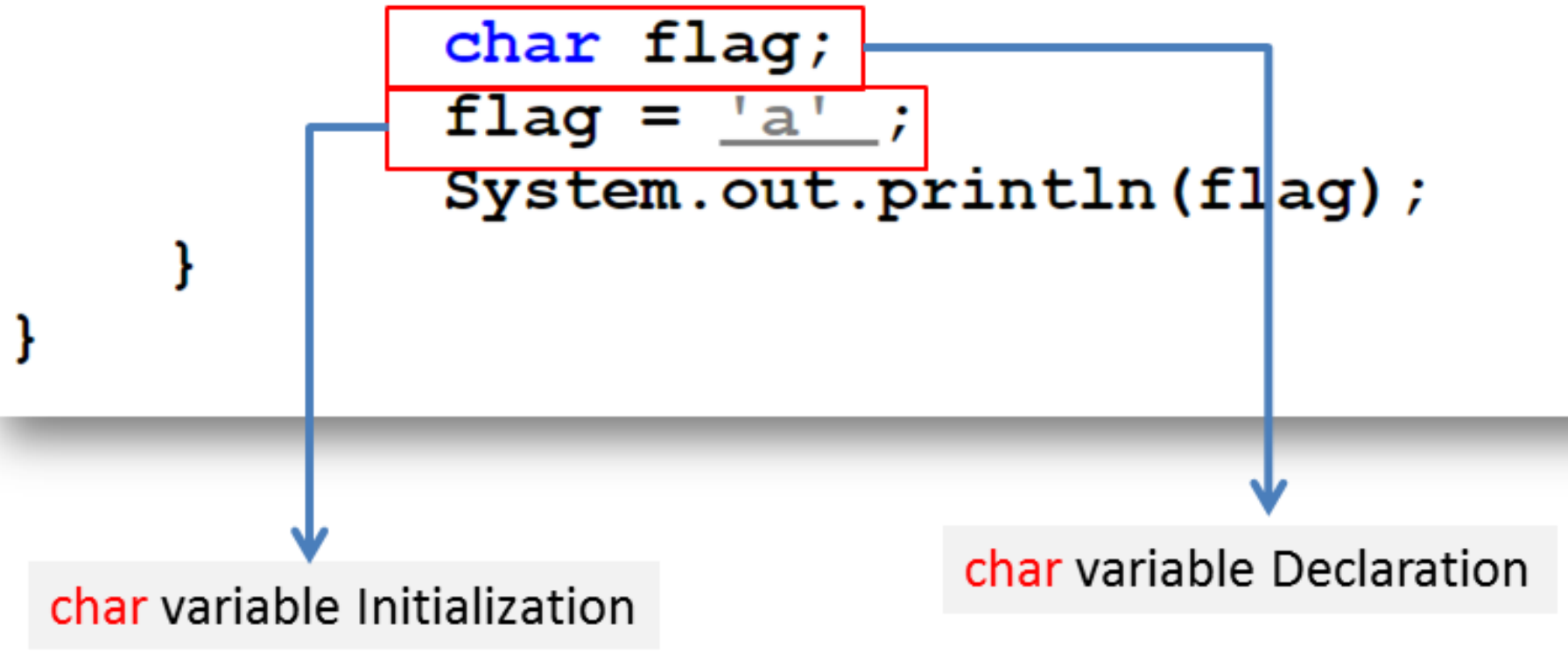
Numeric Data Types and Operations

Java has six numeric types for integers and floating-point numbers with operators +, -, *, . and %

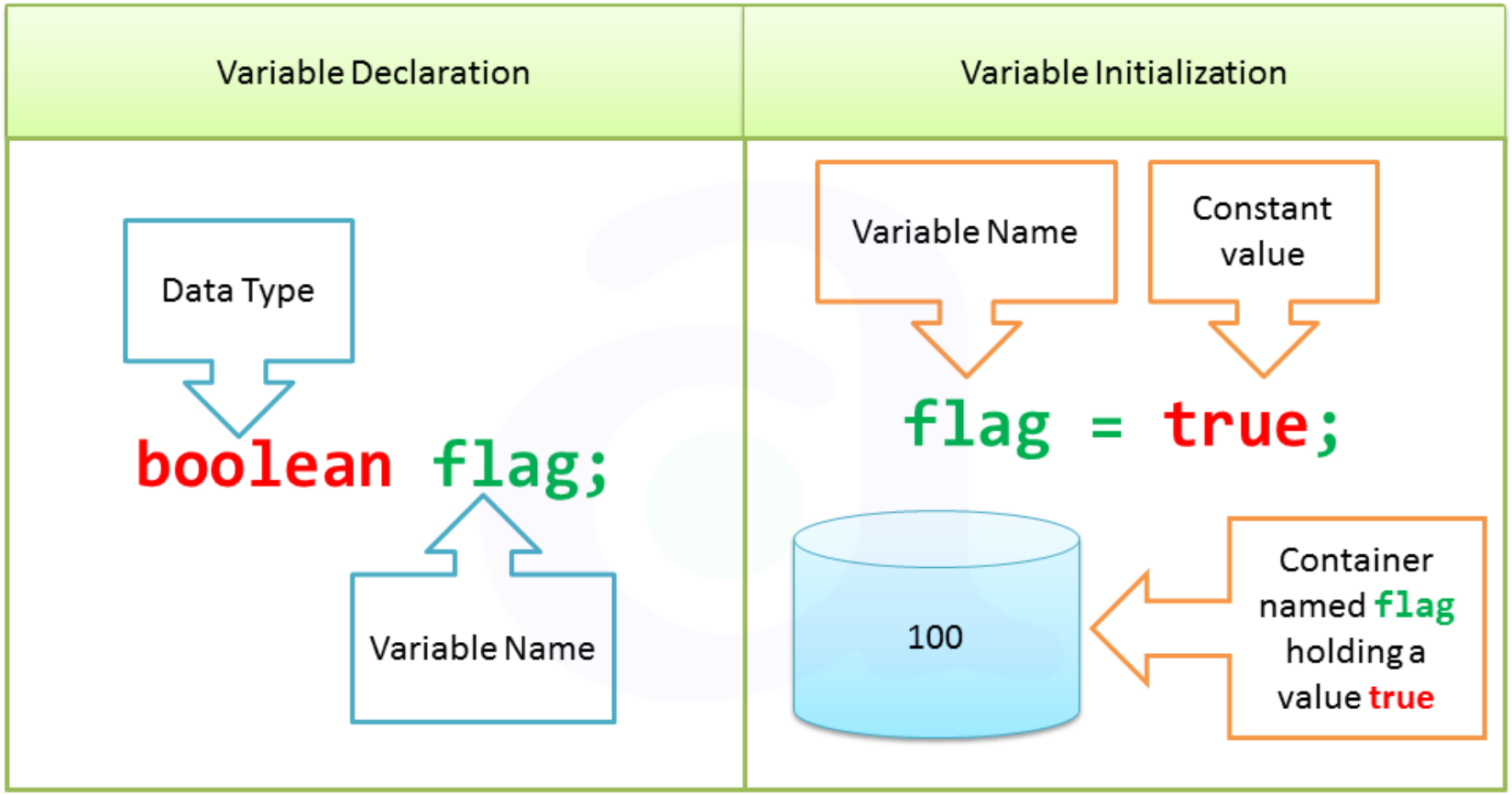


Orders of Implicit Type-Casting for Primitives

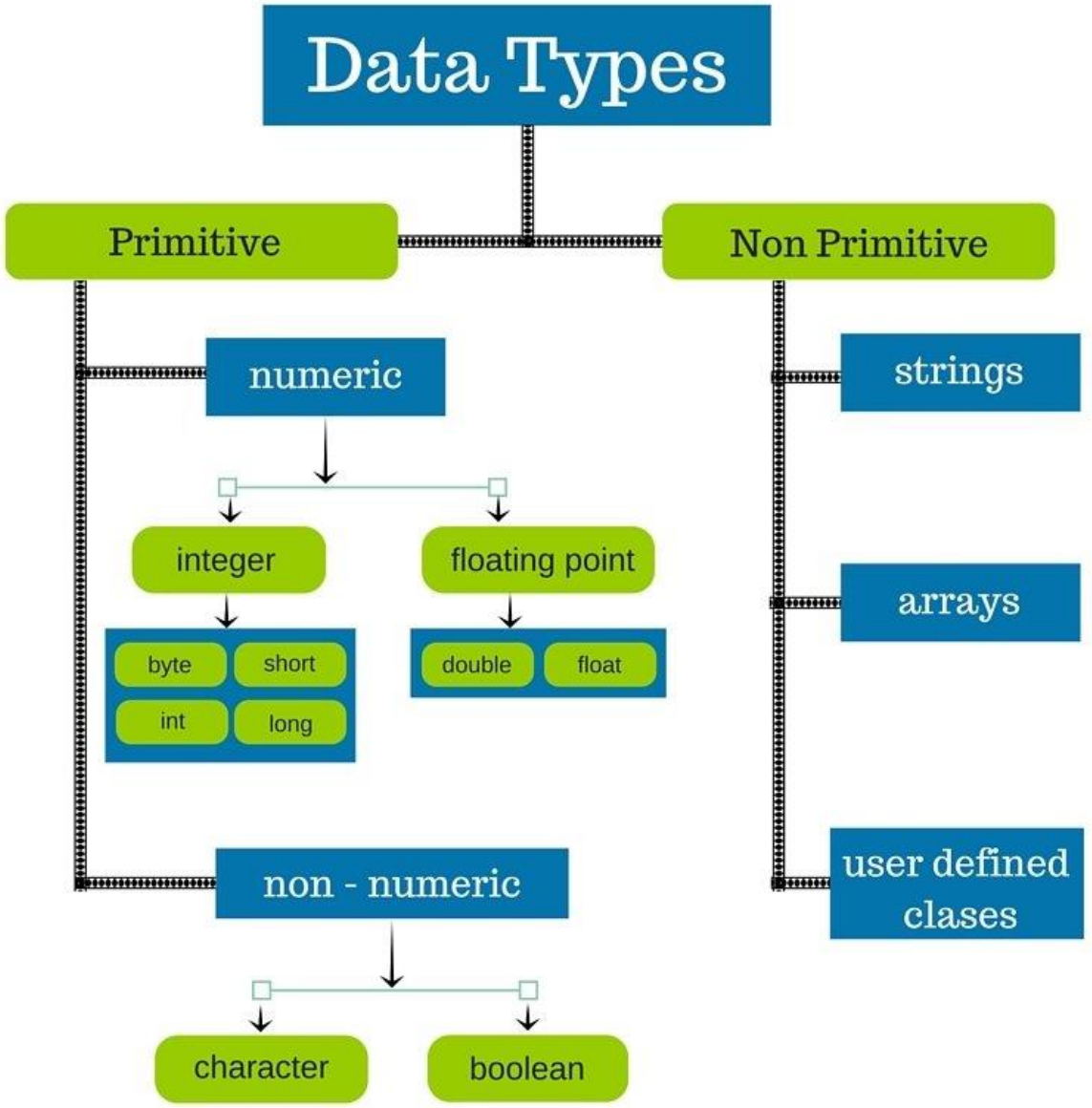
```java
// A Java program to demonstrate char data type
class CharacterExample1 {
    public static void main(String args[])
        {
            char flag;
            flag = 'a' ;
            System.out.println(flag);
        }
}
```



Boolean Data Type

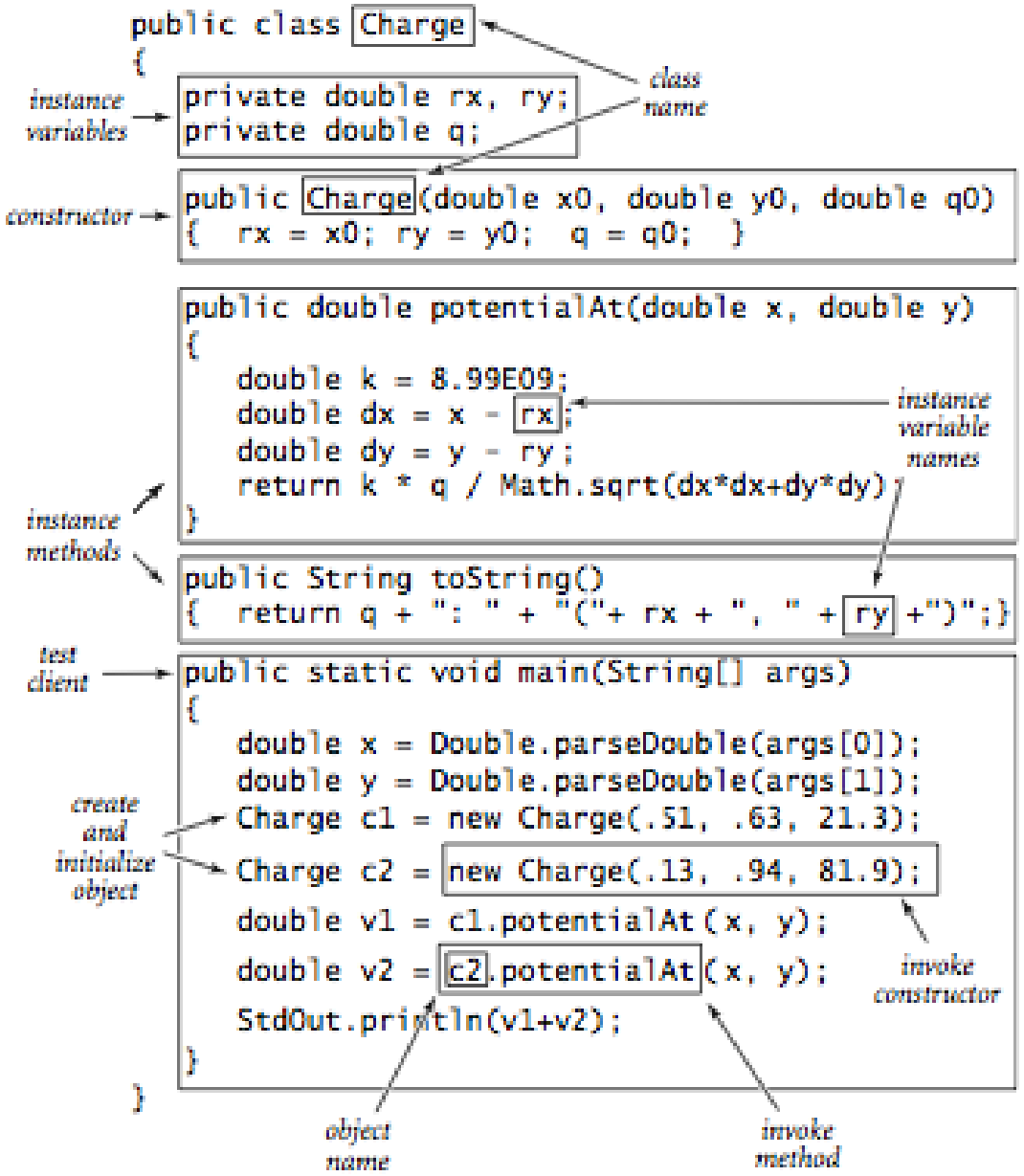


boolean variable Declaration and Initialization


Data Types
Primitive
Non Primitive
numeric
strings
integer
floating point
arrays
byte
short
int
long
double
float
non - numeric
user defined clases
character
boolean

SECTION 3

Basic Java Program



Anatomy of a class

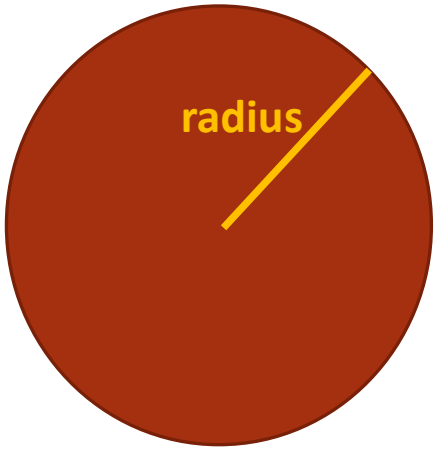
```
class Class_Name{
    final static CONSTANTS;
    static methods(){}
    data fields (instance variables);
    Constructor(){}
    instanceMethods(){}
    overrideMethods(){}
    public static void main(){}
}
```

Java comments and code block marks

Characters	Name	Description
//	Double Slash	Line comment
/* */	Slash star and star slash	Opening and closing of comment text
/** */	Slash double-star and star-slash	Opening and closing of Javadoc comment text Javadoc comment can be extracted into HTML file using the JDK's Javadoc command (Use to describe a module, a method or a variable)
{ }	Braces	For a code block.
[ ]	brackets	For the index variable
( )	parenthesis	For the boundary of an expression or a logic conditions
" "	double quotes	For boundary of a string of text data

Variable, Class and Program

```
public class Example {
    public static void main(String[] args){
        // Variable Declaration
        double radius = 5.0;
        // input part
        Scanner input = new Scanner(System.in);
        radius = input.nextDouble();
        // Processing part
        double area = Math.PI * radius * radius;
        //  Output Part
        System.out.println(area);
    }
}
```



Naming Conventions

(not part of syntax)

Variable and Method names:

Use lowercase for variables and methods. If a method is longer than one word, the first letter for each word, except the first word, may sometime in uppercase.

Example: int aa;

double women_age;

int functionName();

int functionToComputeInterest();

Constant names:

Capitalize every letter in a constant and use underscore between words – for example, the constant PI and MAX_VALUE;

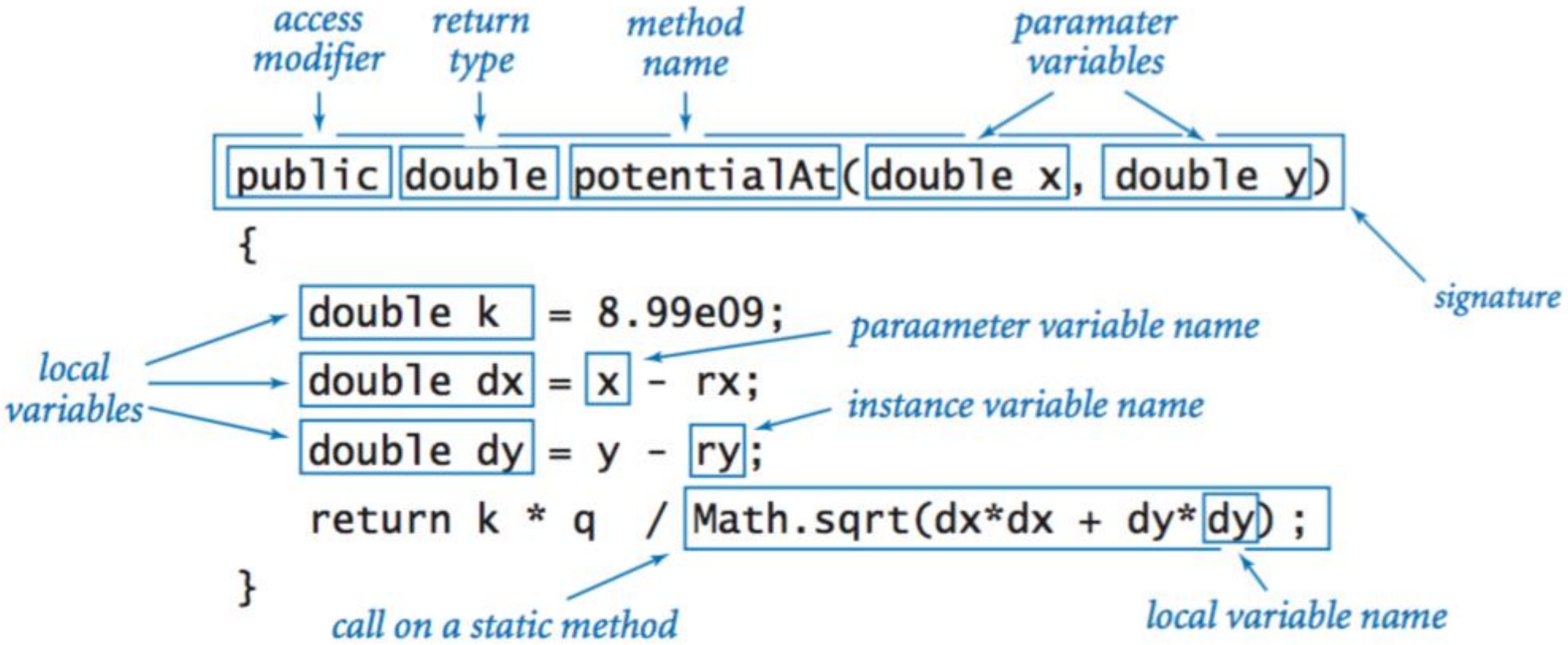
Naming Conventions
(module and package)

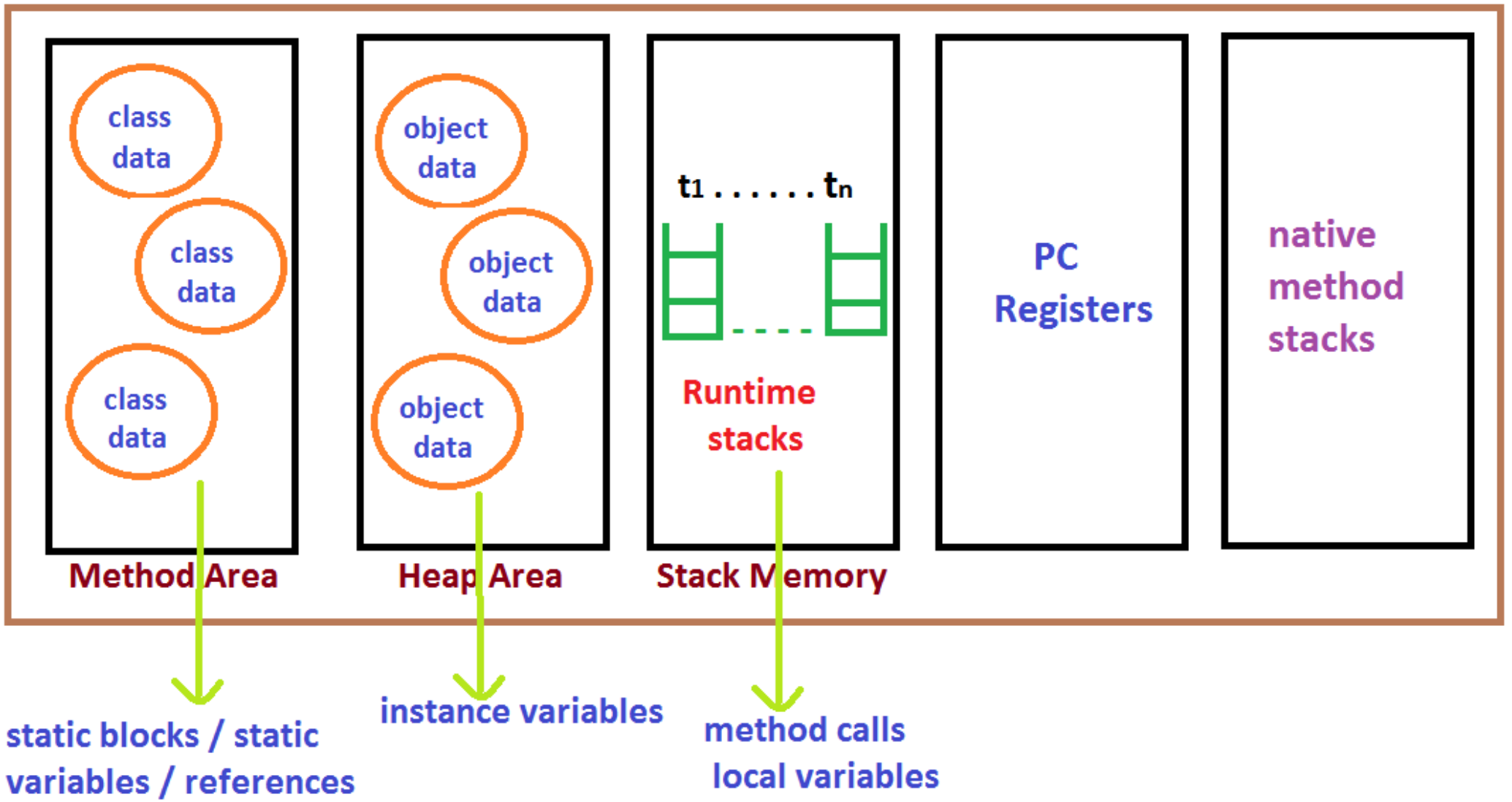
Class names:

- Capitalize the first letter of each word in the name.
- For example, the class name `ComputeArea`.

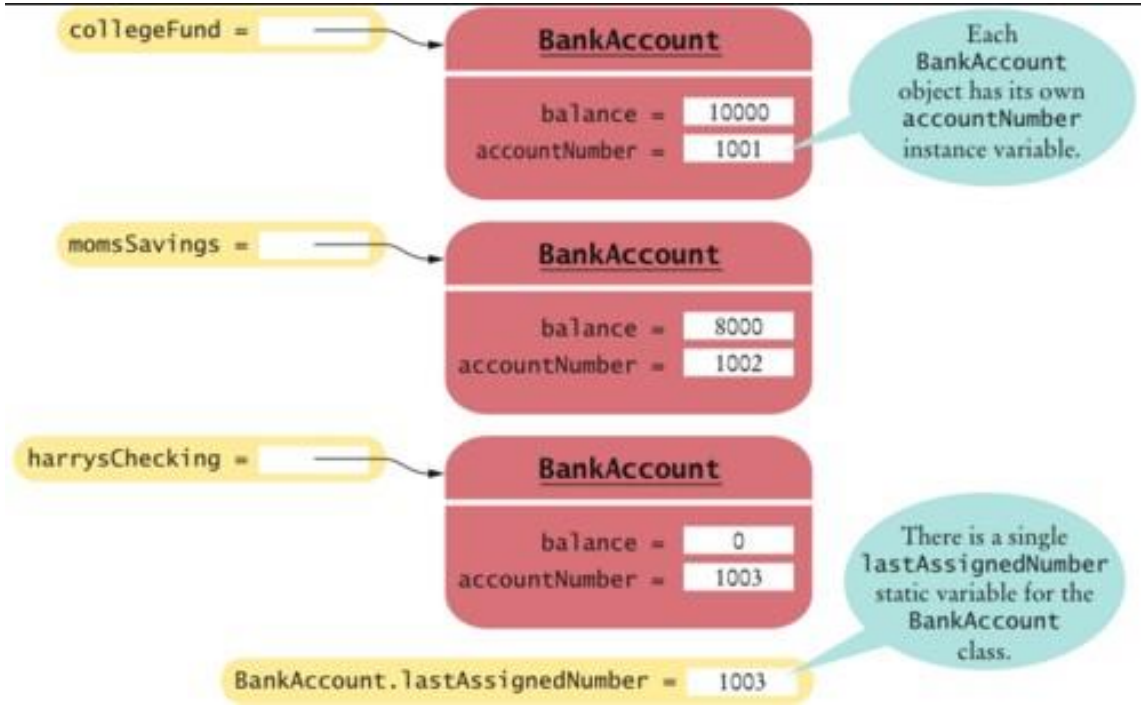
Package names:

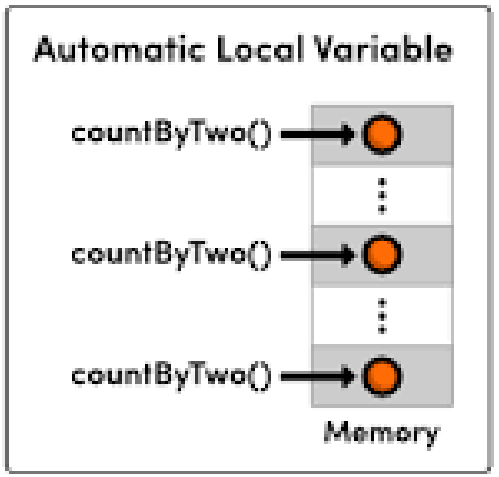
- The whole package name in lower case.

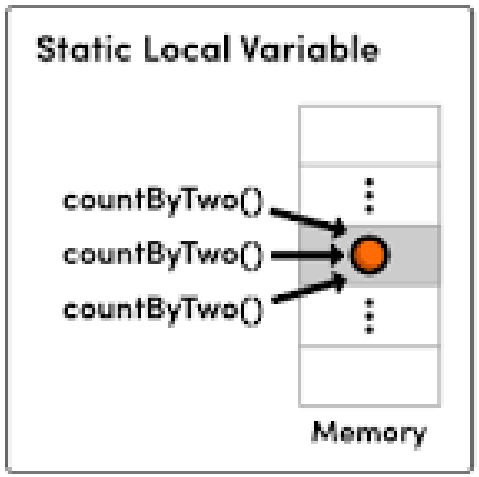

access modifier
return type
method name
paramater variables
public double potentialAt(double x, double y)
{
double k = 8.99e09;
double dx = x - rx;
double dy = y - ry;
return k * q / Math.sqrt(dx*dx + dy*dy) ;
}
signature
local variables
paraameter variable name
instance variable name
call on a static method
local variable name


class data
class data
class data
object data
object data
object data
t1 . . . . . tn
Runtime stacks
PC Registers
native method stacks
Method Area
Heap Area
Stack Memory
static blocks / static variables / references
instance variables
method calls
local variables

Static Members

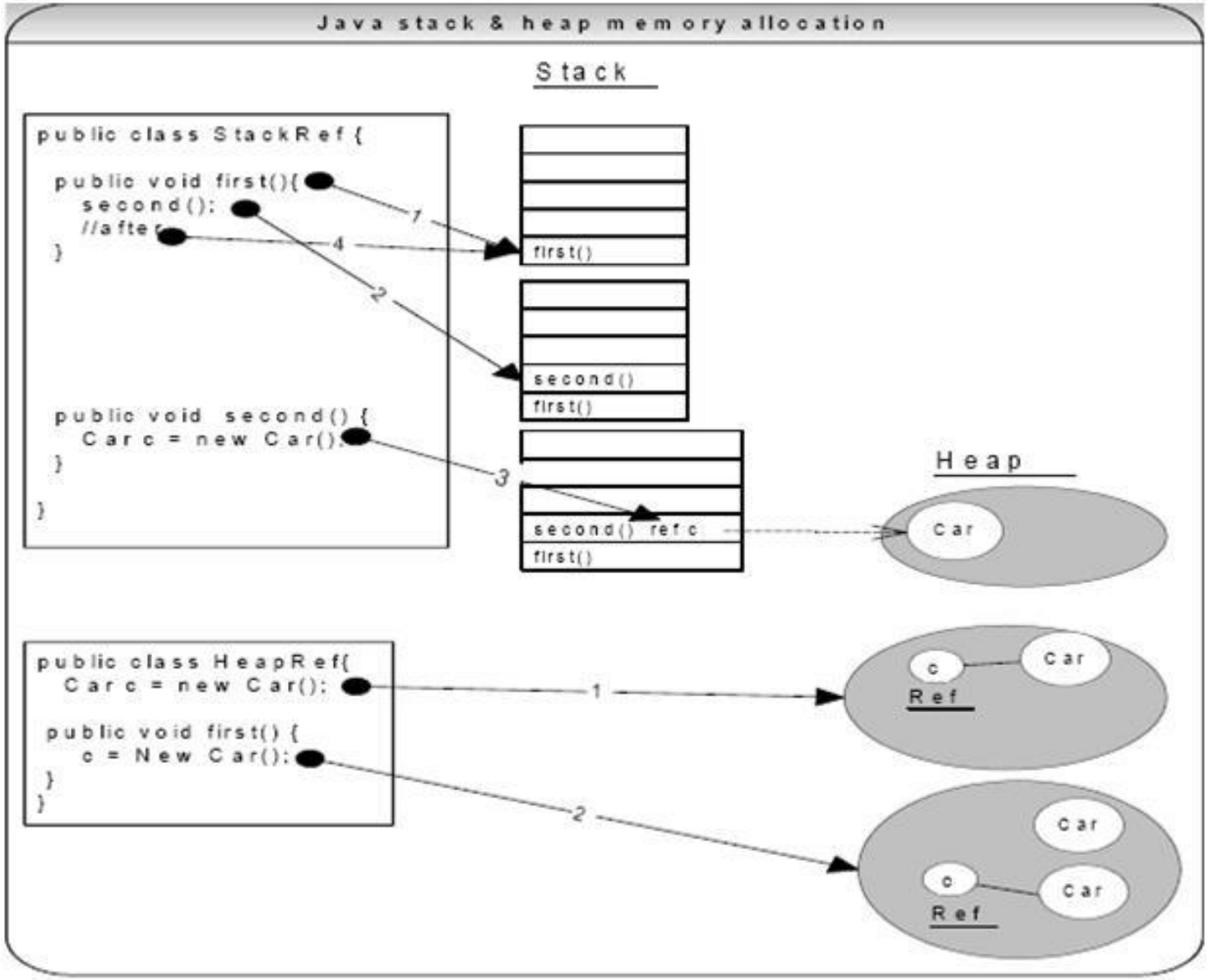






Static Methods (Refers to Chapter 6)

Static Variables (Refers to the Classes and Objects (1) in this Chapter 9)


Java stack & heap memory allocation
Stack
public class StackRef {
public void first(){
second();
//after
}
public void second() {
Car c = new Car();
}
}
first()
second()
first()
second() ref c
first()
Heap
Car
public class HeapRef{
Car c = new Car();
public void first() {
c = New Car();
}
}
1
2
3
4
c
Car
Ref
Car
c
Car
Ref

SECTION 4

Java Arithmetic Operators

Java Arithmetic Operators

Operator	Result
+	Addition
-	Subtraction (also unary minus)
*	Multiplication
/	Division
%	Modulus
++	Increment
+=	Addition assignment
-=	Subtraction assignment
*=	Multiplication assignment
/=	Division assignment
%=	Modulus assignment
--	Decrement

Integer Division and Its Usage

- int a = b * q + r; // a, b, q, r are all integers
- q = a / b;
- b = a / q;
- r = a % q;
- r = a % b;

Multiple of N

- if (m % 2 == 0) System.out.println("m is multiple of 2");
- **Leap Year:**

  boolean leapYear = (year %400==0) || (year %100!=0 && year %4==0);

- **GCD Euclidean Algorithm:**

Week1/GCD.java

```
8  public class GCD
9  {
10   public static int gcd(int m, int n){
11       if (m%n==0) return n;
12       return gcd(n, m%n);
13     }
14   public static void main(String[] args){
15        System.out.println(gcd(48, 32));
16        System.out.println(gcd(65, 52));
17        System.out.println(gcd(52, 65));
18     }
19 }
```

Reverse of Digits

Week2/ReverseDigits.java

- Take the least significant digit by taking modulo-10;
- Multiply-Shift and Add operations

```java
public class ReverseDigits
{
    public static int reverseDigit(int x){
        int r=0;
        int d=0;
        while (x>0){
            d = x % 10;
            r = r * 10 + d;
            x /= 10;
         }
        return r;
     }
    public static void main(String[] args){
        System.out.print("\f");
        System.out.println(reverseDigit(12345));
     }
}
```

Convert Decimal to Binary String

Week2/ToBinary.java

```java
public class ToBinary
{
    public static String toBinary(int dec){
        String r = "";
        while (dec >0){
            int bit = dec % 2;
            r = ""+bit+r;
            dec /=2;
         }
        return r;
     }
    public static void main(String[] args){
        System.out.println(toBinary(127));
        System.out.println(toBinary('A'));
        System.out.println(toBinary('z'));
     }
}
```

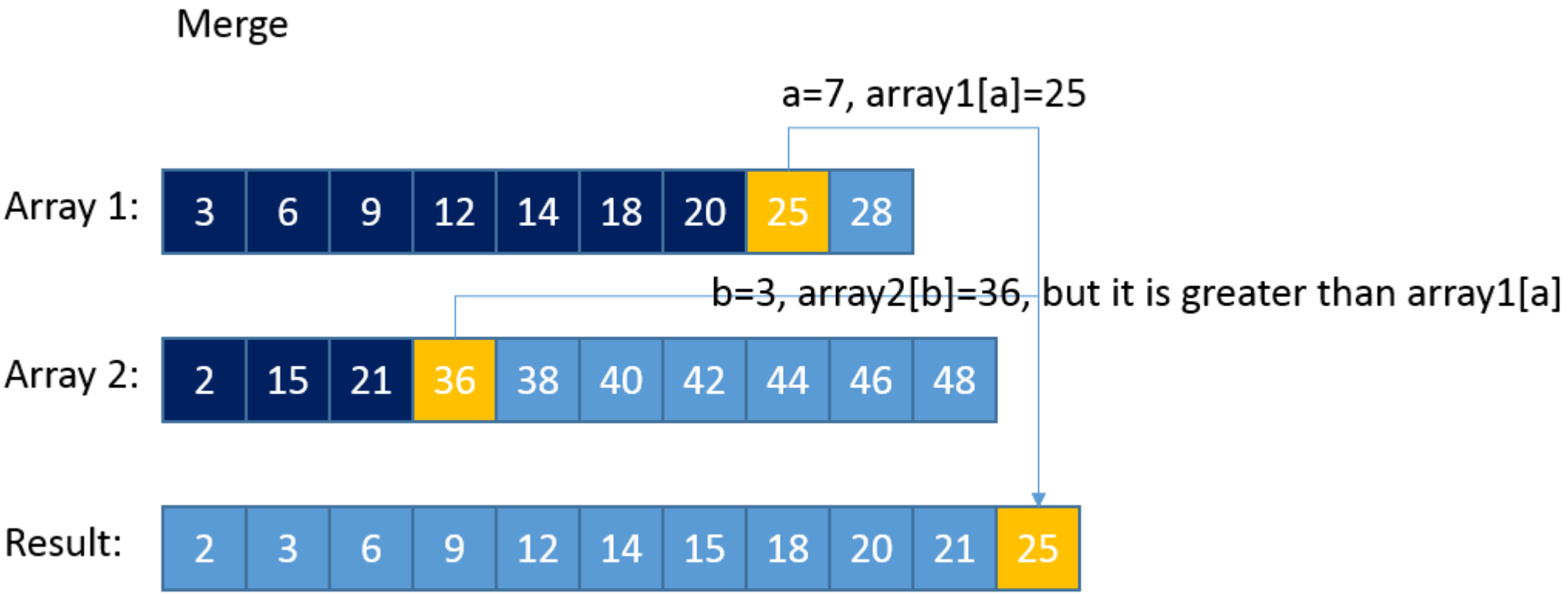
```
1111111
1000001
1111010
```

Merge of Arrays

Week2/MergeArray.java

1. Use integer as indexing pointer to an array. (p1, p2, p3)
2. Post-increment operator
3. Alternating increment of pointers
4. Deal with remaining elements
5. Transcopy

Merge Two Arrays



```java
import java.util.Arrays;
public class MergeArray
{
    public static int[] mergeArray(int[] a1, int[] a2){
        int[] a3 = new int[a1.length+a2.length];
        int p1=0, p2=0, p3=0;
        while (p1<a1.length && p2<a2.length){
            if (a1[p1]<=a2[p2]) a3[p3++]=a1[p1++];
                           else a3[p3++]=a2[p2++];
         }
        while (p1<a1.length){a3[p3++] = a1[p1++];}
        while (p2<a2.length){a3[p3++] = a2[p2++];}

        return a3;
     }
    public static void main(String[] args){
       int[] ary1 = {1, 3, 3, 5, 7, 9, 12, 23};
       int[] ary2 = {2, 2, 4, 8, 10, 14, 16, 18};
       System.out.println(Arrays.toString(ary1));
       System.out.println(Arrays.toString(ary2));
       System.out.println(Arrays.toString(mergeArray(ary1, ary2)));
     }
}
```

```
[1, 3, 3, 5, 7, 9, 12, 23]
[2, 2, 4, 8, 10, 14, 16, 18]
[1, 2, 2, 3, 3, 4, 5, 7, 8, 9, 10, 12, 14, 16, 18, 23]
```

SECTION 5

Java Arithmetic Operators

Boolean Data Type

The Boolean data type declares a variable with the value either true or false.

Relational Operators				
Java Operator	Math Symbol	Name	Example	Result
<	$<$	Less than	radius < 0	false
<=	$\leq$	Less than or Equal to	radius <= 0	false
>	$>$	Greater than	radius > 0	true
>=	$\geq$	Greater than or equal to	radius >= 0	true
==	$=$	Equal to	radius == 0	false
!=	$\neq$	Not Equal to	radius != 0	true

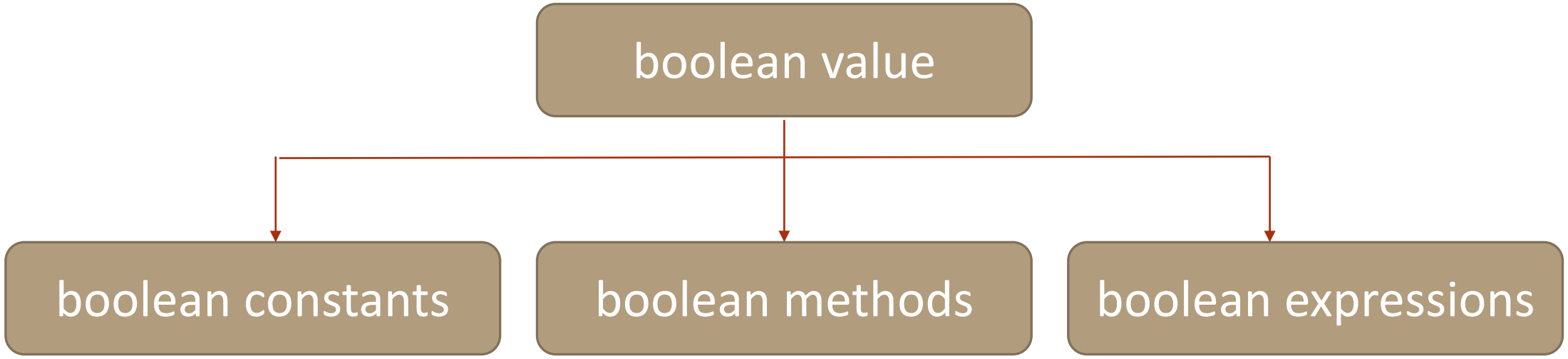
Boolean literals: **true** and **false.** These are the only values that will be returned by the Boolean expressions.

Java boolean Expressions

For example, suppose you have declared two variables: **int i = 5; int j = 10;**

Expression	Value	Explanation
`i == 5`	`true`	The value of `i` is `5`.
`i == 10`	`false`	The value of `i` is not `10`.
`i == j`	`false`	`i` is `5`, and `j` is `10`, so they are not equal.
`i == j - 5`	`true`	`i` is `5`, and `j - 5` is `5`.
`i > 1`	`true`	`i` is `5`, which is greater than `1`.
`j == i * 2`	`true`	`j` is `10`, and `i` is `5`, so `i * 2` is also `10`.

boolean values



true

final boolean YES = **true**;

isLetter()

isLowerCase()

a >= 3

Logical Operators for Implementation of Boolean Logic

Boolean Operators		
Operator	Name	Description
!	not	Logical negation
&&	and	Logical conjunction
||	or	Logical disjunction
^	exclusive or	Logical exclusion (non-AP)

INPUTS		OUTPUTS					
A	B	AND	NAND	OR	NOR	EXOR	EXNOR
0	0	0	1	0	1	0	1
0	1	0	1	1	0	1	0
1	0	0	1	1	0	1	0
1	1	1	0	1	0	0	1

Truth Table for Operator !

p	!p	Example (assume age = 24, gender = 'M')
true	false	!(age > 18) is false, because (age > 18) is true.
false	true	!(gender != 'M') is true, because (grade != 'M') is false.

Truth Table for Operator &&

p1	p2	p1 && p2	Example (assume age = 24, gender = 'F')
false	false	false	(age > 18) && (gender == 'F') is true, because (age > 18) and (gender == 'F') are both true.
false	true	false	
true	false	false	(age > 18) && (gender != 'F') is false, because (gender != 'F') is false.
true	true	true	

Truth Table for Operator | |

p1	p2	p1 || p2	Example (assume age = 24, gender = 'F')
false	false	false	(age > 34) || (gender == 'F') is true, because (gender == 'F') is true.
false	true	true	
true	false	true	(age > 34) || (gender == 'M') is false, because (age > 34) and (gender == 'M') are both false.
true	true	true	

Truth Table for Operator ^

p1	p2	p1 ^ p2	Example (assume age = 24, gender = 'F')
false	false	false	(age > 34) ^ (gender == 'F') is true, because (age > 34) is false but (gender == 'F') is true.
false	true	true	
true	false	true	(age > 34) || (gender == 'M') is false, because (age > 34) and (gender == 'M') are both false.
true	true	false	

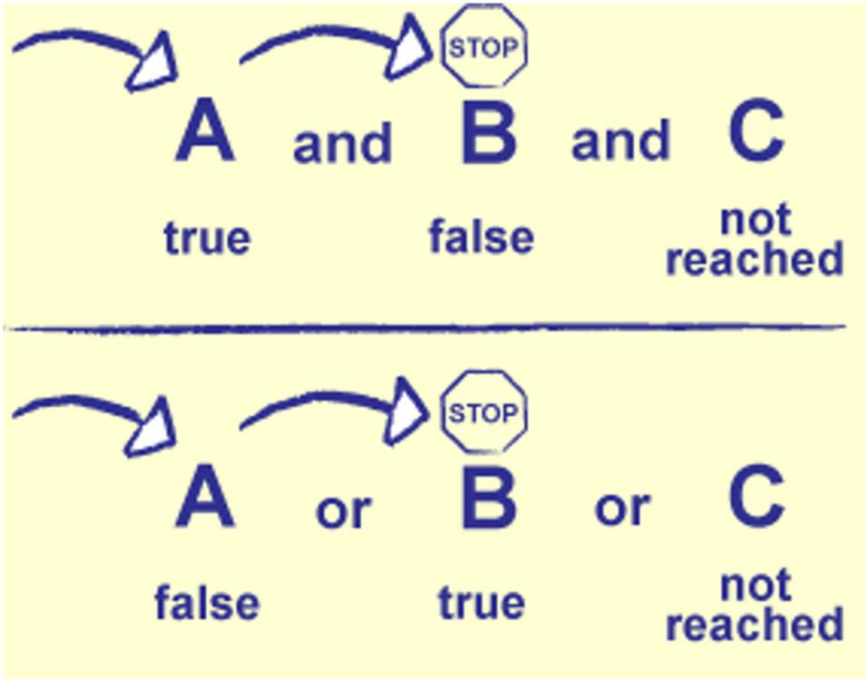
Short-Circuit Evaluation

Week2/ShortCircuit.java

```java
public class ShortCircuit{
   public static void main(String[] argv) {
      int denom = 0;
      int num = 3;
      if (denom != 0 && num / denom > 10) {
         System.out.println("Here");
      } else {
         System.out.println("There");
      }
   }
}
```

Short-Circuit Example:

int count =0;
int total = 0;
boolean result = (count !=0 && **total/count >0**);



Name	AND form	OR form
Identity law	$1A = A$	$0 + A = A$
Null law	$0A = 0$	$1 + A = 1$
Idempotent law	$AA = A$	$A + A = A$
Inverse law	$A\overline{A} = 0$	$A + \overline{A} = 1$
Commutative law	$AB = BA$	$A + B = B + A$
Associative law	$(AB)C = A(BC)$	$(A + B) + C = A + (B + C)$
Distributive law	$A + BC = (A + B)(A + C)$	$A(B + C) = AB + AC$
Absorption law	$A(A + B) = A$	$A + AB = A$
De Morgan's law	$\overline{AB} = \overline{A} + \overline{B}$	$\overline{A + B} = \overline{A}\,\overline{B}$

SECTION 6

Simple Design Patterns for Decision and Repetition

If-Statements and If-Then-Else Statements

Standard If-Else Statement:

```
int m=3;
boolean even;
if (m%2==0) even = true;
else even = false;
```

Standard If-Else Statement:

```
int m=3;
boolean odd;
if (m%2!=0) odd = true;
else odd = false;
```

Default True:

```
int m=3;
boolean even = true;
if (m%2!=0) even = false;
```

Default False:

```
int m=3;
boolean odd = false;
if (m%2!=0) odd = true;
```

Conditional Statement: (Non-AP)

```
int m=3;
boolean odd = (m%2!=0) true: false;
```

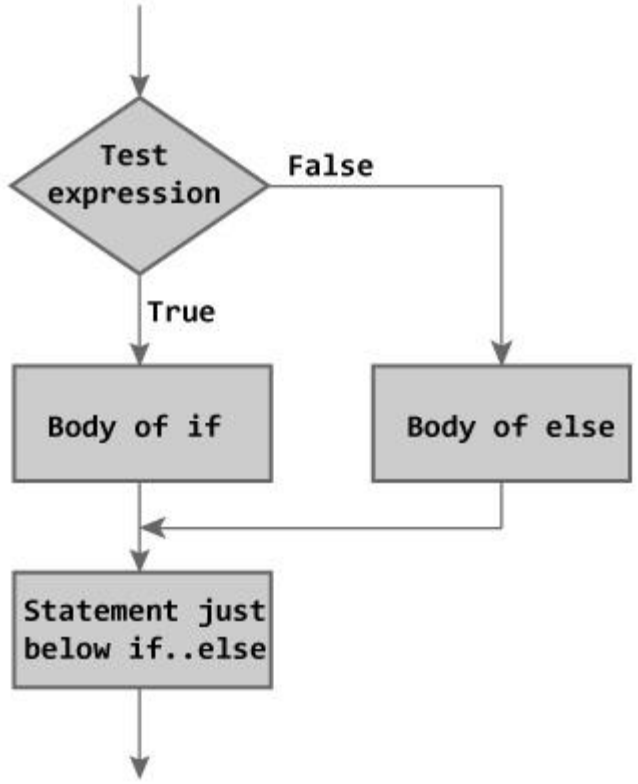


Figure: Flowchart of if...else Statement

Dangling If

else belongs to closest if

The else clause matches the most recent if clause in the same block.

```
int i = 1;
int j = 2;
int k = 3;

if (i > j)
  if (i > k)
    System.out.println("A");
else
    System.out.println("B");
```

(a)

Equivalent

```
int i = 1;
int j = 2;
int k = 3;

if (i > j)
  if (i > k)
    System.out.println("A");
  else
    System.out.println("B");
```

(b)

Loops for Repetition

100 times

```
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
…
…
…
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
```

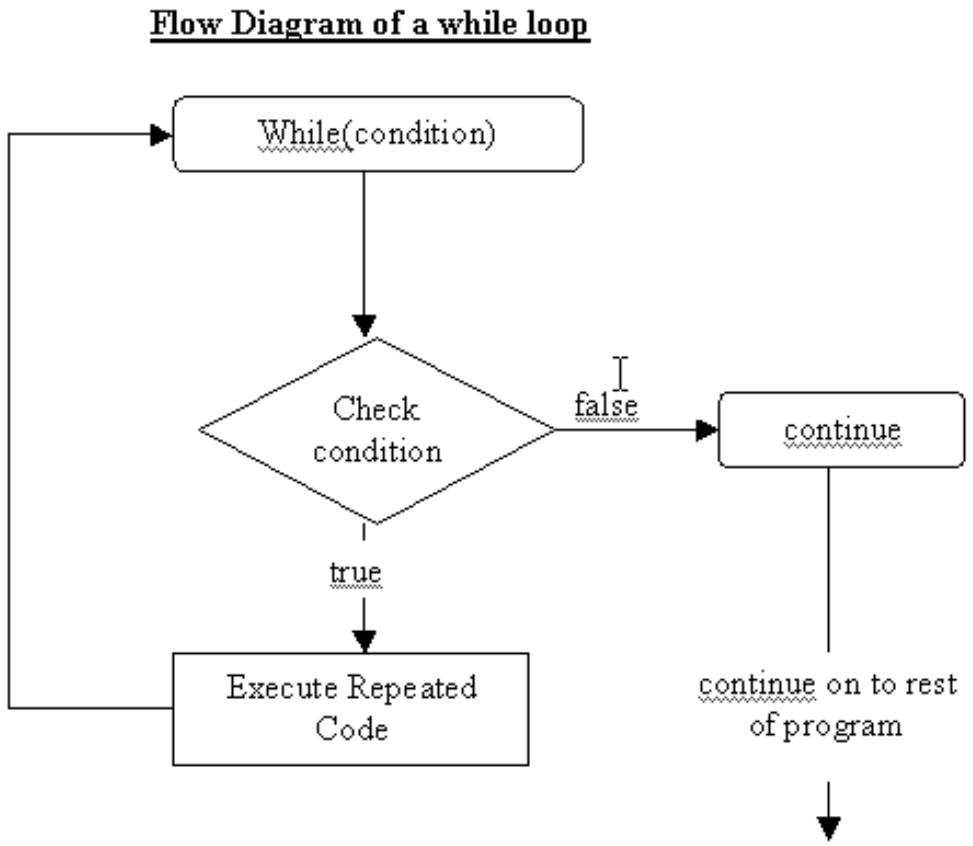
Solution to it: while-loop

```
int count = 0;
while (count < 100) {
   System.out.println("Welcome to Java");
   count++;
}
```

while loop

The syntax for the while loop is:

```
while (loop-continuation-condition) {
    // loop body
    Statement(s);
}
```



Comparison of if-statement and while-loop

```
int x = 0;                    // if-statement
if (x < 10) {
    System.out.println("Welcome to Java.");
}

int x = 0;                    // while-loop
while (x < 10) {
    System.out.println("Welcome to Java.");
    x++;
}
```

LOOP Structures Supported By Java

Loops:

- for-loop (later lecture)
- while-loop
- do-while-loop
- for-each-loop

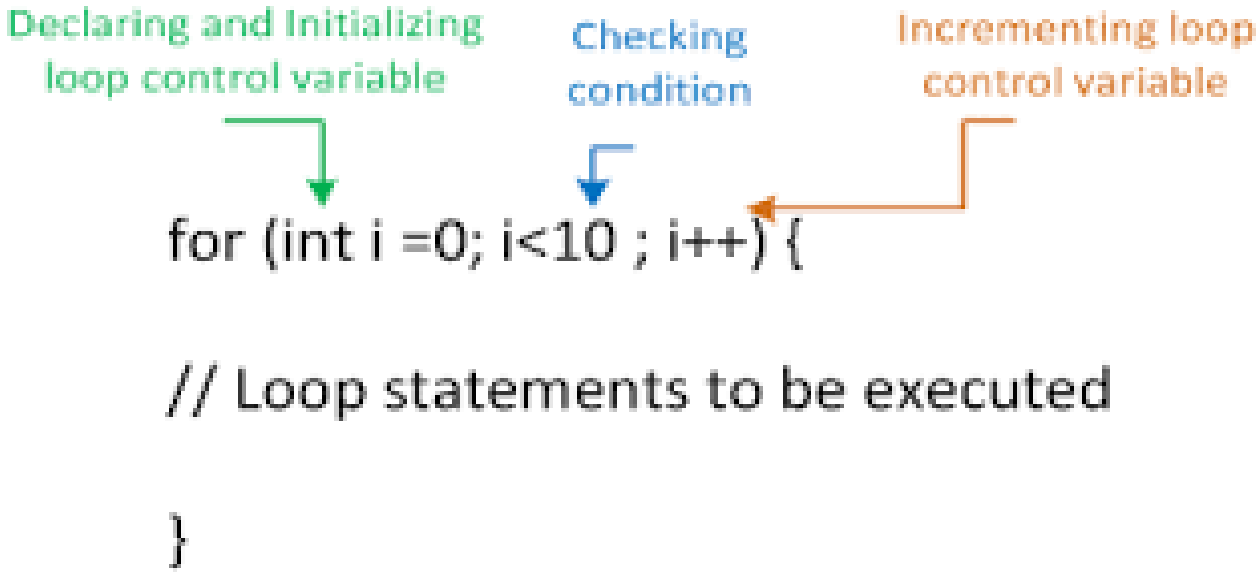
Loop Breaks: (later in other lecture)

- {} /* empty braces as pass function */
- Continue /* skip the rest of iteration */
- Break /* skip the rest of loop */
- Return /* skip the rest of function */
- System.exit(0); /* skip the rest of program */

for loop

Syntax of for loop:

```
for (initial_condition; continuation-condition; action-after-each-iteration)
{
  // loop body:
  Statement(s);
}
```



Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println(
    "Welcome to Java!");
}
```

Declare i

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println(
    "Welcome to Java!");
}
```

Execute initializer
i is now 0

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println( "Welcome to Java!");
}
```

(i < 2) is true
since i is 0

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Execute adjustment statement
i now is 1

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

(i < 2) is still true
since i is 1

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Print Welcome to Java

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Execute adjustment statement
i now is 2

Trace for Loop

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

(i < 2) is false
since i is 2

Trace for Loop

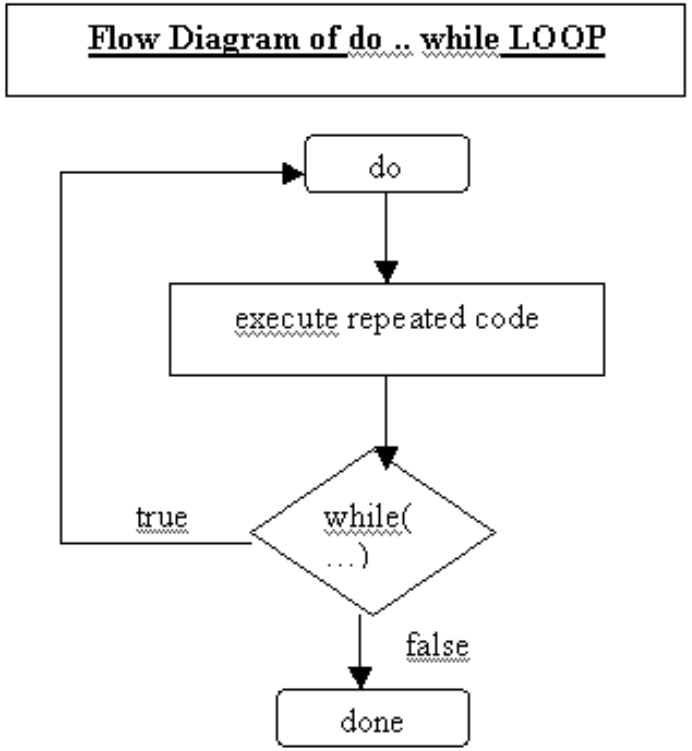
```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java");
}
```

do … while loop

The do-while loop is a variation of the while loop.

Its syntax is:

```
do {
    // loop body;
    statement(s);
} while (loop-continuation-condition);
```



Difference between do-while-loop and while-loop

The difference between a while loop and a do-while-loop is the order in which the loop-continuation-condition is evaluated and the loop body executed. You can write a loop using either the while-loop or the do-while loop. Sometimes one is a more convenient choice than the other.

SECTION 7

Loop Patterns

LP1_Repetition

- Loop only repeat for certain times.

LP2_IndexedLoop

- Loop with a counter

LP3_SentinelLoop

- Loop breaks on conditions

LP4_FlagLoop (Combined Loop)

- Searching for First Occurrence using a Combined Loop.
- Searching for Last Occurrence Using a flag loop.

LP5_MultiplyLoop

- Vector to Vector multiplication to create 2D space.

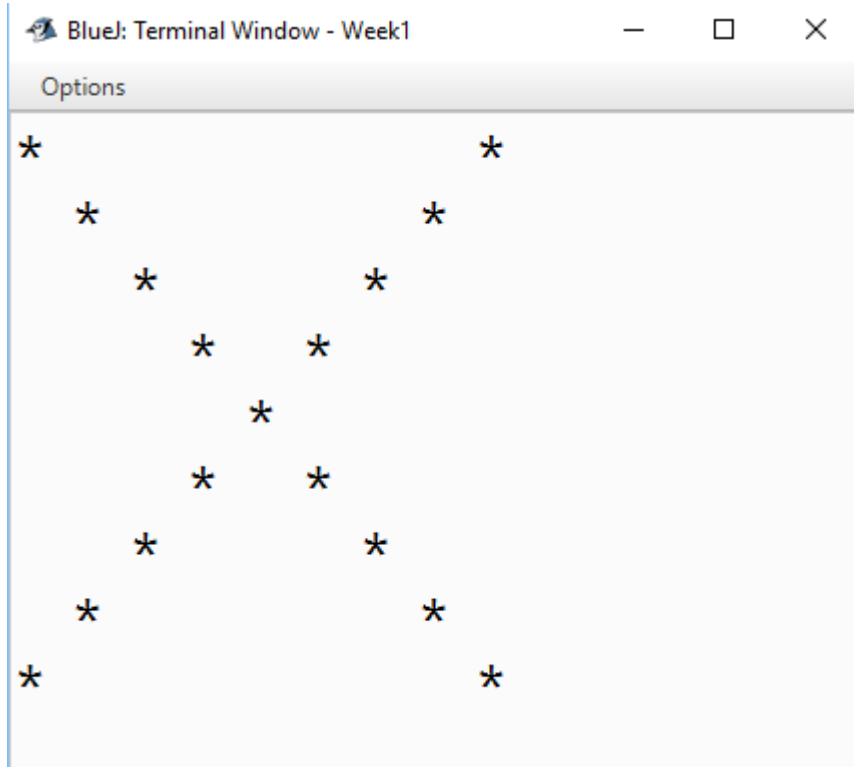
factors ↓

factors → ×	0	1	2	3	4	5	6	7	8	9	10
0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	6	7	8	9	10
2	0	2	4	6	8	10	12	14	16	18	20
3	0	3	6	9	12	15	18	21	24	27	30
4	0	4	8	12	16	20	24	28	32	36	40
5	0	5	10	15	20	25	30	35	40	45	50
6	0	6	12	18	24	30	36	42	48	54	60
7	0	7	14	21	28	35	42	49	56	63	70
8	0	8	16	24	32	40	48	56	64	72	80
9	0	9	18	27	36	45	54	63	72	81	90
10	0	10	20	30	40	50	60	70	80	90	100

	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	6	7
2	0	2	4	6	10	12	14	16
3	0	3	6	11	14	17	22	25
4	0	4	10	14	20	24	30	34
5	0	5	12	17	24	31	36	43
6	0	6	14	22	30	36	44	52
7	0	7	16	25	34	43	52	61

LP6_NestedLoop

- NestedLoop for 2D Indexing



LP7_Histogram

- Use baskets to classify marbles.

SECTION 8

Conversion of Number Systems

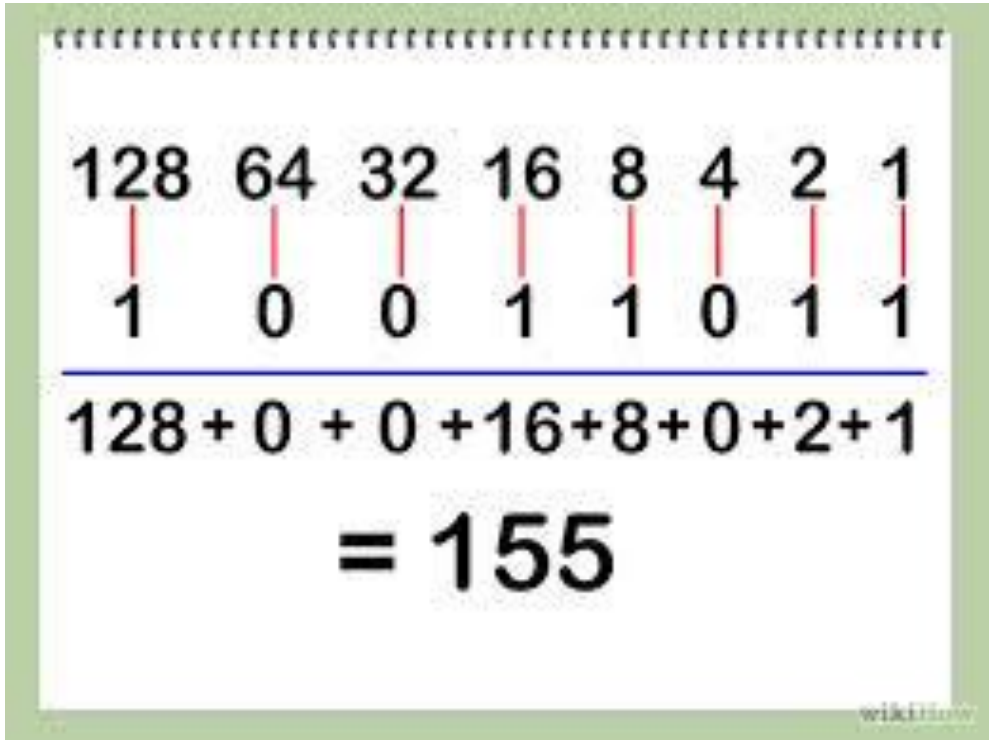
Binary to Decimal

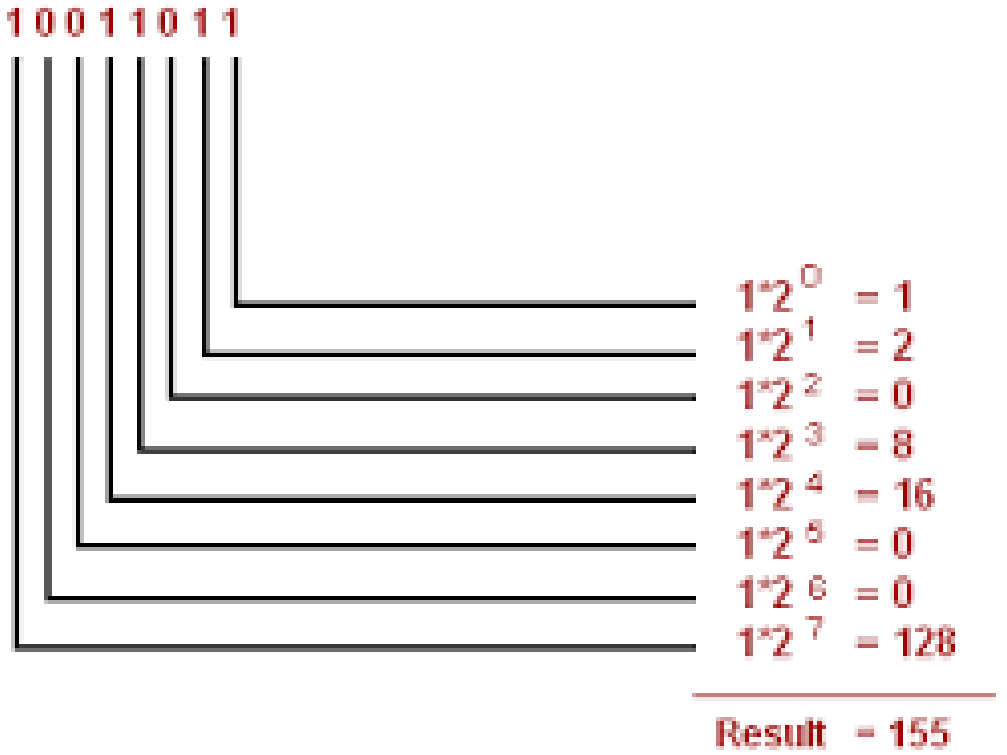
Binary Value	Decimal Representation	Decimal Value
	8 4 2 1	
0 0 0 0	0 + 0 + 0 + 0	0
0 0 0 1	0 + 0 + 0 + 1	1
0 0 1 0	0 + 0 + 2 + 0	2
0 0 1 1	0 + 0 + 2 + 1	3
0 1 0 0	0 + 4 + 0 + 0	4
0 1 0 1	0 + 4 + 0 + 1	5
0 1 1 0	0 + 4 + 2 + 0	6
0 1 1 1	0 + 4 + 2 + 1	7
1 0 0 0	8 + 0 + 0 + 0	8
1 0 0 1	8 + 0 + 0 + 1	9
1 0 1 0	8 + 0 + 2 + 0	10

Decimal, Binary, Octal, Hexidecimal Values

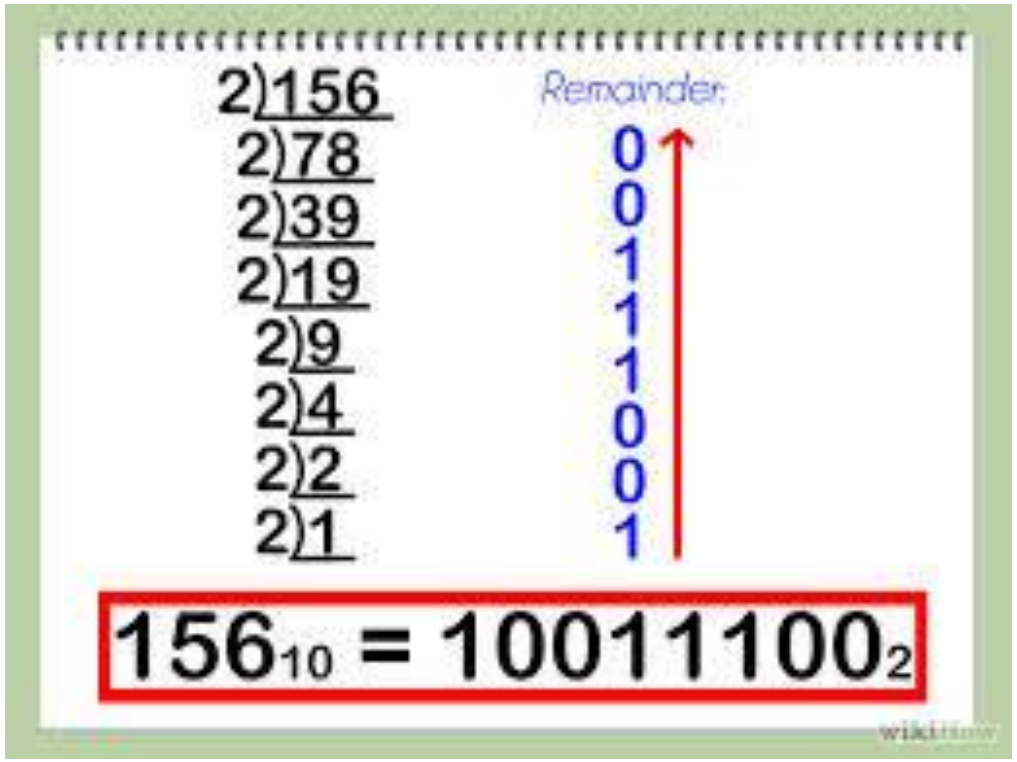
Decimal	Binary	Octal	Hexidecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Binary/Decimal Conversion





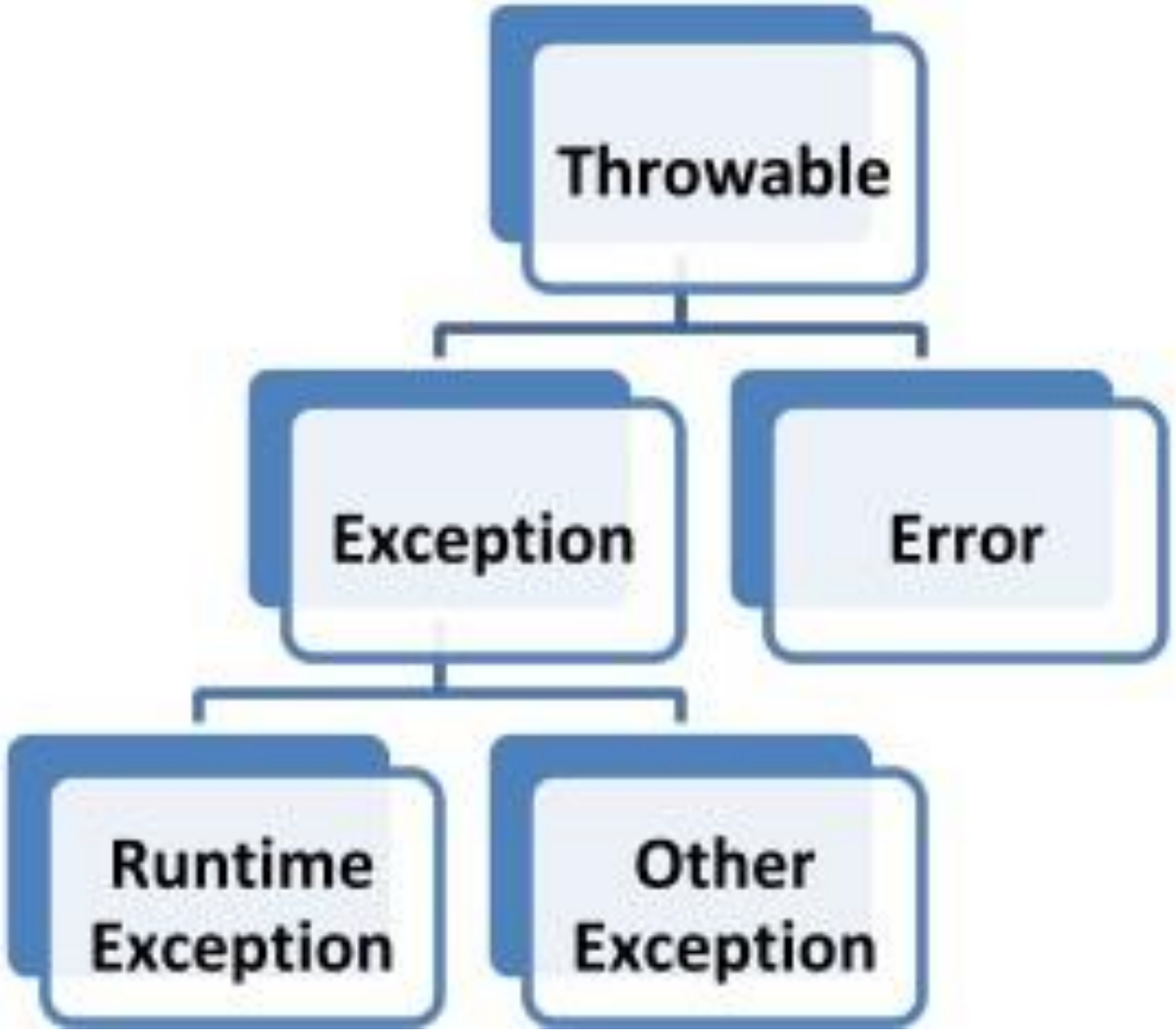
Decimal to Binary



Divider	Dividend	Remainder
2	202	0
2	101	1
2	50	0
2	25	1
2	12	0
2	6	0
2	3	1
		1

SECTION 8

Errors and Exceptions


Throwable
Exception
Error
Runtime Exception
Other Exception

```java
try {
    int budget = 1000;
    System.out.println("Success");
}
catch(Exception ex) {
    System.out.println(ex);
}
finally {
    System.out.println("This always runs");
}
```

Errors and Exceptions

- An exception is an error condition that occurs during the execution of a Java program. For example, if you divide an integer by zero, an **ArithmeticException** will be thrown. If you use a negative array index, an **ArrayIndexOutOfBoundsException** will be thrown.
- An unchecked exception is one that is automatically handled by Java's standard exception handling methods, which terminate execution. It is thrown if an attempt is made to divide an integer by 0, or if an array index goes out of bounds, and so on. The exception tells you that you now need to fix your code!

Errors and Exceptions

- A checked exception is one where you provide code to handle the exception, either a try/catch/finally statement, or an explicit throw new ... Exception clause. These exceptions are not necessarily caused by an error in the code. For example, an unexpected end-of-file could be due to a broken network connection.
- Checked exceptions are not part of the AP Java subset.

Exception
ArithmeticException
NullPointerException
ArrayIndexOutOfBoundsException
IndexOutOfBoundsException
IllegalArgumentException
ConcurrentModificationException

The following unchecked exceptions are in the AP Java subset:

Example 1

```
if (nurnScores 0)
    throw new ArithmeticException("Cannot divide by zero");

else
    findAverageScore();
```

Example 2

```
public void setRadius(int newRadius) {
      if (newRadius < 0)
        throw new IllegalArgumentException ("Radius cannot be negative");
      else
        radius = newRadius;
}
```