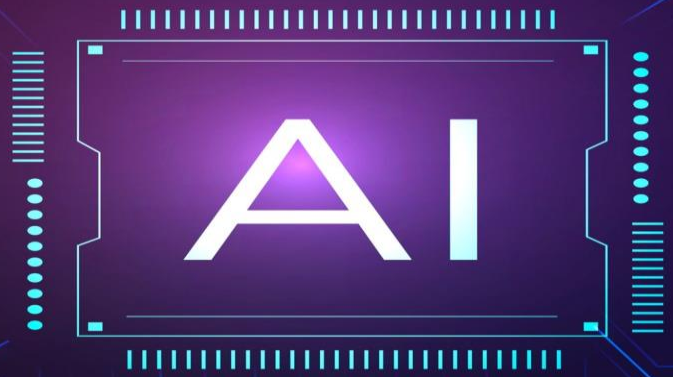


AP Computer Science A

Java Programming Essentials [Ver. 3.0]

Unit 1: Elementary Programming

CHAPTER 2A: DATA TYPES

DR. ERIC CHOU IEEE SENIOR MEMBER

Objectives

Variables

- Storage of Data – Type – ID and Value
- Identifier
- Variable Declaration and Initialization
- Naming Convention

Objectives

Data Types

- Primitive Data Versus Reference Data Type
- Constants
- Integer Number
- Real Number

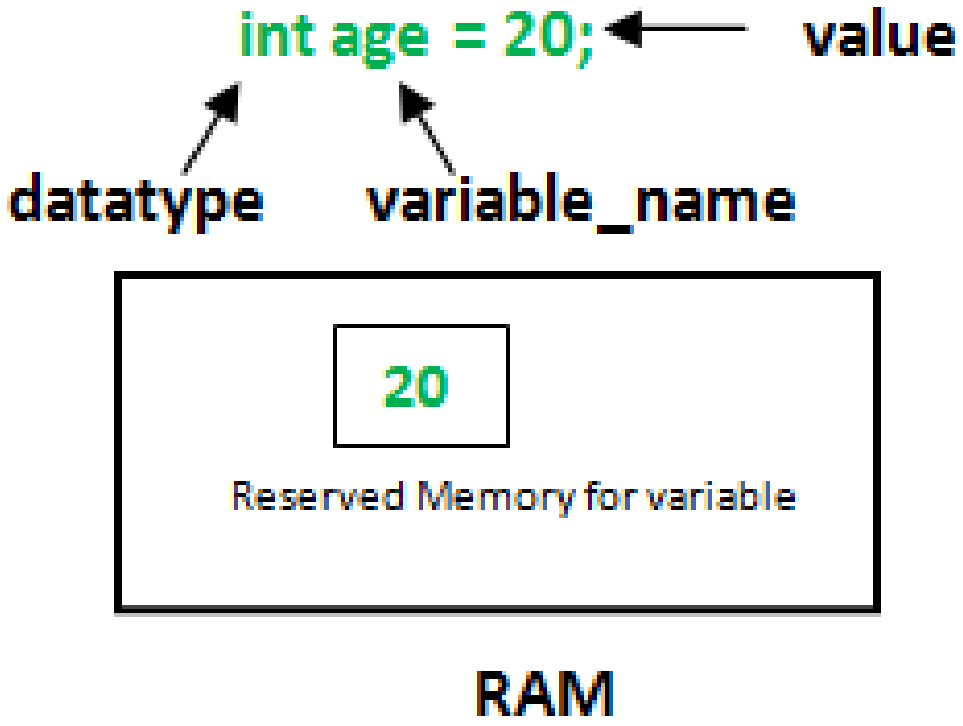
Objectives

Reference Data Types – Basic Class and Objects

- Storage of Data – Type – ID and Value
- Identifier
- Variable Declaration and Initialization
- Naming Convention

Variables

LECTURE 1

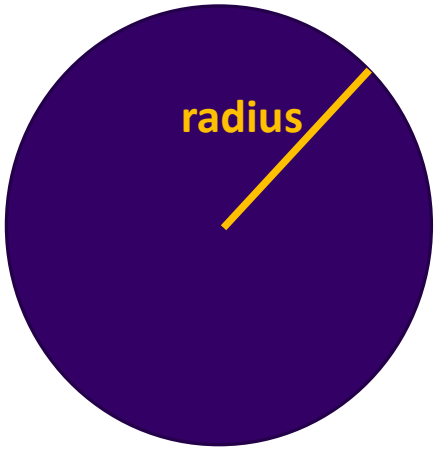

int age = 20;
value
datatype
variable_name
20
Reserved Memory for variable
RAM

Identifier

LECTURE 2

Where will see a lot of identifiers

```
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);
    }
}
```



Identifiers

- Identifiers are the name that identify the elements such as **variables, classes, methods** in a program.
- All identifiers in Java must obey the following rules:
  - An identifier is a sequence of characters that consists of letters, digits underscores (_), and dollar sign ($). An identifier must start with a letter, an underscore (_), or a dollar sign ($). It can not start with a digit (number).
  - An identifier cannot be a reserved word.
  - An identifier cannot be true, false, or null.
  - An identifier can be of any length.

Variables

Variables are used to represent values that may be changed in the program.

- A variable must be declared before used.
- A variable declaration in syntax: <data type> <variable name>;
- Examples of variable declarations:
  - int count;
  - double radius;
  - double interestRate;

Variables

Variables are used to represent values that may be changed in the program.

- Primitive data type:

  byte, short, int, long, float, double, char, boolean;

- Reference data type: <class name>
- Multiple instance for variable declaration is allowed in Java:

  datatype variable1, variable2, …, variablen;

- Declaration and assignment in the same statement is also allowed:
  int count=1;

Identifiers for Methods

public static void main(String[] args){ … }

public double abs(double a){ … }

Declaration

LECTURE 3

Declaring Variables

```
int x;                  // Declare x to be an
                        // integer variable;
double radius;          // Declare radius to
                        // be a double variable;
char a;                 // Declare a to be a
                        // character variable;
```

Assignment Statements

```
x = 1;                  // Assign 1 to x;

radius = 1.0;           // Assign 1.0 to radius;

a = 'A';                // Assign 'A' to a;
```

Variables

```
// Compute the first area
radius = 1.0;
area = radius * radius * 3.14159;
System.out.println("The area is " + area + " for radius "+radius);
// Compute the second area
radius = 2.0;
area = radius * radius * 3.14159;
System.out.println("The area is " + area + " for radius "+radius);
```

Assignment Statement and Assignment Expressions

An assignment statement designates a value for a variable. An assignment statement can be used as an expression in Java.

Syntax (assignment statement):

```
<variable> = <expression> ;
```

- An expression represents a computation involving values, variables, and operators that taking them together, evaluates to a value.

```
int y=1;
double radius = 1.0;
int x = 5 * (3 / 2) ;
x = 1;  // correct;
1 = x;  // incorrect;
```

Assignments

- Evaluate the + sign first, then the assignment.

```
x = 1;
x = x + 1;
```

- If a value is assigned to multiple variables, you can use this syntax:

```
i = j = k = 1;
```

- Which is equivalent to:

```
k = 1;
j = k;
i = j;
```

Naming Convention

LECTURE 4

Naming Conventions
(not part of syntax)

- Naming conventions can vary from team to team. Every programming team may have their own conventions.
- Right here, we are discussing the commonly used naming conventions, but it is not mandatory.

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.

Java Standard Naming Conventions

Package Name - A package should be named in lowercase characters.

Class Name - Class names should be nouns in UpperCamelCase.

Interface Name - Interface name should start with an uppercase letter and be an adjective.

Method Name - Methods should be verbs and in lowerCamelCase.

Variable Name - Variable name should in lowerCamelCase.

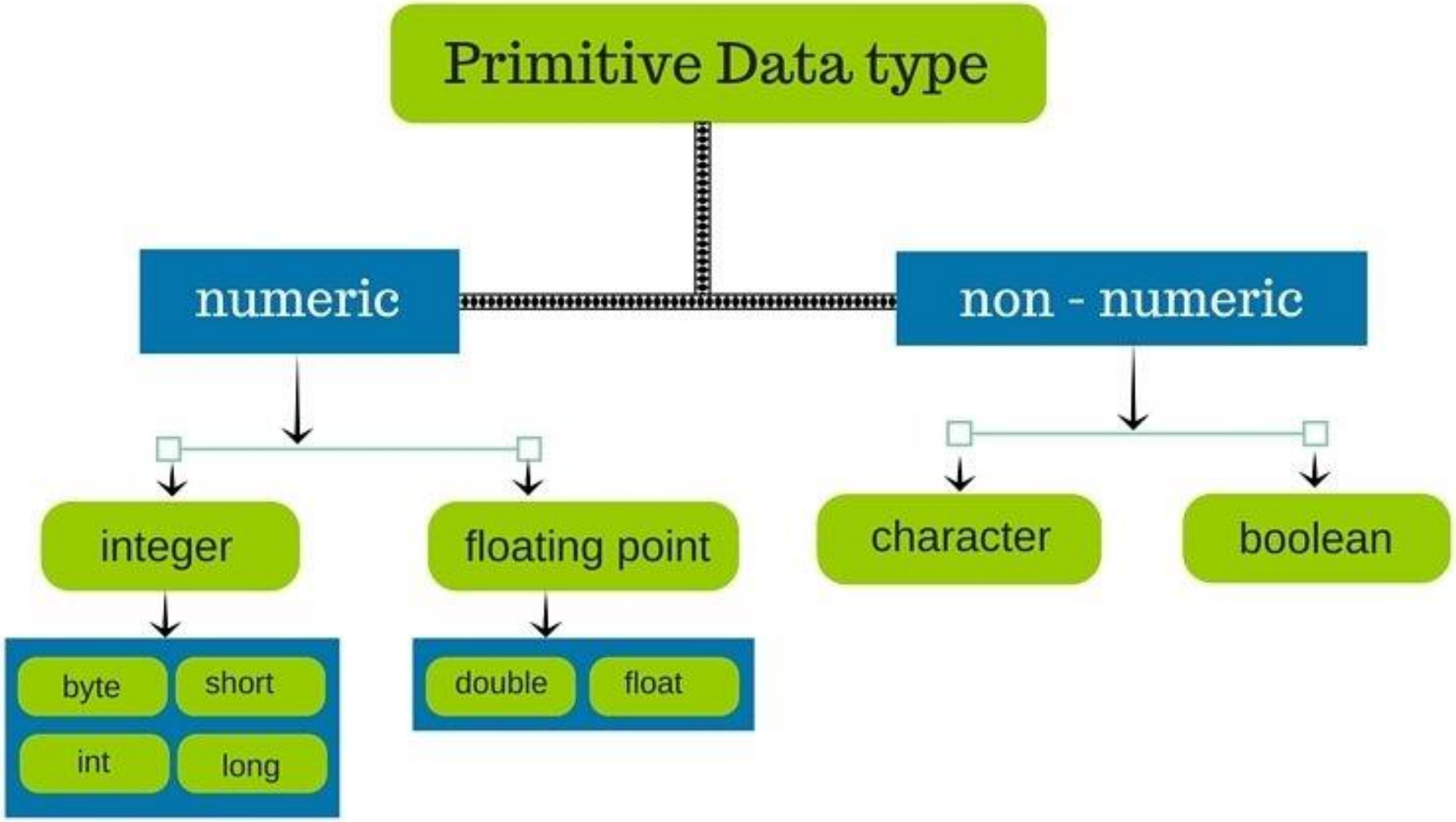
Constant Variable - Constant variable names should be written in upper characters separated by underscores.

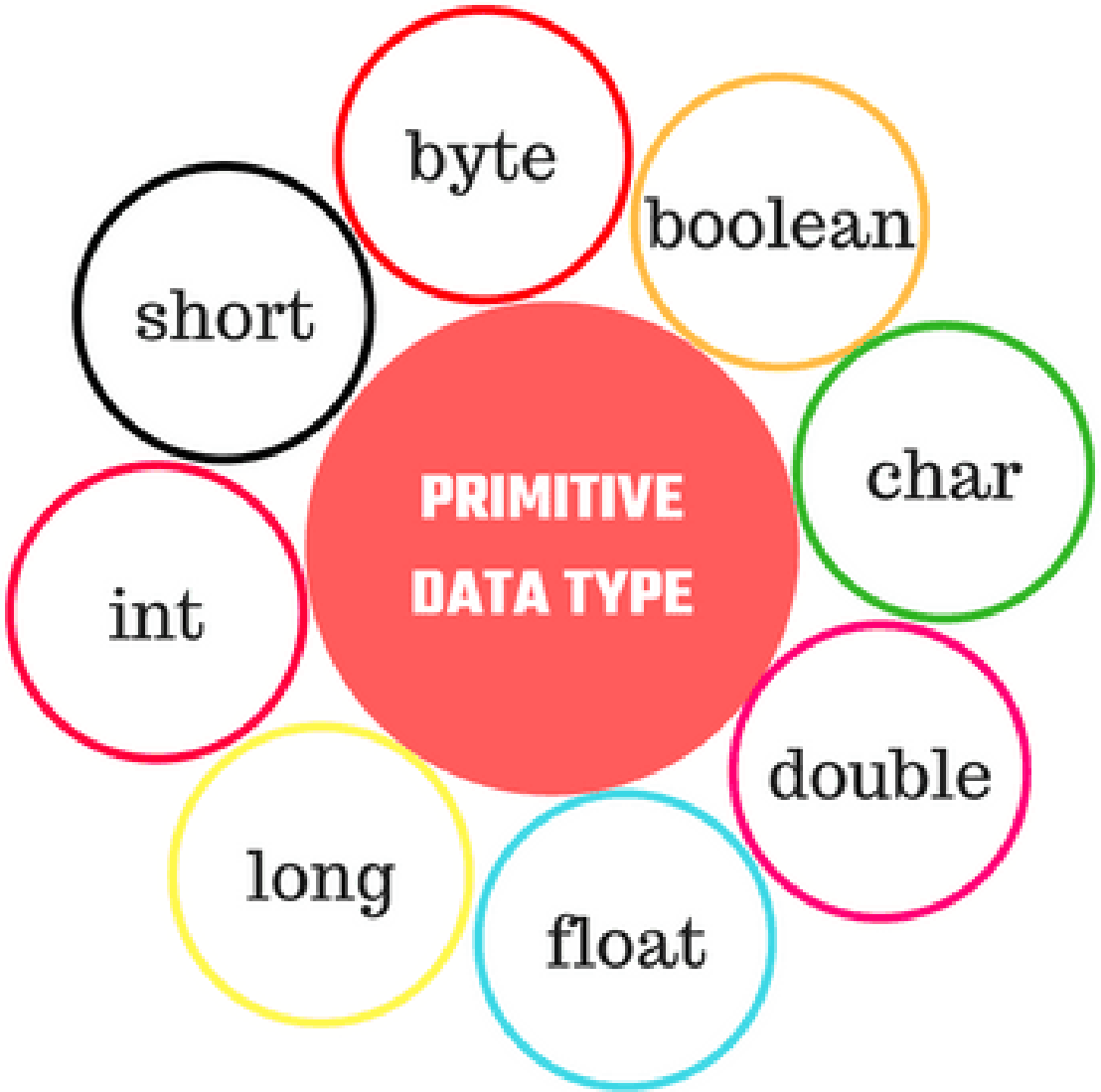
Abstract Class Name - Abstract class name must start with Abstract or Base prefix.

Exception Class Name - Exception class name must end with Exception suffix

Data Types

LECTURE 5

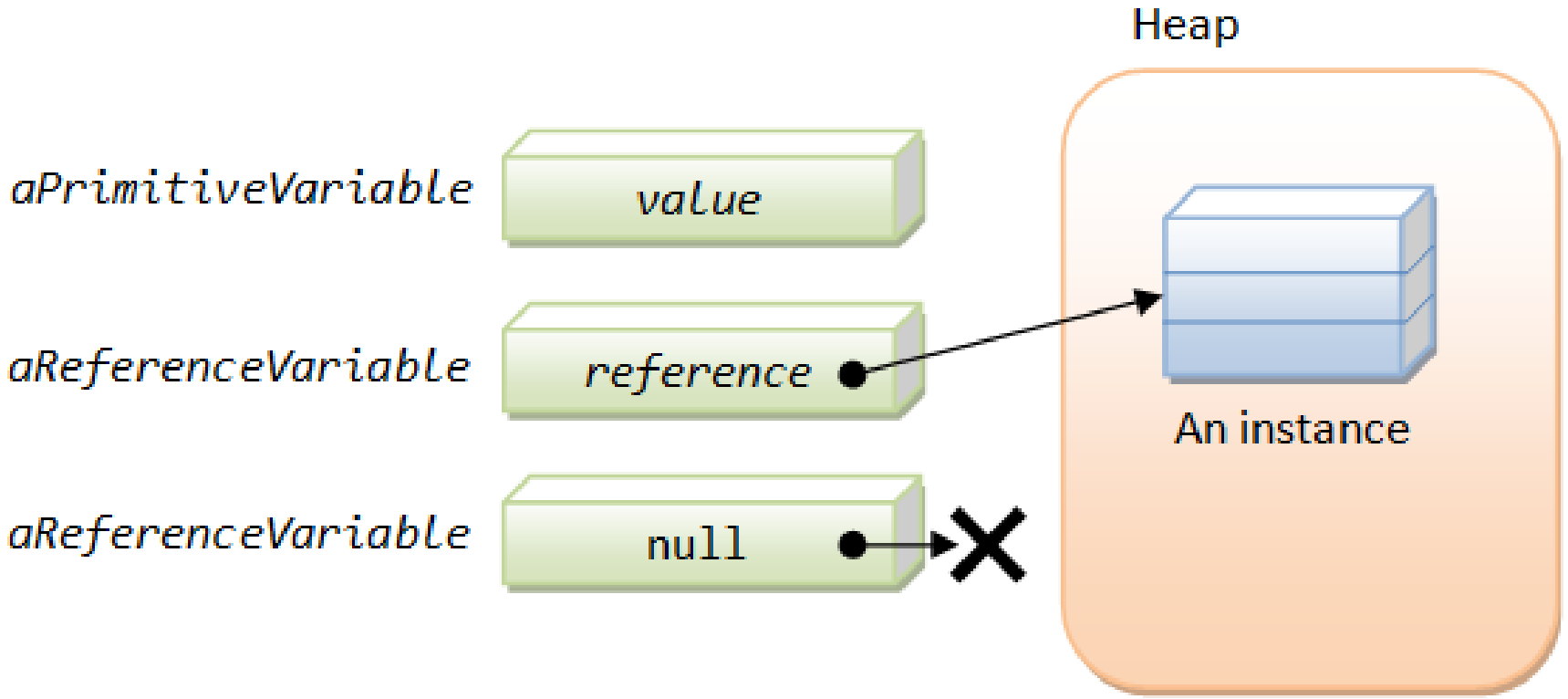

Primitive Data type
numeric
non - numeric
integer
floating point
character
boolean
byte
short
int
long
double
float

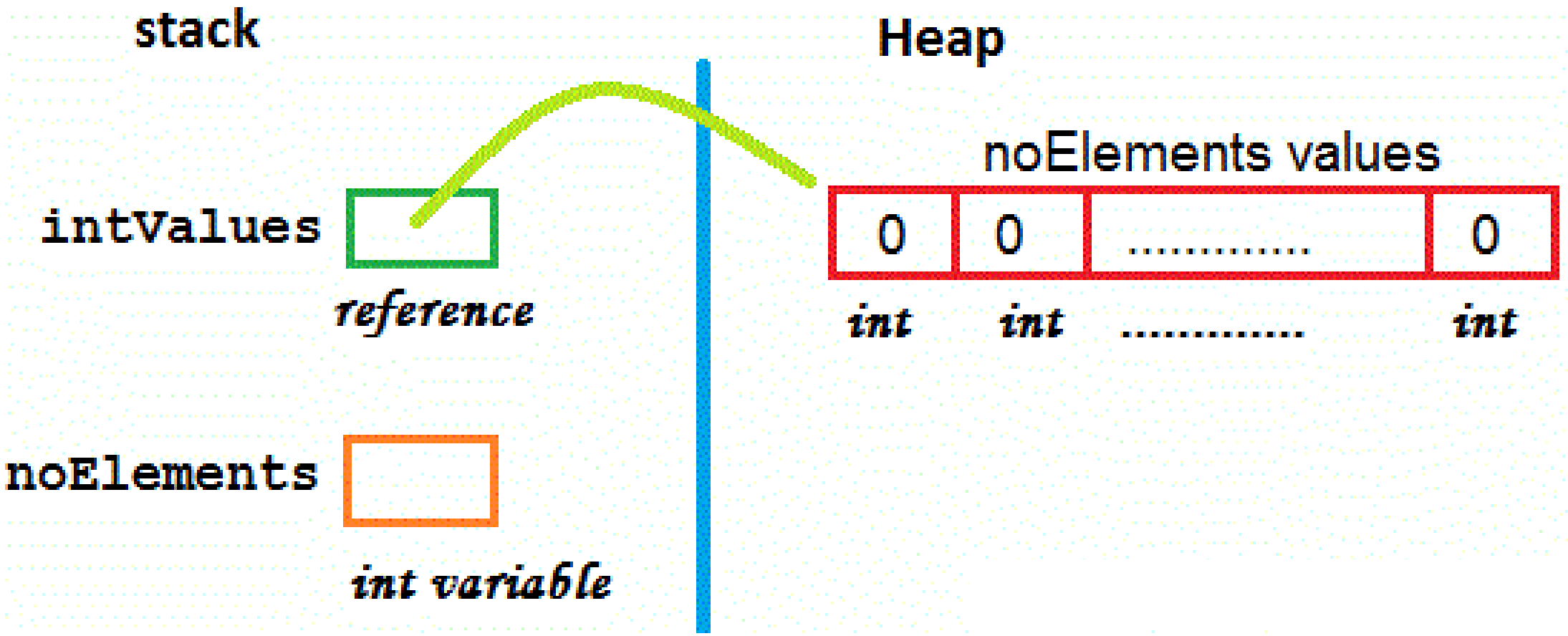

byte
boolean
short
PRIMITIVE
DATA TYPE
char
int
double
long
float

Reference Data Type

- A **reference type** is a data type that's based on a class rather than on one of the primitive types that are built in to the Java language. The class can be a class that's provided as part of the Java API class library or a class that you write yourself.
- **Reference types** are any instantiable class as well as arrays
- String, Scanner, Random, Die, int[], String[], etc.
- **Reference variables** store addresses. (**Address Pointer** is the value of the reference variable.)

Reference Data Type




stack
Heap
intValues
reference
noElements values
0
0
.....
0
int
int
.....
int
noElements
int variable

Constants

LECTURE 6

Declaring constants

- Java does not directly support constants. However, a final variable is *effectively* a constant.
- The **final** modifier causes the variable to be unchangeable
- Java constants are normally declared in ALL CAPS

```
class Math
{
public final double PI=3.14;



}
```

Named Constants

A named constant is an identifier that represents a permanent value.

Syntax:

final <datatype> CONSTANTNAME = <value> ;

The word final is a Java reserved keyword for declaring a constant.

A constant in Java (or most of other language) is usually in all **UPPERCASE**.

Benefits for using constants:

(1) you don't have to repeatedly type the same value over over again if it is used multiple times;

(2) if you have to change the constant value, you need to change it only in a single location in the source code; and

(3) a descriptive name for a constant makes the program easier to read.

Named Constants

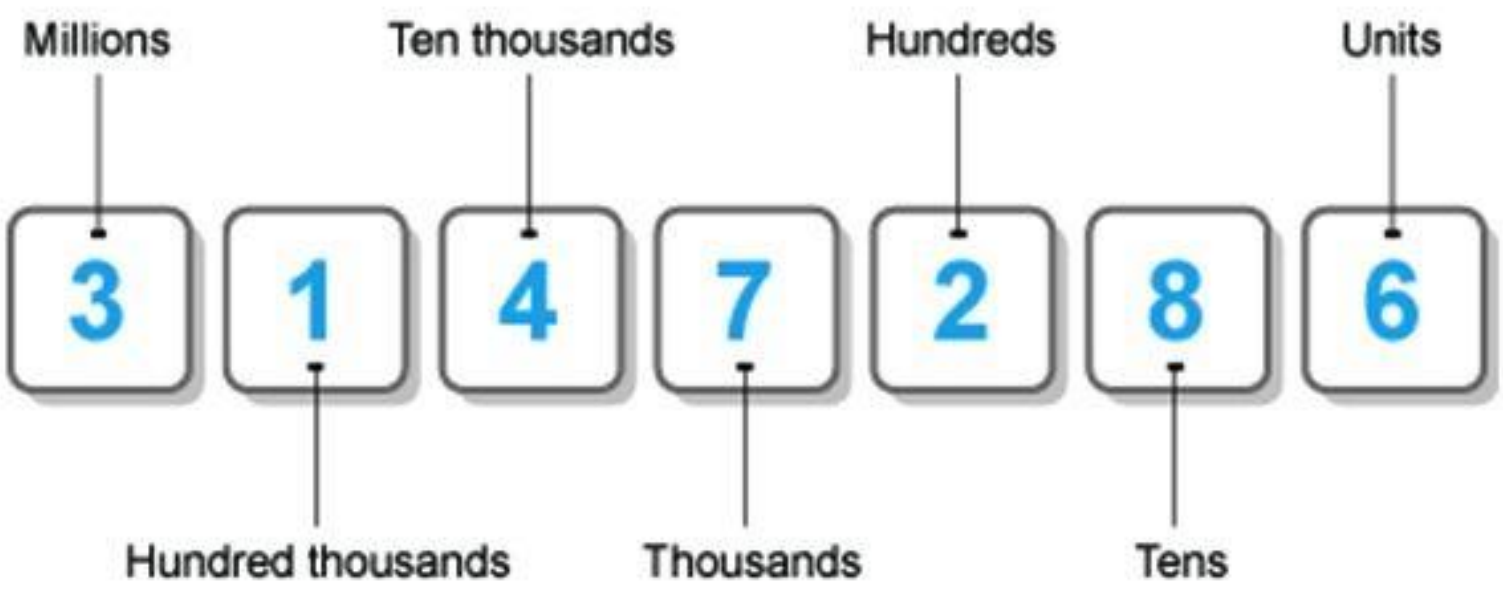
```
final datatype CONSTANTNAME = VALUE;


final double PI = 3.14159;
final int SIZE = 3;
```

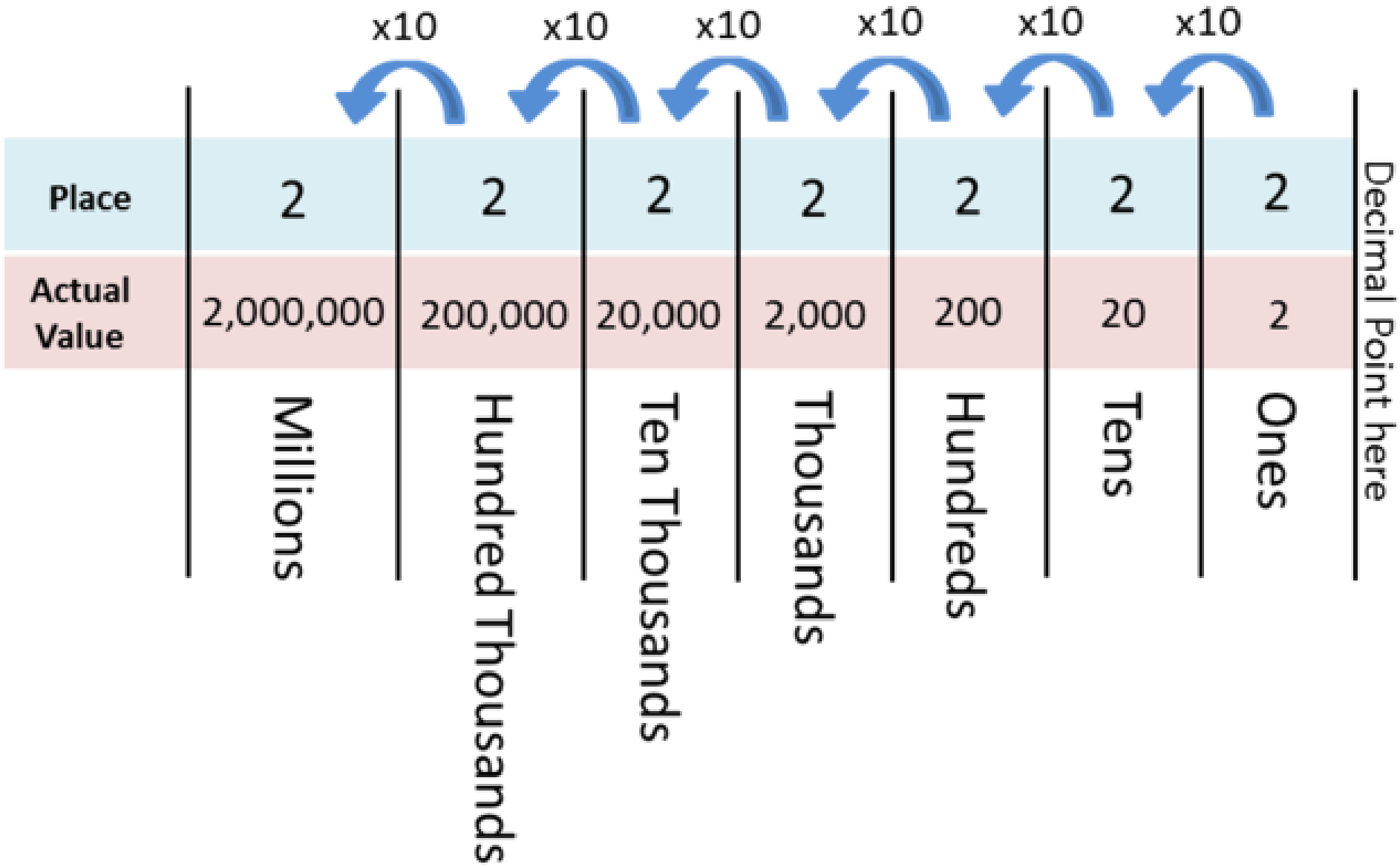
Number System

LECTURE 7

Place Value


Millions
Ten thousands
Hundreds
Units
3
1
4
7
2
8
6
Hundred thousands
Thousands
Tens

	3th Place	2nd Place	1st Place	Decimal Point	1st Decimal Place	2st Decimal Place	3st Decimal Place	4st Decimal Place
Value of place (words)	Hundred	Ten	One	.	Tenths	Hundredths	Thousandths	Ten Thousandths
Value of place (digits)	100	10	1	.	1/10	1/100	1/1 000	1/10 000


x10
x10
x10
x10
x10
x10
Place
2
2
2
2
2
2
2
Actual Value
2,000,000
200,000
20,000
2,000
200
20
2
Millions
Hundred Thousands
Ten Thousands
Thousands
Hundreds
Tens
Ones
Decimal Point here

quinary

A place value Base-5 number system.

Five digits are used: 0, 1, 2, 3, 4.

in the quinary system the base number is 5

5^5	5^4	5^3	5^2	5^1	5^0
3125's	625's	125's	25's	5's	1's

Used in the tally marks system of counting.

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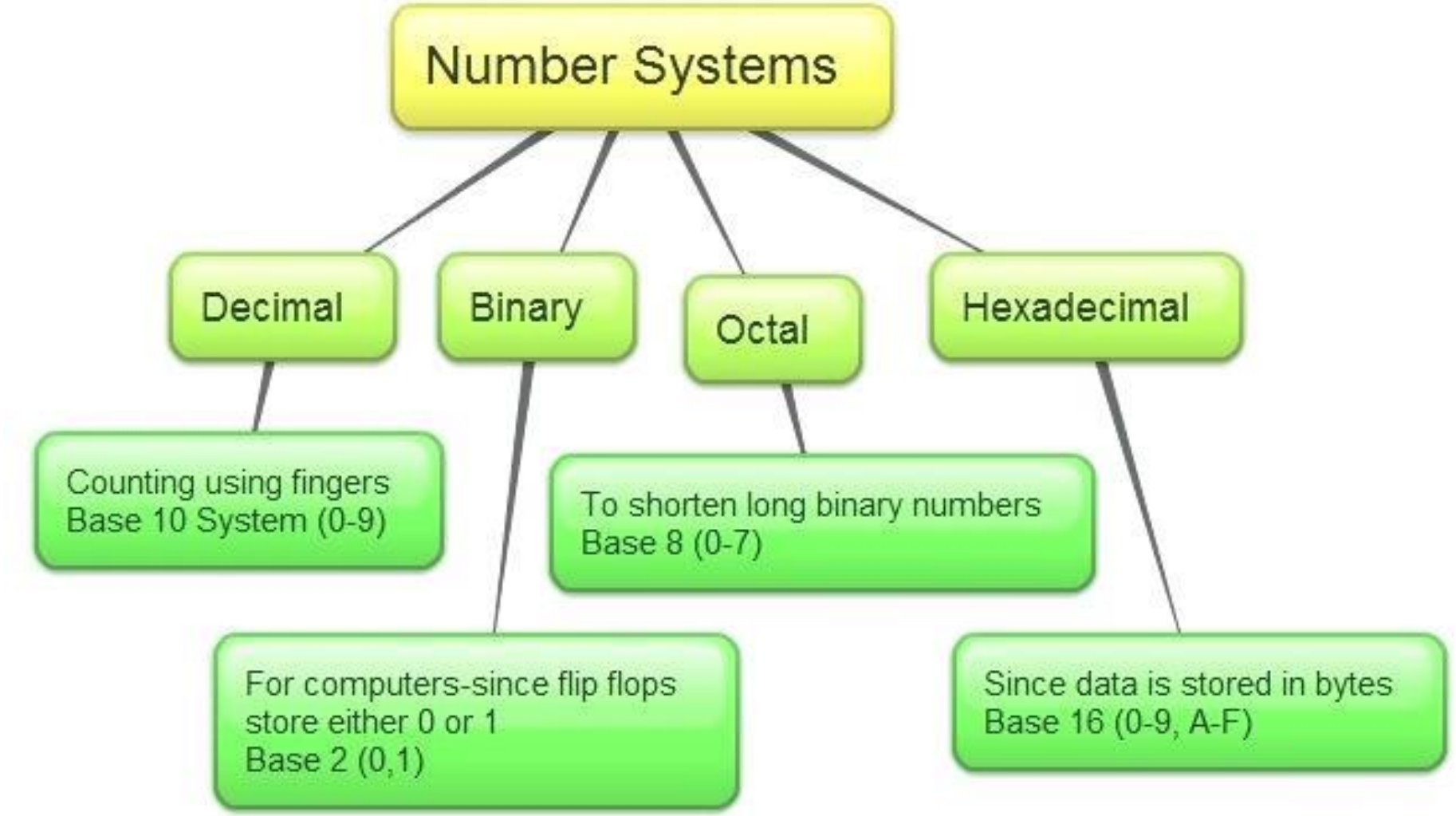
1101001_2

Digit	1	1	0	1	0	0	1
Place value	2^6	2^5	2^4	2^3	2^2	2^1	2^0

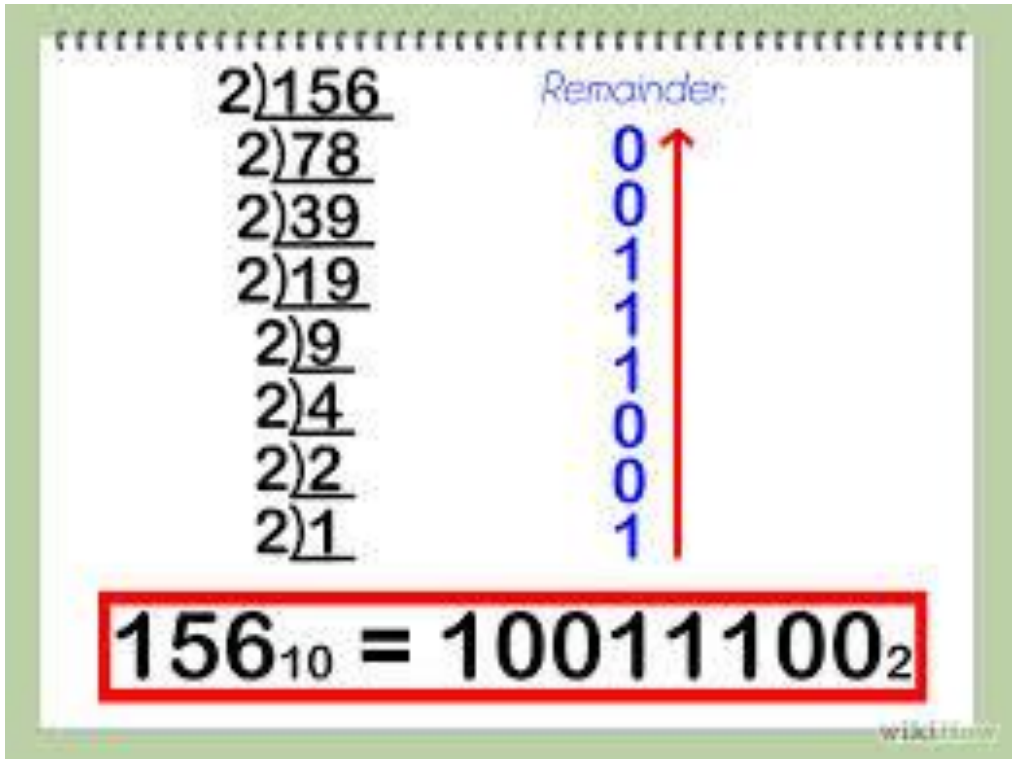
The place values of the binary number system are powers of 2.


Number Systems
Decimal
Binary
Octal
Hexadecimal
Counting using fingers
Base 10 System (0-9)
For computers-since flip flops
store either 0 or 1
Base 2 (0,1)
To shorten long binary numbers
Base 8 (0-7)
Since data is stored in bytes
Base 16 (0-9, A-F)

Binary Numbers

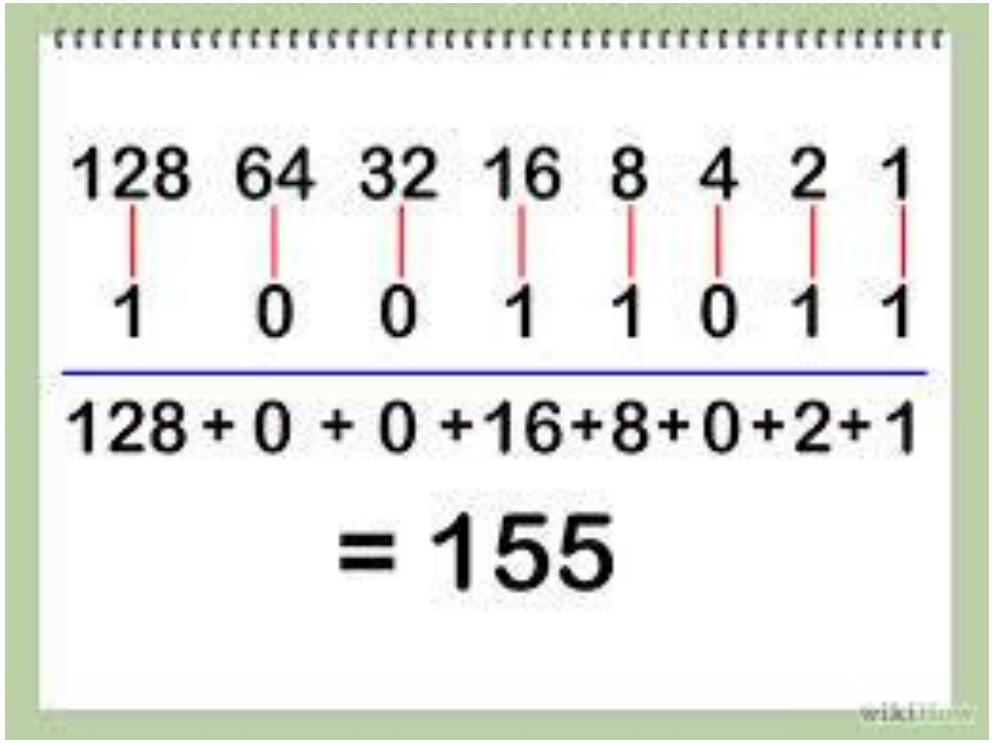
LECTURE 8

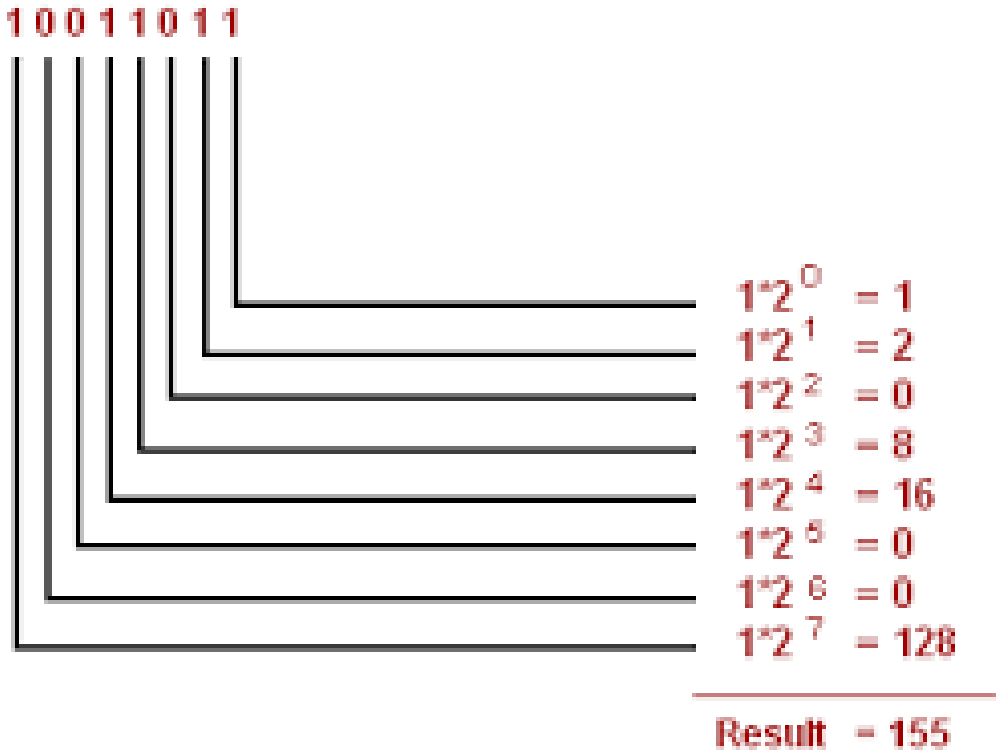
Decimal to Binary



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

Binary/Decimal Conversion

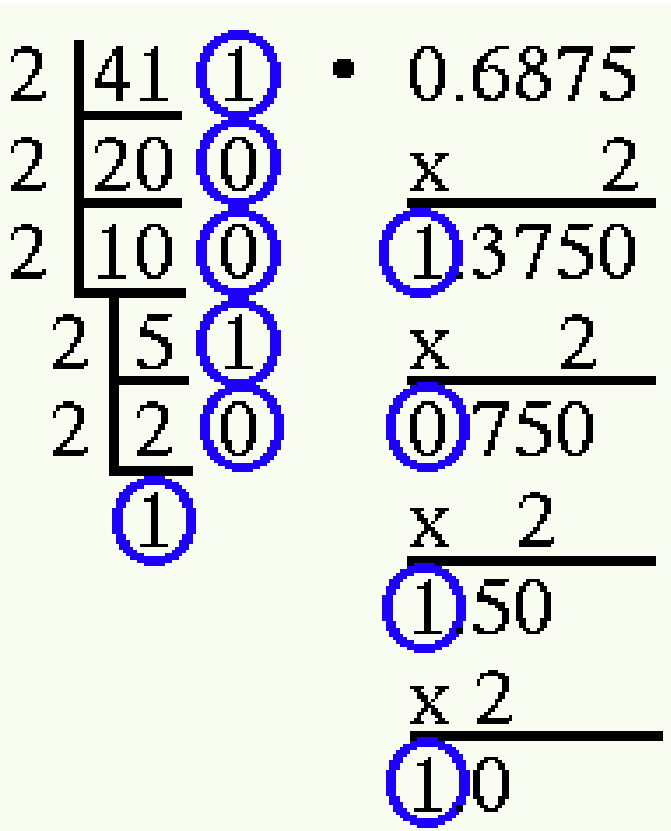


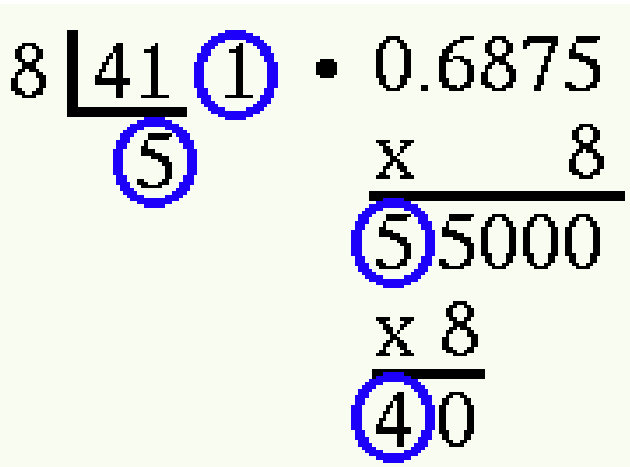


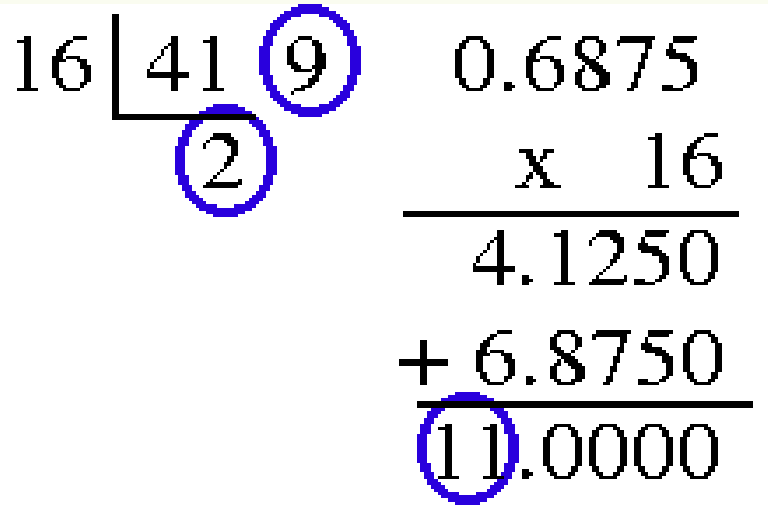
Binary Value	Decimal Representation	Decimal Value
	8 4 2 1	
0 0 0 0	0 + 0 + 0 + 0	0
0 0 0 1	0 + 0 + 0 + 1	1
0 0 1 0	0 + 0 + 2 + 0	2
0 0 1 1	0 + 0 + 2 + 1	3
0 1 0 0	0 + 4 + 0 + 0	4
0 1 0 1	0 + 4 + 0 + 1	5
0 1 1 0	0 + 4 + 2 + 0	6
0 1 1 1	0 + 4 + 2 + 1	7
1 0 0 0	8 + 0 + 0 + 0	8
1 0 0 1	8 + 0 + 0 + 1	9
1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


2 | 41 1
2 | 20 0
2 | 10 0
2 | 5 1
2 | 2 0
1
• 0.6875
x 2
1.3750
x 2
0.750
x 2
1.50
x 2
1.0


8 | 41 1
5
• 0.6875
x 8
5.5000
x 8
4.0


16 | 41 9
2
0.6875
x 16
4.1250
+ 6.8750
11.0000

Integer Types

LECTURE 9

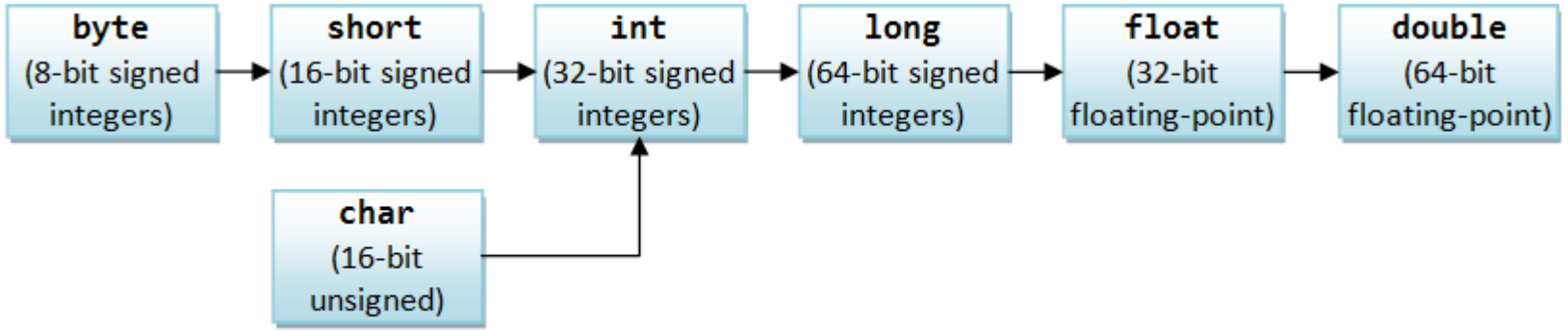
Numeric Data Types and Operations

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

Name	Data	Range	Default Value	Size
byte	signed integer	[-128, 127]	0	8 bits
short	signed integer	[-32768, 32767]	0	16 bits
int	signed integer	[-2147483648, 2147483647]	0	32 bits
long	signed integer	[-9223372036854775808, 9223372036854775807]	0	64 bits
float	floating-point	**MIN:** ±1.4E-45 **MAX:** ±3.4028235E+38	0.0	32 bits
double	floating-point	**MIN:** ±4.9E-324 **MAX:** ±1.79769313486231570E+308	0.0	64 bits
char	Unicode	['\u0000', '\uFFFF']	'\u0000'	16 bits
boolean	logical value	{false, true}	false	≥ 1 bit

Numeric Data Types and Operations

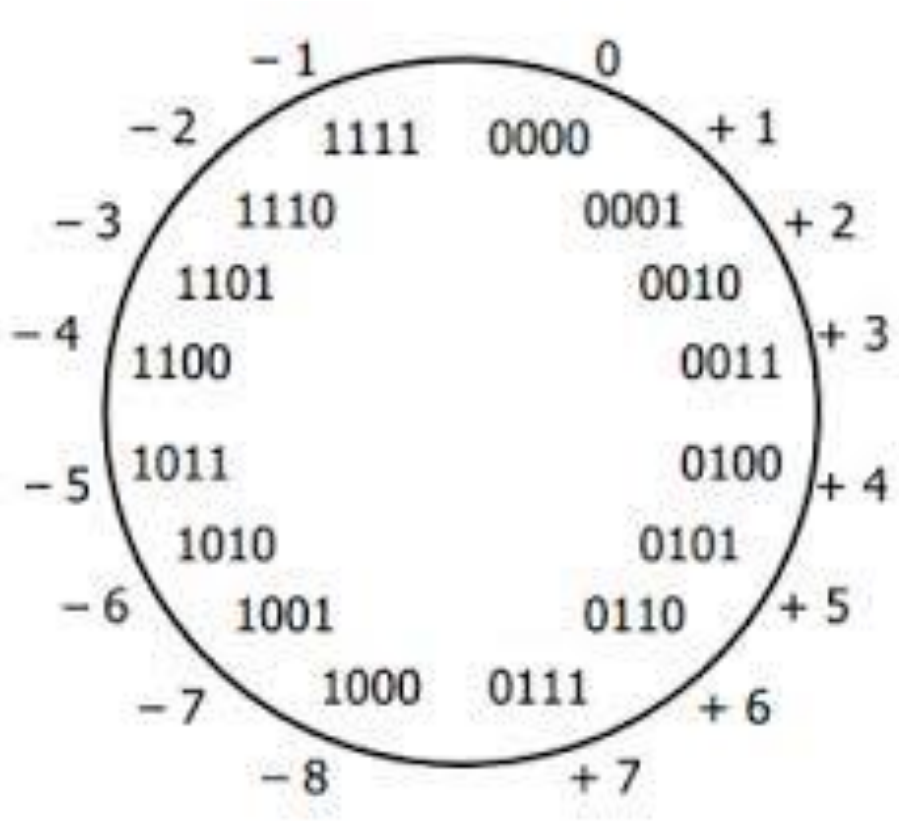
Java has six numeric types for integers and floating-point numbers with operators +, -, *, . and %



Orders of Implicit Type-Casting for Primitives

Integer.MIN_VALUE
Integer.MAX_VALUE

Two’s Complement



Negative number is represented as two’s complement.

For byte number’s (8 bits):

$-X = (2^8 - 1) - X + 1;$

$X + (-X) = X + (2^8 - X) = 2^8 = 0\ ;$

eg.

A = 0100 -> A’s One’s Complement = 1011 ->

A’s Two’s Complement -> 1100

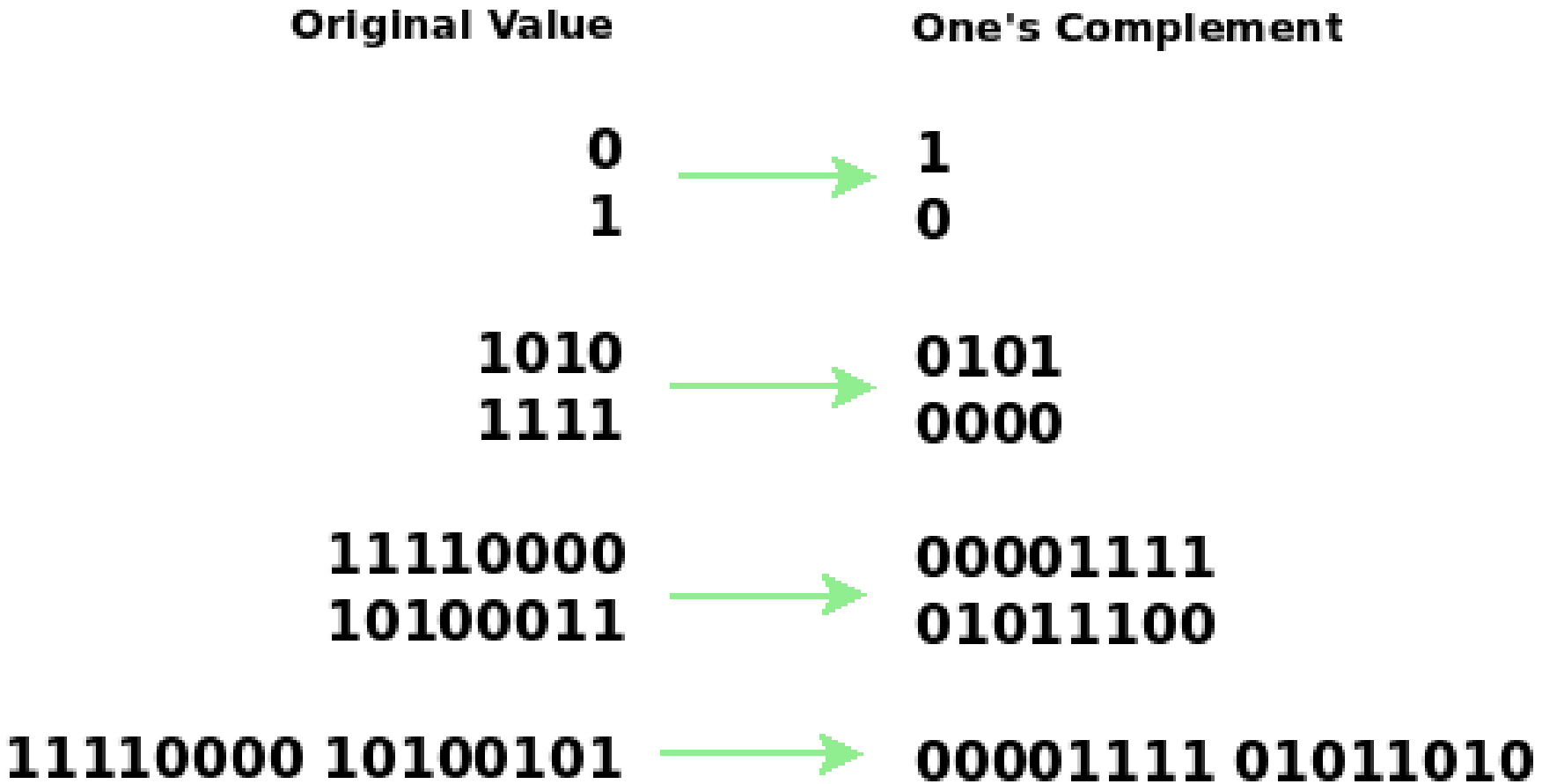
The number 2^8 is a overflow for the byte format, because unsigned byte number range

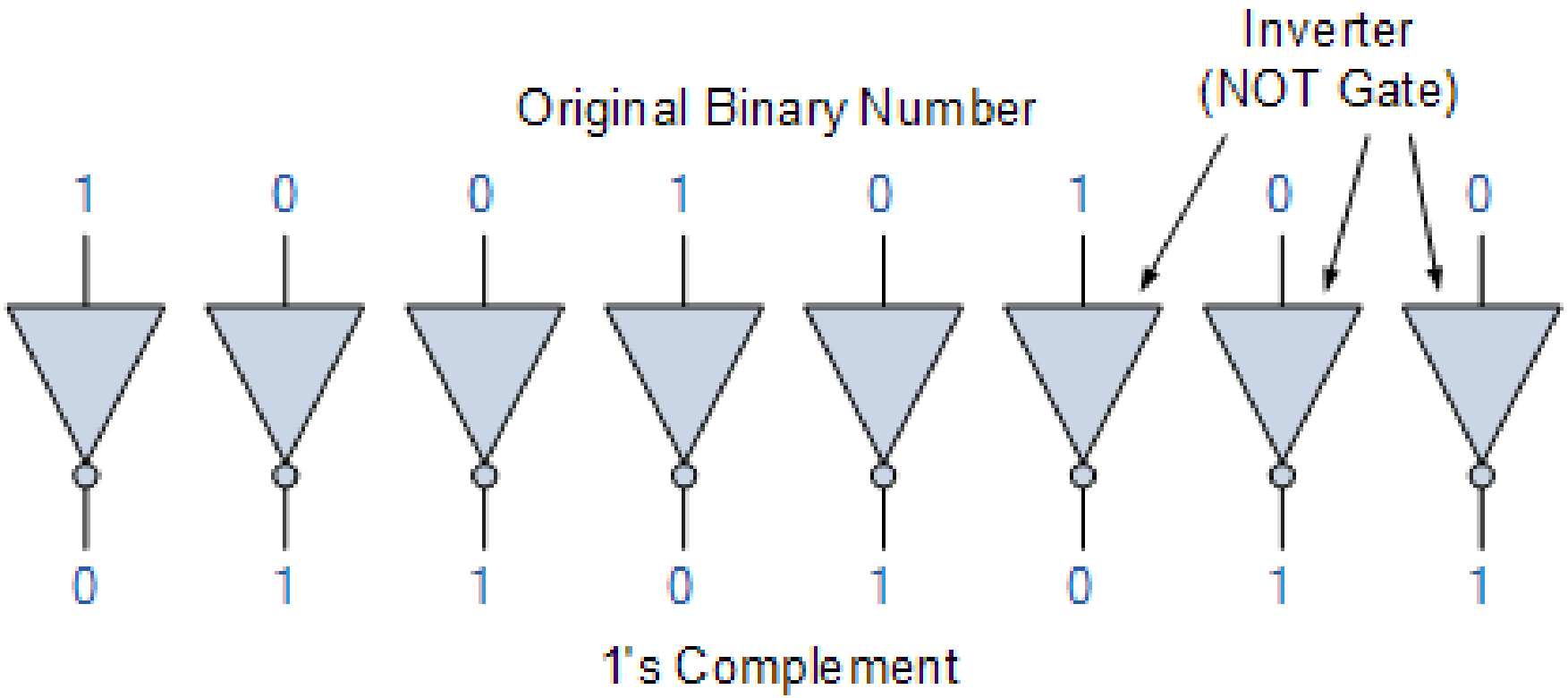
from 0 to $2^8 - 1$ = 11111111.

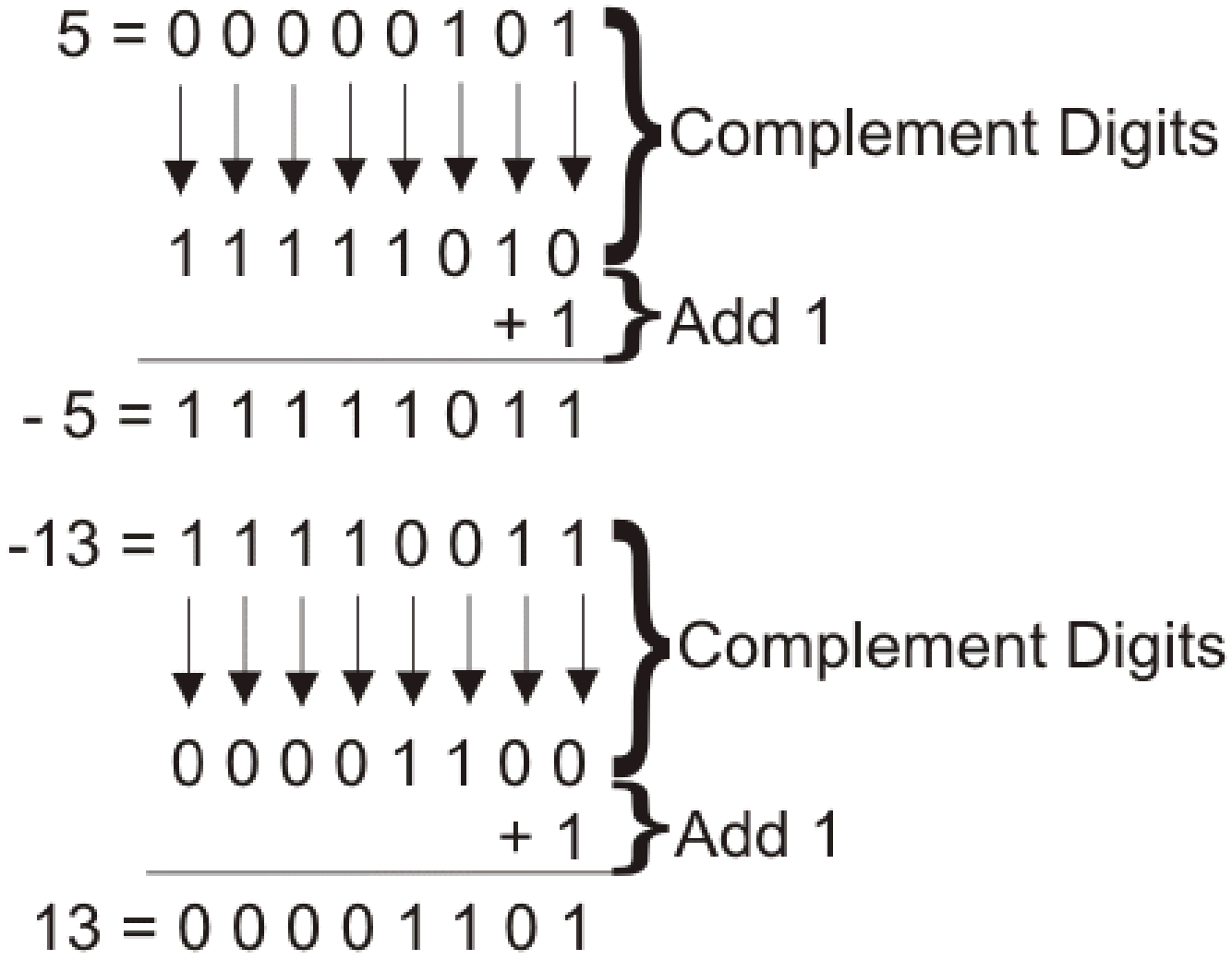
Therefore, this method can work for computer.

One's Complement

Invert all bits. Each 1 becomes a 0, and each 0 becomes a 1.




Inverter
(NOT Gate)
Original Binary Number
1 0 0 1 0 1 0 0
0 1 1 0 1 0 1 1
1's Complement


5 = 0 0 0 0 0 1 0 1
Complement Digits
1 1 1 1 1 0 1 0
+ 1
Add 1
- 5 = 1 1 1 1 1 0 1 1
-13 = 1 1 1 1 0 0 1 1
Complement Digits
0 0 0 0 1 1 0 0
+ 1
Add 1
13 = 0 0 0 0 1 1 0 1

Finding 2's Complement

	-128	64	32	16	8	4	2	1	
X	0	1	0	0	1	1	1	1	**Number : 79 decimal**
$(2^8-1)-X$	1	0	1	1	0	0	0	0	**Flip the bits**
	0	0	0	0	0	0	0	1	**Add 1**
$NegX = (2^8-1)-X+1$	1	0	1	1	0	0	0	1	**Number: -79 in 2's Complement format**

Integer Literals

LECTURE 10

Java Integer literals

- Theoretically Literal means – Any number, text or other information that represents a **value**.
- Different values that can be assigned to an integer variable (Integer data type Literal)

Literal Types

Literal Type	Assignment Statement	Explanation
Decimal	**int** num = 20;	Decimal 20 is assigned to the variable num
Octal	**int** num = 020;	"**020**" is octal number , so first octal number is converted into integer and then it is assigned to variable "**num**"
Hexadecimal	**int** num = 0x20;	"**0x20**" is hexadecimal number , It is first converted into Decimal then assigned to variable "**num**"
Binary	**int** num = 0b1010;	"**0b1010**" is binary number , assigned to the variable "**num**" after converting it into decimal number
Long	**long** num = 563L;	"**563L**" is long number , assigned to the variable "**num**"

Java integer literal and Underscore

1. In JDK 7, we can embed one or more underscores in an integer literal.
2. It makes easier to read large integer literals.
3. When the literal is compiled, the underscores are discarded. **int num = 19_90;**
4. Java compiler will discard '_' from the above number and will assign 1990 to variable "num". Thus it is as good as writing – **int num = 1990;**

Literal	Using Underscore	Actual Value
Integer Literal	45_89	4589
Octal Literal	045_23	Equivalent Octal : 04523
Hexadecimal Literal	0x56_23	Equivalent Hex : 0x5623
Binary Literal	0b1000_1001	Equivalent Binary : 10001001

Java integer literal and Underscore

Note : Using Underscore in Integer

1. Don’t Use Underscore as first and last character.
2. It is used to read long number easily

Illegal ways of using underscore

- Below are some places where we cannot put the underscore while using the Java integer literal –

1. We cannot put underscore at the beginning or end of a number
2. Underscore should not be placed adjacent to a decimal point in a floating point literal
3. Use of underscore prior to an F or L suffix is illegal
4. Underscore should not be used in positions where a string of digits is expected

Characters

LECTURE 11

Characters

- The data type **char** represents a single character in Java.
- Character values are written as a symbol: ‘a’, ‘)’, ‘A’, etc.
- A **char** value in Java is really represented as an integer.
  - Each character has an associated integer value. The integer value is the ASCII value or Unicode value (UTF-16)

ISO / IEC 8859-1 8-bit character set

ASCII

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	00	Null	32	20	Space	64	40	@	96	60	`
1	01	Start of heading	33	21	!	65	41	A	97	61	a
2	02	Start of text	34	22	"	66	42	B	98	62	b
3	03	End of text	35	23	#	67	43	C	99	63	c
4	04	End of transmit	36	24	$	68	44	D	100	64	d
5	05	Enquiry	37	25	%	69	45	E	101	65	e
6	06	Acknowledge	38	26	&	70	46	F	102	66	f
7	07	Audible bell	39	27	'	71	47	G	103	67	g
8	08	Backspace	40	28	(	72	48	H	104	68	h
9	09	Horizontal tab	41	29	)	73	49	I	105	69	i
10	0A	Line feed	42	2A	*	74	4A	J	106	6A	j
11	0B	Vertical tab	43	2B	+	75	4B	K	107	6B	k
12	0C	Form feed	44	2C	,	76	4C	L	108	6C	l
13	0D	Carriage return	45	2D	-	77	4D	M	109	6D	m
14	0E	Shift out	46	2E	.	78	4E	N	110	6E	n
15	0F	Shift in	47	2F	/	79	4F	O	111	6F	o
16	10	Data link escape	48	30	0	80	50	P	112	70	p
17	11	Device control 1	49	31	1	81	51	Q	113	71	q
18	12	Device control 2	50	32	2	82	52	R	114	72	r
19	13	Device control 3	51	33	3	83	53	S	115	73	s
20	14	Device control 4	52	34	4	84	54	T	116	74	t
21	15	Neg. acknowledge	53	35	5	85	55	U	117	75	u
22	16	Synchronous idle	54	36	6	86	56	V	118	76	v
23	17	End trans. block	55	37	7	87	57	W	119	77	w
24	18	Cancel	56	38	8	88	58	X	120	78	x
25	19	End of medium	57	39	9	89	59	Y	121	79	y
26	1A	Substitution	58	3A	:	90	5A	Z	122	7A	z
27	1B	Escape	59	3B	;	91	5B	[	123	7B	{
28	1C	File separator	60	3C	<	92	5C	\	124	7C	|
29	1D	Group separator	61	3D	=	93	5D	]	125	7D	}
30	1E	Record separator	62	3E	>	94	5E	^	126	7E	~
31	1F	Unit separator	63	3F	?	95	5F	_	127	7F	□

Java-Supplementary Characters and UTF-16 Encoding

- The **char** data type are based on the original **Unicode** specification, which defined characters as fixed-width 16-bit entities. The Unicode standard has since been changed to allow for characters whose representation requires more than 16 bits.
- The range of legal code points is now **U+0000** to **U+10FFFF**, known as Unicode scalar value.

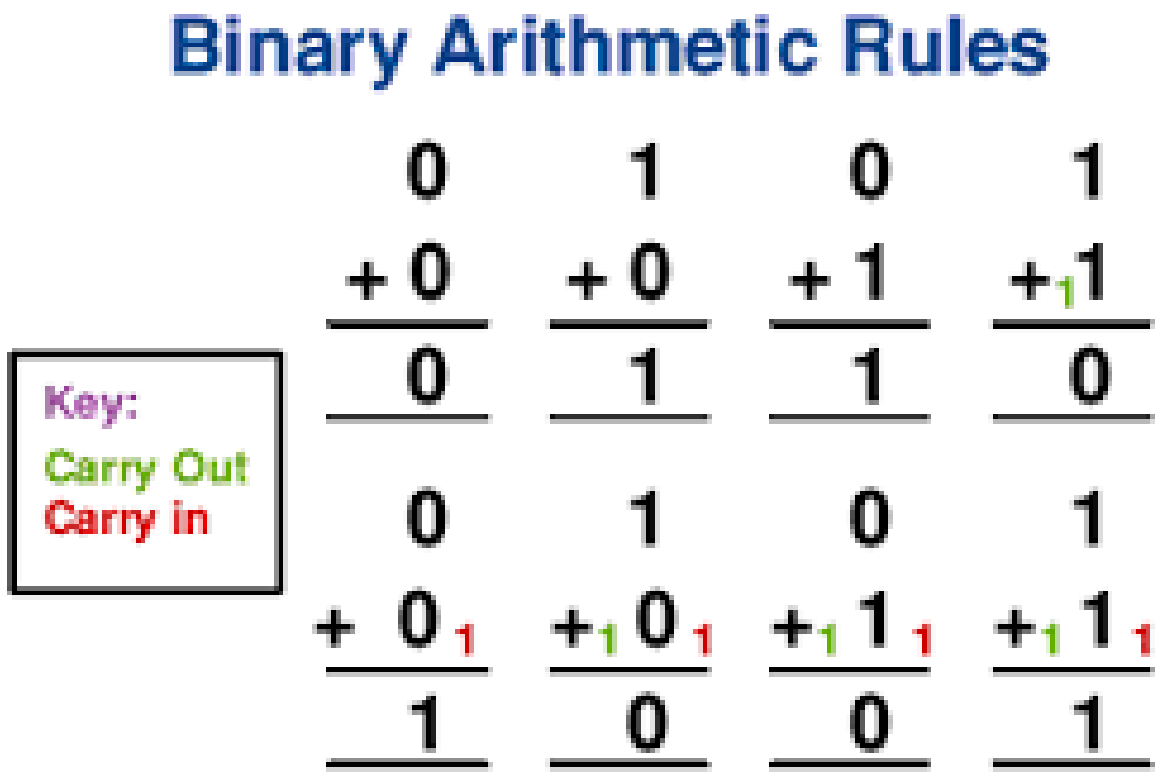
Java-Supplementary Characters and UTF-16 Encoding

- The set of characters from **U+0000** to **U+FFFF** is sometimes referred to as the Basic Multilingual Plane (**BMP**). Characters whose code points are greater than **U+FFFF** are called supplementary characters.
- The Java 2 platform uses the UTF-16 representation in char arrays and in the **String** and **StringBuffer** classes. In this representation, supplementary characters are represented as a pair of char values, the first from the high-surrogates range, (\uD800-\uDBFF), the second from the low-surrogates range (\uDC00-\uDFFF).

Bit-Level Integer Operations

LECTURE 12

Binary Addition



Binary Addition

C		101111000
X	190	10111110
Y	+ 141	+ 10001101
$X + Y$	331	101001011

C		001011000
X	173	10101101
Y	+ 44	+ 00101100
$X + Y$	217	11011001

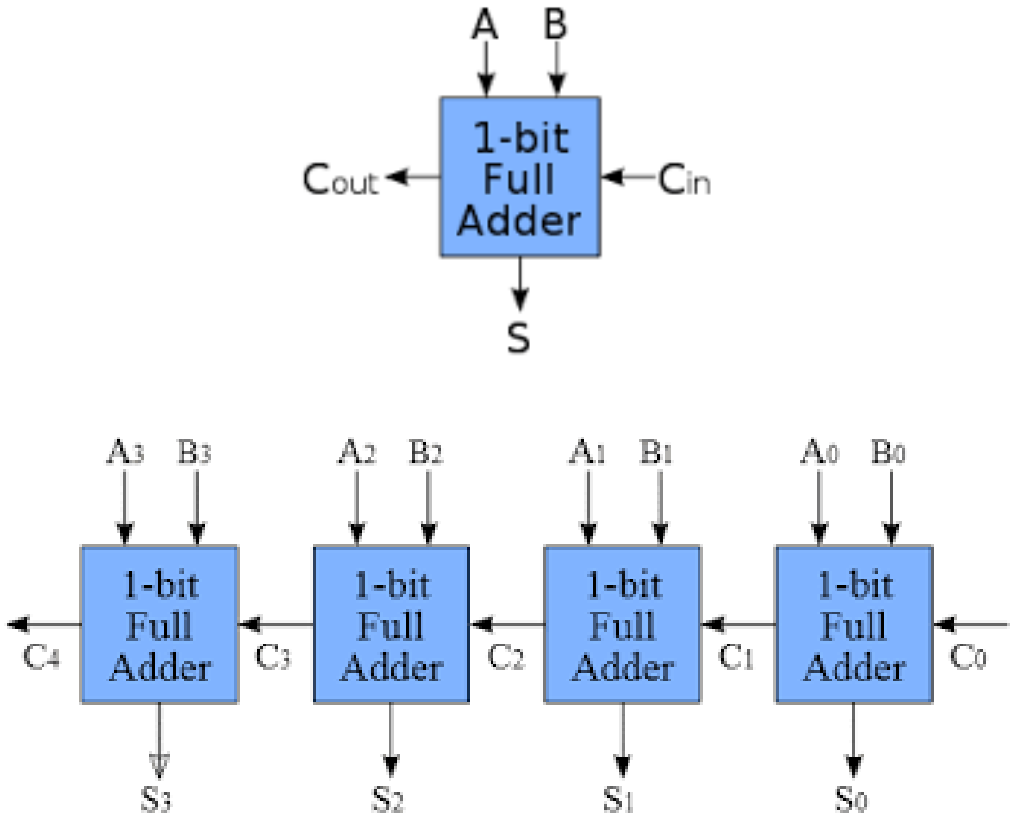
C		011111110
X	127	01111111
Y	+ 63	+ 00111111
$X + Y$	190	10111110

C		000000000
X	170	10101010
Y	+ 85	+ 01010101
$X + Y$	255	11111111

Hardware Design for a One-bit adder

Row	Inputs			Outputs		Comment
	x	y	c_{in}	c_{out}	s	
0	0	0	0	0	0	$0+0+0=00_2$
1	0	0	1	0	1	$0+0+1=01_2$
2	0	1	0	0	1	$0+1+0=01_2$
3	0	1	1	1	0	$0+1+1=10_2$
4	1	0	0	0	1	$1+0+0=01_2$
5	1	0	1	1	0	$1+0+1=10_2$
6	1	1	0	1	0	$1+1+0=10_2$
7	1	1	1	1	1	$1+1+1=11_2$

Hardware Design for a One-bit adder



Subtraction (A-B) = (A + -B)

using Two's compliment addition for subtraction

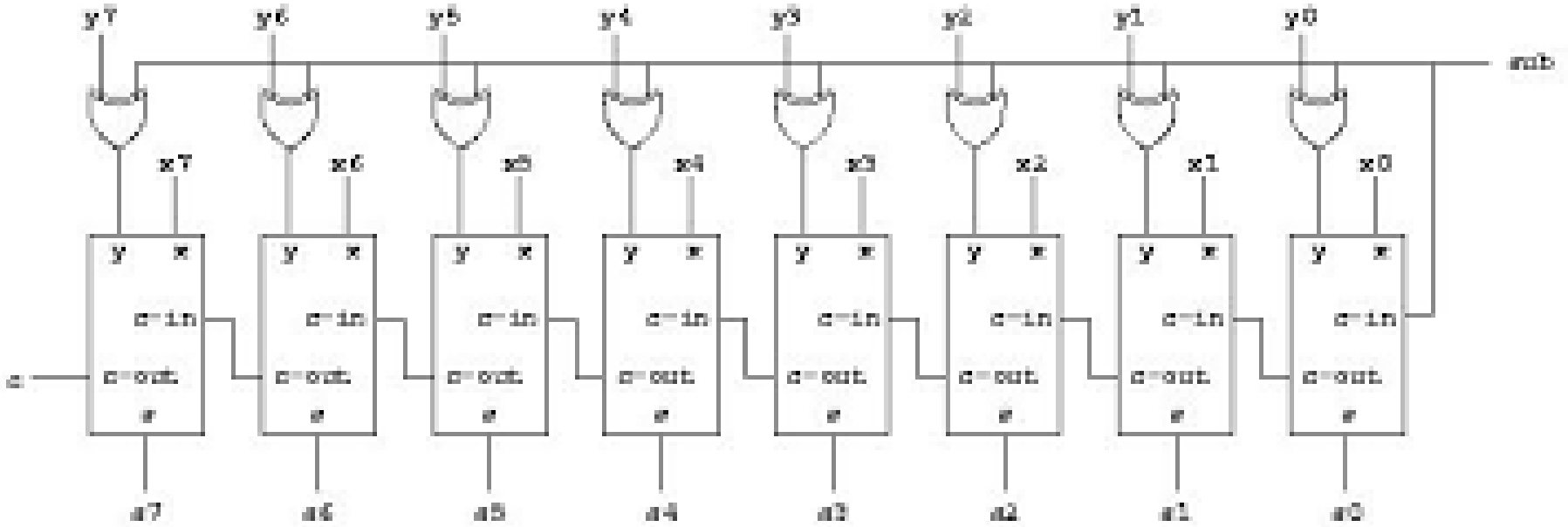
- 12_{ten} - 5_{ten} (using Java int data type example)

$$
\begin{array}{ll}
 & 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 1100 \quad (12_{ten}) \\
- & 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0101 \quad (\ 5_{ten}) \\
\hline
= & 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0111 \quad (\ 7_{ten})
\end{array}
$$

- 12_{ten} - $5_{ten} = 12_{ten} + (-5_{ten})$

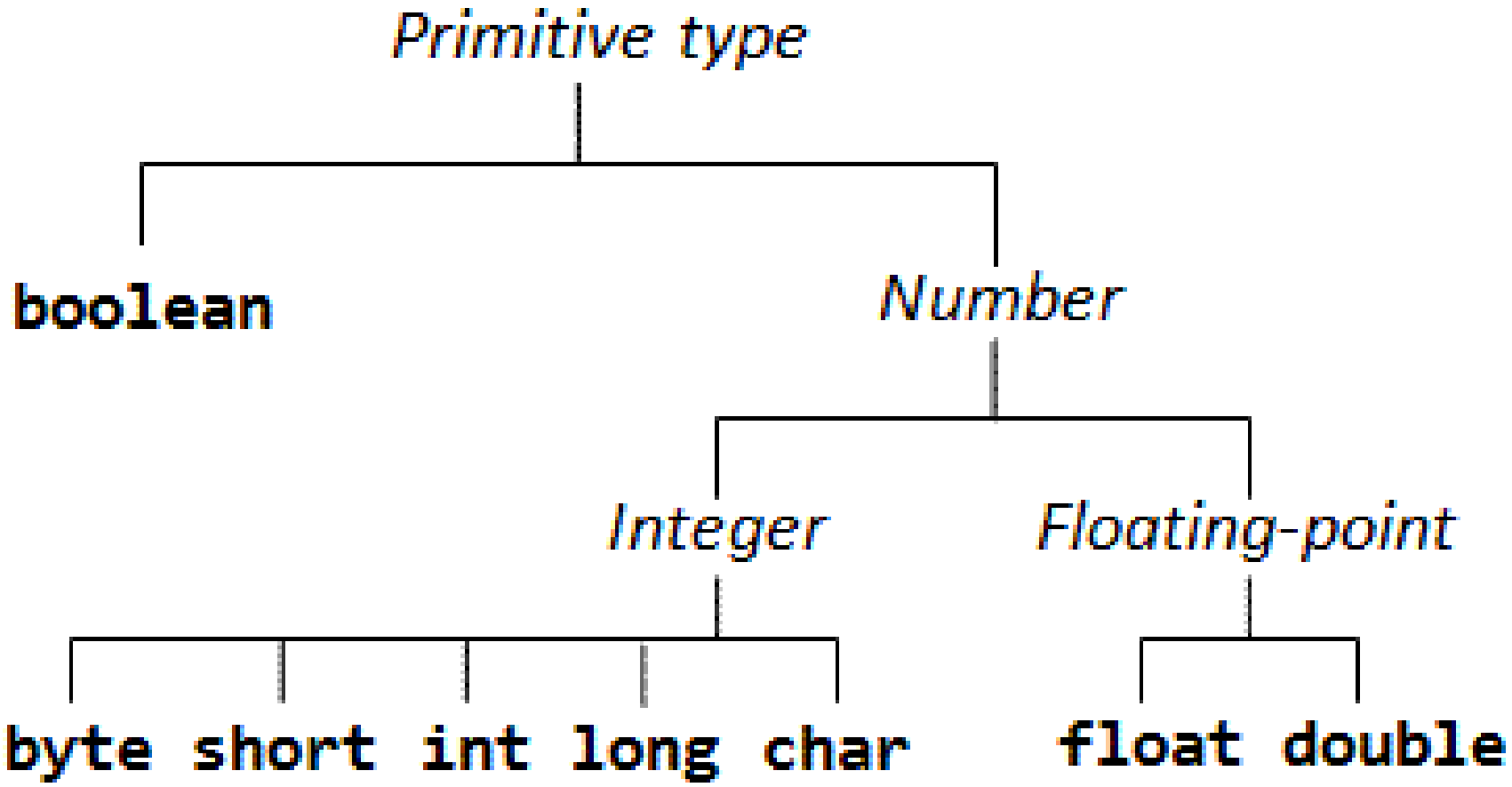
$$
\begin{array}{ll}
 & 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 1100 \quad (12_{ten}) \\
+ & 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1011 \quad (-5_{ten}) \\
\hline
= & 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0111 \quad (\ 7_{ten})
\end{array}
$$

Full 8-bit adder/subtractor design



Floating Point Data Types

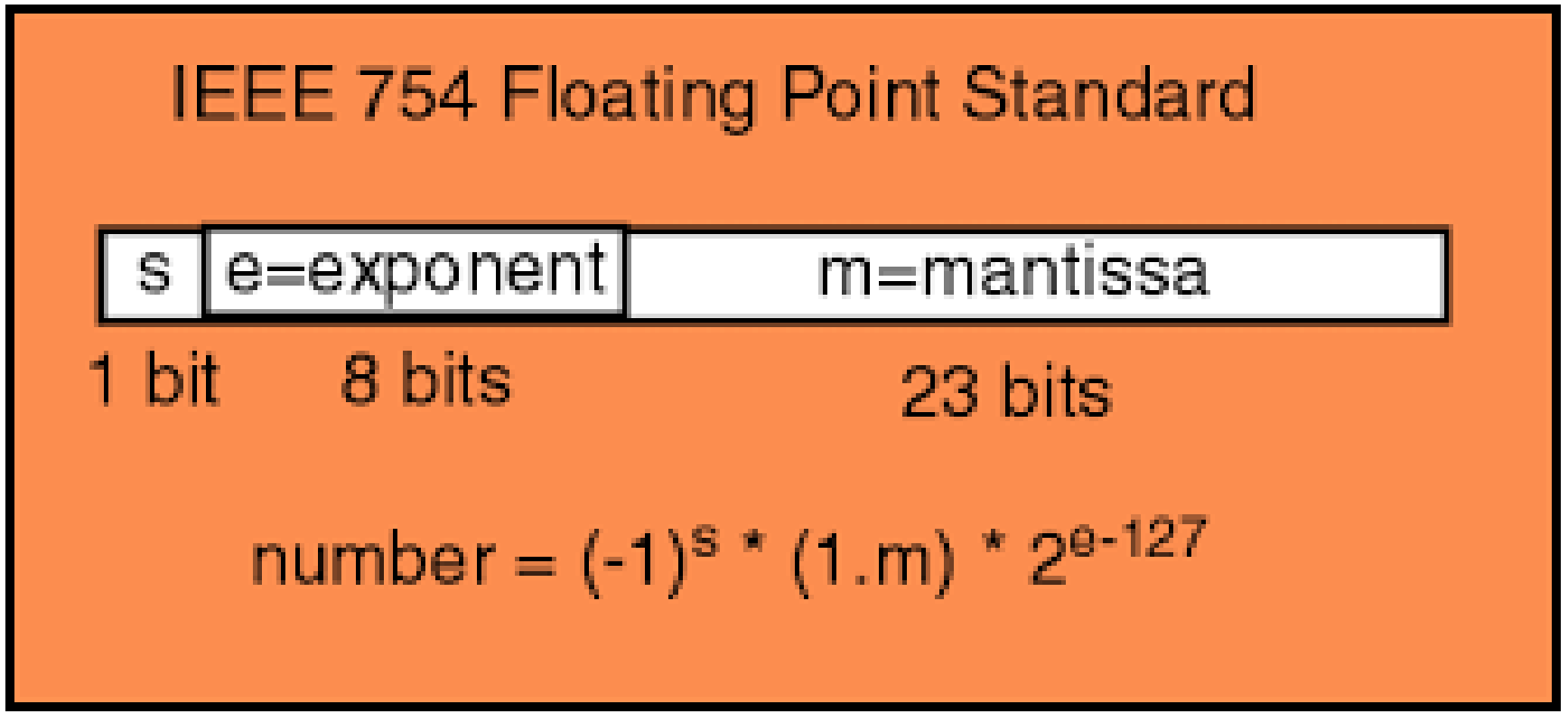
LECTURE 13


Primitive type
boolean
Number
Integer
Floating-point
byte short int long char
float double

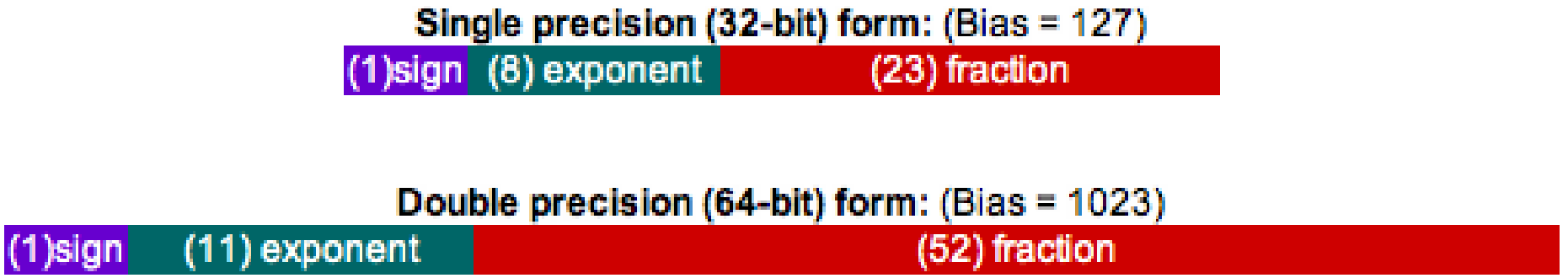
Java's special number rules
(different from other languages)

- **Java doesn't have unsigned number primitives.**
  - unsigned number is seldom used.
  - If you need to use unsigned number, use **char** data type instead. Because char does not follow the number operation rules while **char** can still operate the **bit-wise** operations.
- **Java's char is 16 bit.** (supporting Unicode: UTF-16)
- **IEEE 754 binary floating point representation. (Java's Float Standard)**

Java's special number rules



Java's special number rules

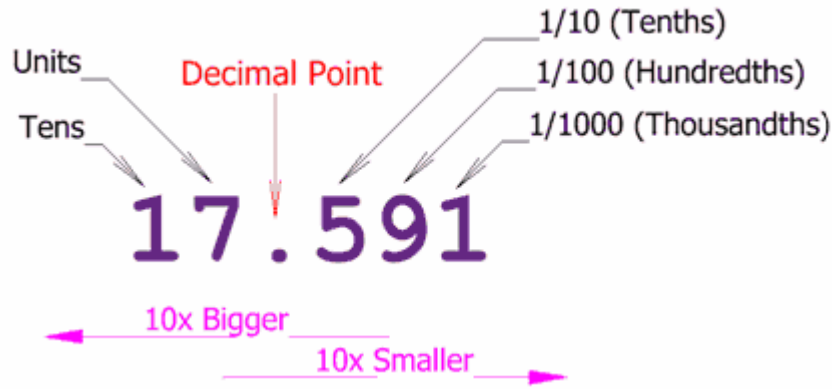


Floating Point Literals

LECTURE 14

Floating Point Literal : Primitive Data Type in Java Programming

1. Decimal values with a fractional component is called floating point.
2. They can be expressed in either standard or scientific notation.



Standard Notation

1. Standard notation consists of a whole number component followed by a decimal point followed by a fractional component.
2. For example : 78.0, 3.14159 represent valid standard-notation floating-point numbers.

Scientific Notation

Scientific notation uses a standard-notation, floating-point number plus a suffix that specifies a power of 10 by which the number is to be multiplied.

The exponent is indicated by an E or e followed by a decimal number, **which can be positive or negative**.

Valid Examples are :

- 6.02E21
- 314159E–05
- 2e+100.

Scientific Notation

- **Floating-point literals in Java default to double precision. 0.333F 0.333D (Same double Format)**

Literal	Representation	Size	Default
Floating Point Number	F or f	32 bits	–
Double Number	D or d	64 bits	It is default type

Live Example : Assigning Values to Floating Point Literal

```
public static void main(String args[])
    { double d1 = 45.6;
      float  f1 = 32.5;
    }
```

Short Notes :

1. Jdk 7 also provides us facility for writing hexadecimal literal but they are rarely used.
2. We can use Underscore inside Literals.

```
double num = 1_567_2_82.0;
```

Named Constants

```
final datatype CONSTANTNAME = VALUE;


final double PI = 3.14159;
final int SIZE = 3;
```

Constants are Immutable Data
Literals are Data Representations

- Constants are used to hide coding complexity. (One way of doing abstraction)
- Constants for Scientific Calculation:

  Math.PI (3.141592….), Math.E

- Replacing Long URL or Long Text Message:

  final String googleURL = "http://www.google.com"

- Constants for Program Control: (declare at the head of program and update only once.)

  final int STEPS = 100;

  final int TRIALS = 100000000;

  final int MODE = 0; // 0: debug, 1: development, 2: analysis, 3: production

Basic Java Program Unit

LECTURE 15

ComputeArea.java

```
public class ComputeArea {
    public static void main(String[] args) {
            double radius;       // Declare radius
            double area;         // Declare area
            // Assign a radius
          radius = 20; // New value is radius
            // Compute area
            area = radius * radius * 3.14159;
            // Display results
            System.out.println("The area for the circle of radius “ + radius + " is " + area);
            }
}
```

Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

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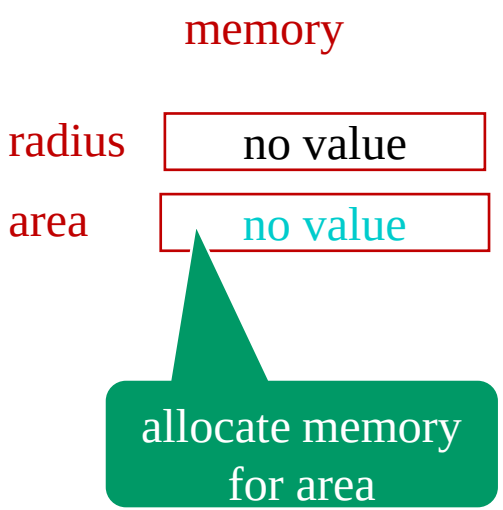
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



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  }
}
```

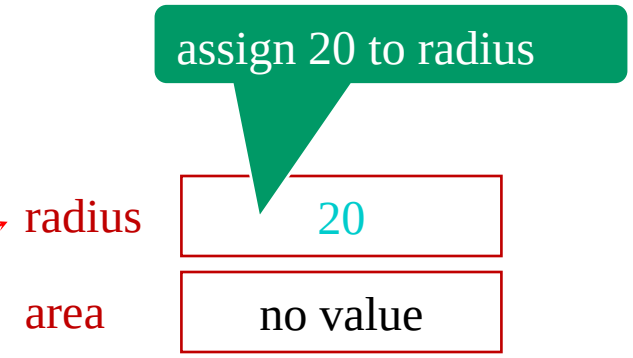

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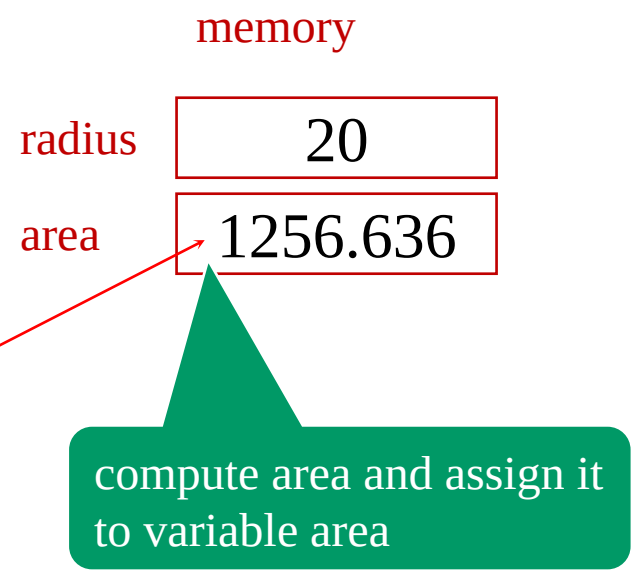
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



Trace a Program Execution

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public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```
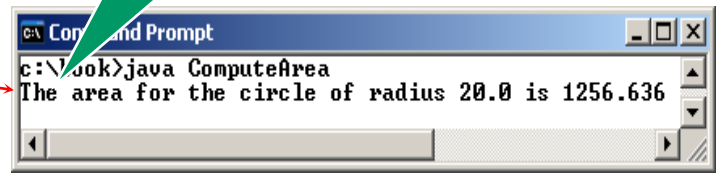

memory

radius	20
area	1256.636

print a message to the console



Input>process>output

Every system has:

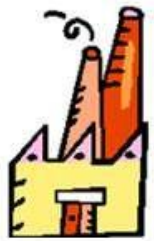
Input
(ingredients that are put into the system)

Process
(what happens to make the system work)

Output
(what the system creates)

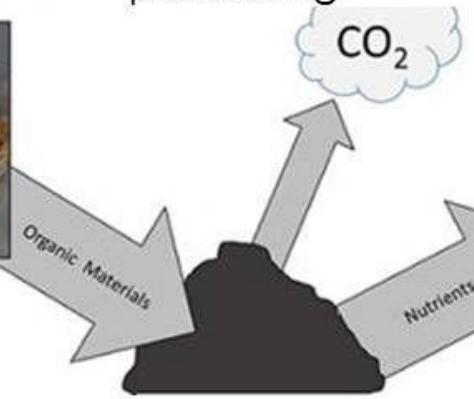
For example…

Input: cow enters processing factory



Process: slaughter, butchery, meat processing.

Output: Burger to eat!



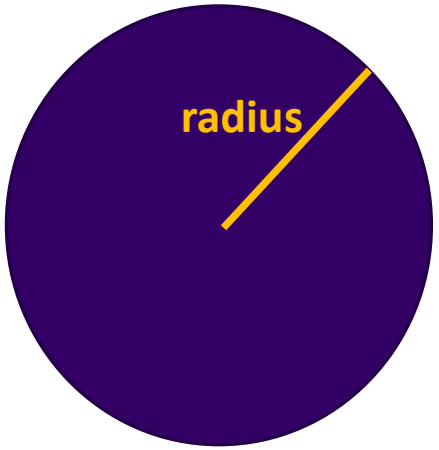
Input: leftover food

Process: composting and spreading compost on fields

Output: New food grown!

How to input from Console?

```
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);
    }
}
```



Demonstration Program

COMPUTEAREA.JAVA