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Java Foundations

3-2

Numeric Data

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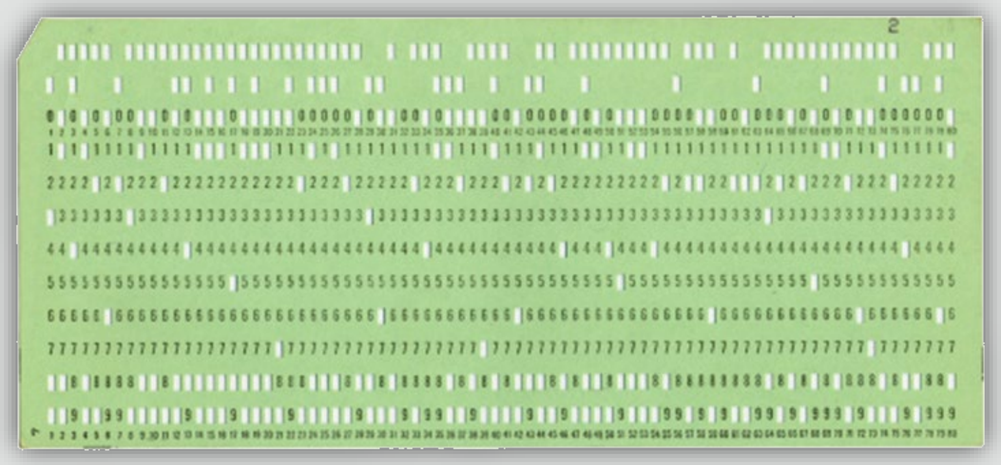
Objectives

- This lesson covers the following objectives:
  - Differentiate integer data types (byte, short, int, long)
  - Differentiate floating point data types (float, double)
  - Manipulate and do math with numeric data
  - Use parentheses and order of operations

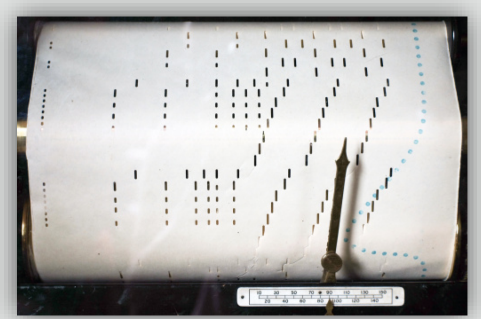
A Bit About Data

- In the early days of computing, data was stored on punch cards



- Each slot had 2 possible states:
  - Punched
  - Not punched

Reading Punch Card Data



An 1800s piano roll

- An AutoPiano reads punch cards
- A column represents a key on the piano
- The punch card scrolls through the piano, triggering keys
- Each slot has 2 possible states with 2 possible results:

State	Result
Punched	Play note
Not punched	Don't play note

A Bit About Modern Computing

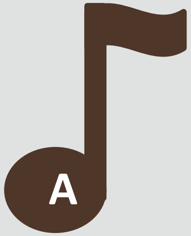
- Modern data processing still needs to represent 2 states:
  - This is interpreted as binary code: **10011101**
  - A single **1** or **0** is called a bit

	AutoPiano	**Modern Computing**
Bit	Hole punched/Not punched	1/0
Bits are instructions for …	Mechanical components	The processor
Medium	Mechanical	Electro-Magnetism
Bits store data about…	Piano keys	Numbers

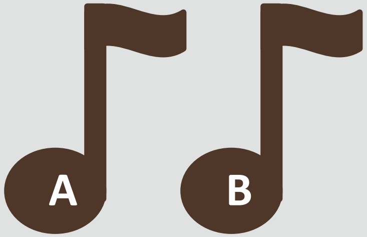
Let's take a closer look at this

Bits of Data

- One AutoPiano key is represented by 1 bit
  - 0: Don’t play
  - 1: Play



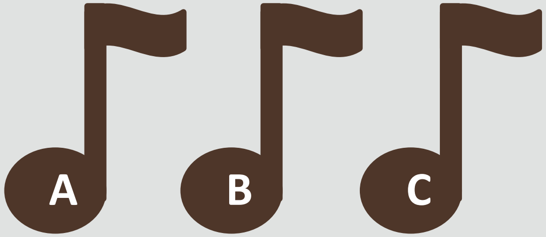
- Two keys require 2 bits
  - There are 4 possible combinations of keys
  - We can calculate this as 2^2



	A key	B key
Silence	0	0
B only	0	1
A only	1	0
Both A and B	1	1

Bigger Bits of Data

- Three keys require 3 bits
  - There are 8 possible combinations of keys
  - We can calculate this as 2^3
- Eight keys require 8 bits
  - There are 256 possible combinations
  - We can calculate this as 2^8



A key	B key	C key
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

Bits and Bytes

- Eight bits are called a byte
- A Java byte can store 256 possible values
  - Possible values are from -128 to 127
  - 128 values below 0
  - 127 values above 0
  - 1 value equal to 0

✓

```
byte x = 127;
```

✗

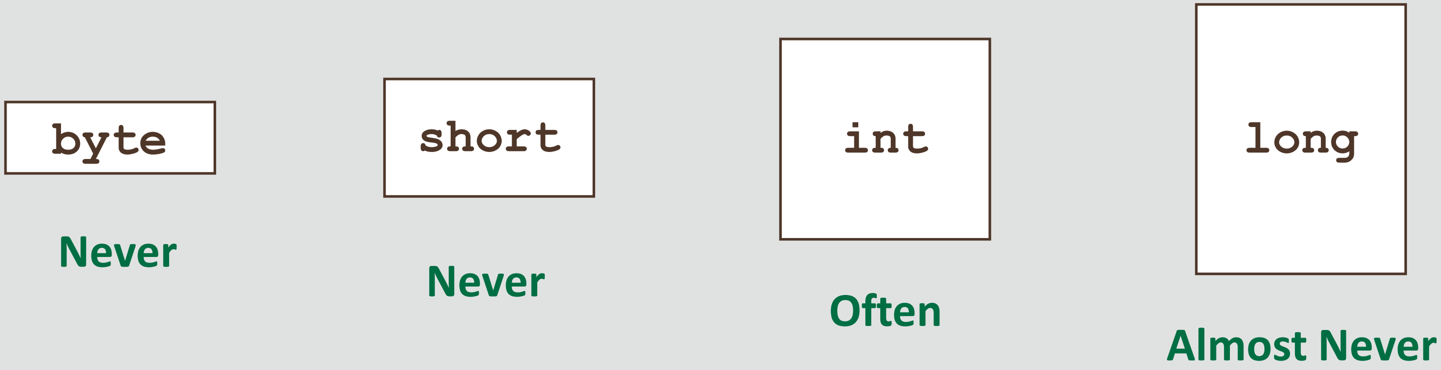
```
byte z = 128;    //Too high
```

Some New Integral Primitive Types

Type	Length	Number of Possible Values	Minimum Value	Maximum Value
Byte	8 bits	2^{8}, or… 256	-2^{7}, or… –128	$2^{7}-1$, or… 127
short	16 bits	2^{16}, or… 65,535	-2^{15}, or… –32,768	$2^{15}-1$, or… 32,767
int	32 bits	2^{32},or… 4,294,967,296	-2^{31}, or… –2,147,483,648	$2^{31}-1$, or… 2,147,483,647
long	64 bits	2^{64}, or… 18,446,744,073,709,551,616	-2^{63}, or… –9,223,372,036,854,775,808L	$2^{63}-1$, or… 9,223,372,036,854,775,807L

Note the L

When Will I Use Each Data Type?



`byte`

Never

`short`

Never

`int`

Often

`long`

Almost Never

- byte and short types are used to save memory consumption on older or smaller devices
- But modern desktops contain abundant memory
- Of these 4 types, we’ll mostly use ints in this course

Find x

```
int x = 20;
x = 25;
x = 5 + 3;

System.out.println();
```

- x always equals 20 …
  - Until you assign x a different value
- x could be assigned a calculated value

Values for `x`: ~~20~~ ~~25~~ 8

Find x

```
int x = 20;
x = 25;
x = 5 + 3;
x = x + 1;
x += 1;
x++;
System.out.println();
```

- x could be assigned a new value based on its current value:
  - Java provides the shorthand += operator to do this
  - Adding 1 to a variable is so common that Java provides the shorthand ++ operator

Values for `x`: ~~20~~ ~~25~~ ~~8~~ ~~9~~ ~~49~~ 11

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Find x Again

- x could be assigned the value of another variable:
  - Changing y doesn't change x
  - y and x are separate variables

```
int y = 20;
int x = y;
y++;

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

- Output:

```
x  20
y  21
```

Standard Mathematical Operators

Purpose	Operator	Example	Comments
Addition	+	sum = num1 + num2;	If num1 is 10 and num2 is 2, sum is 12
Subtraction	–	diff = num1 – num2;	If num1 is 10 and num2 is 2, diff is 8
Multiplication	*	prod = num1 * num2;	If num1 is 10 and num2 is 2, prod is 20
Division	/	quot = num1 / num2;	If num1 is 31 and num2 is 6, quot is 5 The remainder portion is discarded Division by 0 returns an error

Why?

Combining Operators to Make Assignments

Purpose	**Operator**	**Examples** **int a = 6, b = 2;**	**Result**
Add to and assign	+=	a += b	a = 8
Subtract from and assign	-=	a -= b	a = 4
Multiply by and assign	*=	a *= b	a = 12
Divide by and assign	/=	a /= b	a = 3
Get remainder and assign	%=	a %= b	a = 0

Modulus Operator

Purpose	Operator	Example	Comments

Remainder	%
	modulus
		num1 = 31;
		num2 = 6;
		
		mod = num1 % num2;
		
		mod is 1
			Remainder finds the remainder of the first number divided by the second number.
			5 R 1
			6 | 31
			30
			----- 	
			1
			Remainder always gives an answer with the same sign as the first operand.

Increment and Decrement Operators (++ and --)

- The long way:
  - age = age + 1;

  or

  - count = count – 1;

- The short way:
  - age++;

  or

  - count--;

More on Increment and Decrement Operators

Operator	Purpose	Example

`++`	Pre-increment
	(++variable)
		`int id = 6;`
		`int newId = ++id;`
		id is 7, newId is 7

	Post-increment
	(variable**++**)
		`int id = 6;`
		`int newId = id++;`
		id is 7, newId is 6

`--`	Pre-decrement (--variable)	(Same principle applies)
	Post-decrement (variable--)	

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Increment and Decrement Operators (++ and ––)

```
int count=15;
int a, b, c, d;
a = count++;
b = count;
c = ++count;
d = count;
System.out.println(a + ", " + b + ", " + c + ", " + d);
```

- Output:

```
15, 16, 17, 17
```

Exercise 1, Part 1

- Import and edit the `Chickens01` project
- Read this story and calculate/print the totalEggs collected between Monday and Wednesday:
  - Farmer Brown's chickens always lay eggsPerChicken eggs precisely at noon, which he collects that day
  - On Monday, Farmer Brown has chickenCount chickens
  - On Tuesday morning, Farmer Brown gains 1 chicken
  - On Wednesday morning, a wild beast eats half the chickens!
  - How many eggs did Farmer Brown collect if he starts with …
    - eggsPerChicken = 5, chickenCount = 3
    - eggsPerChicken = 4, chickenCount = 8

Exercise 1, Part 2

- Your program should produce the following output:

```
45      First scenario
84      Second scenario
```

Integer Division Deception

- The wild beast ate half the chickens
- When we divide 9 chickens in half, Java thinks 9/2 = 4
  - But 9/2 = 4.5
  - Shouldn’t Java round up to 5?
  - What’s going on here?

Java Division

- Java integers aren’t rounded
- Java integers are truncated, meaning any numbers after the decimal point are removed

```
int x = 9/2;
System.out.println(x);  //prints 4
```

- We need other data types if we have scenarios that require floating point precision!

Floating Point Primitive Types

Type	Float Length	When will I use this?
float	32 bits	Never
double	64 bits	Often

Double the precision of a float

- Example:
  - public float pi = 3.141592F;
  - public double pi = 3.141592;

Note the F

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Double Deception

- The original problem:

```
int x = 9/2;
System.out.println(x);  //prints 4
```

- Shouldn’t a double x fix this?

```
double x = 9/2;
System.out.println(x);  //prints 4.0
```

  - No?!?!
  - Why not?

Double Deception

```
double x = 9/2;
System.out.println(x);  //prints 4.0
```

- Java solves the expression, truncates the .5, and then turns the answer into a double
- The expression contains only ints, Java won’t allocate the additional memory that doubles require until it absolutely has to
  - Solution: Include a double in the expression

```
double x = 9/2.0;
System.out.println(x);  //prints 4.5
```

One Final Note

- Declare a variable with the final keyword to make its value unchangeable (immutable)

```
final double PI = 3.141592;
PI = 3.0;          //Not Allowed
```

- Java complains if you try to change a final variable's value
- Final variable naming conventions:
  - Capitalize every letter
  - Separate words with an underscore
    - MINIMUM_AGE
    - SPEED_OF_LIGHT

Exercise 2, Part 1

- Import and edit the `Chickens02` project
- Read this story and calculate/print the required values:
  - On Monday, Farmer Fred collects 100 eggs
  - On Tuesday, Farmer Fred collects 121 eggs
  - On Wednesday, Farmer Fred collects 117 eggs
  - What is the dailyAverage of eggs collected?
  - How many eggs could be expected in a 30-day monthlyAverage?
  - If an egg can be sold for a profit of $0.18, what is Farmer Fred’s total monthlyProfit for all eggs?

Exercise 2, Part 2

- Your program should produce the following output:

```
Daily Average:    112.66666666666667
Monthly Average:  3380.0
Profit:           $608.4
```

Parentheses in Mathematical Expressions

- This expression without parentheses …

```
int x = 10 +20 +30 / 3;                    //x=40
```

- Is just like writing this expression with parentheses:

```
int x = 10 +20 +(30 / 3);                  //x=40
```

- If you want to find an average, use parentheses like this:

```
int x = (10 +20 +30) / 3;                  //x=20
```

Operator Precedence

- Here’s an example of the need for rules of precedence:

```
int x = 25 - 5 * 4 / 2 - 10 + 4;
```

- Is the answer 34 or 9?

Rules of Precedence

- Operators within a pair of parentheses
- Increment and decrement operators (++ or - -)
- Multiplication and division operators, evaluated from left to right
- Addition and subtraction operators, evaluated from left to right

- If operators of the same precedence appear successively, the operators are evaluated from left to right

Using Parentheses

- Expression are evaluated with the rules of precedence
- However, you should use parentheses to provide the intended structure
- Examples:

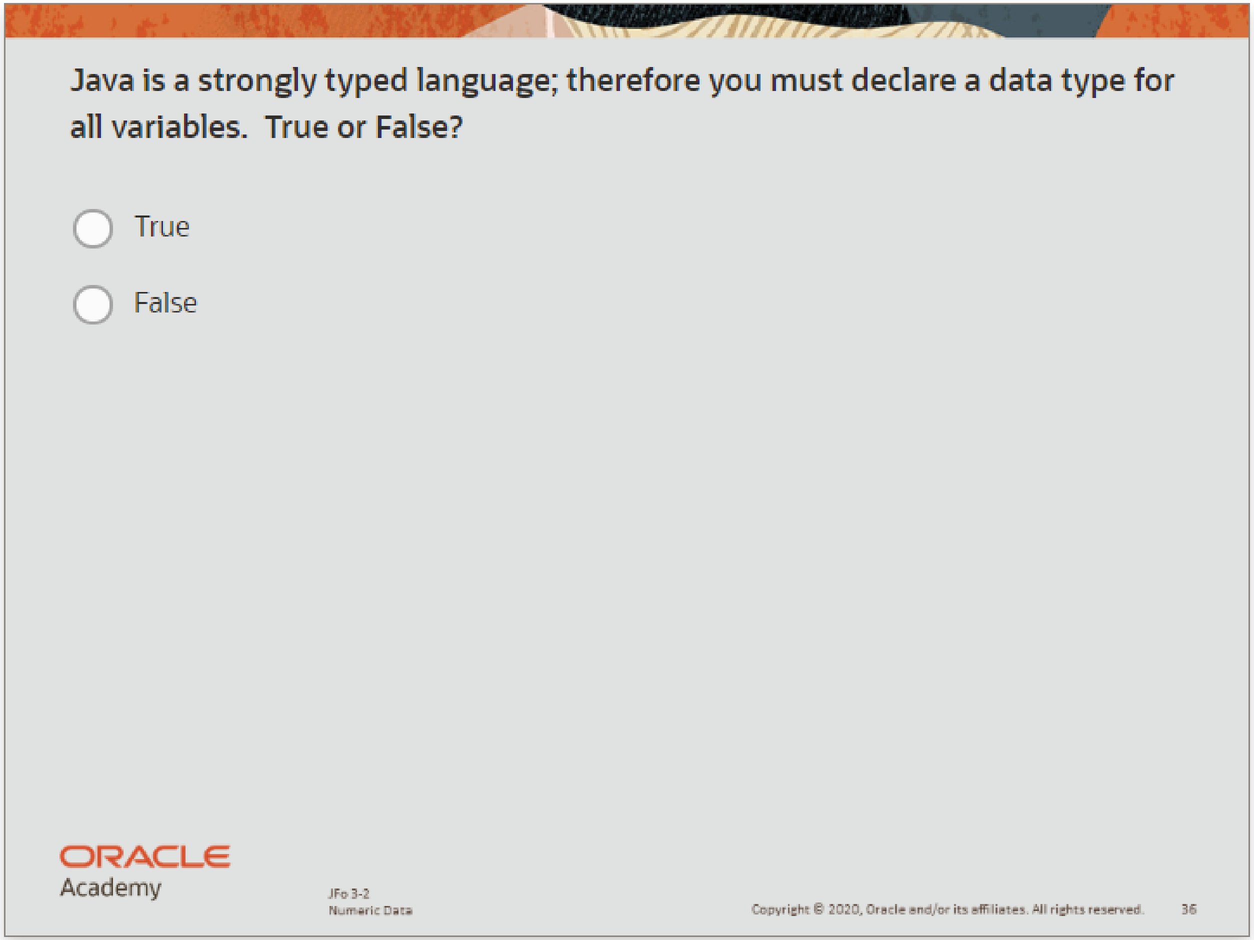
```
int x = (((25 - 5) * 4) / (2 - 10)) + 4;
int x = ((20 * 4) / (2 - 10)) + 4;
int x = (80 / (2 - 10)) + 4;
int x = (80 / -8) + 4;
Int x = -10 + 4;
int x = -6;
```

Summary

- In this lesson, you should have learned how to:
  - Differentiate integer data types (byte, short, int, long)
  - Differentiate floating point data types (float, double)
  - Manipulate and do math with numeric data
  - Use parentheses and order of operations

☑ Quiz

Click the **Quiz** button to edit this object



Java is a strongly typed language; therefore you must declare a data type for all variables. True or False?

○ True

○ False

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