Activity 3: Data Types

Java supports two main types of data: *primitive types* like `int` and `double` that represent a single value, and *reference types* like `String` and `Scanner` that represent more complex information.

Model 1 The % Operator

9 / 4	*evaluates to*	2
10 / 4	*evaluates to*	2
11 / 4	*evaluates to*	2
12 / 4	*evaluates to*	3
13 / 4	*evaluates to*	3
14 / 4	*evaluates to*	3
15 / 4	*evaluates to*	3
16 / 4	*evaluates to*	4

9 % 4	*evaluates to*	1
10 % 4	*evaluates to*	2
11 % 4	*evaluates to*	3
12 % 4	*evaluates to*	0
13 % 4	*evaluates to*	1
14 % 4	*evaluates to*	2
15 % 4	*evaluates to*	3
16 % 4	*evaluates to*	0

Questions (10 min) **Start time:** _____

1. Which numbers % 4 evaluate to 0 in the table above? If the table were extended to include more rows, which other numbers % 4 would evaluate to 0?

2. Look at the expressions in the second table that evaluate to 1. How do the left operands in these expressions (9, 13, 17) differ from those that evaluate to 0?

3. List three numbers % 5 that will evaluate to 0 and three numbers % 5 that will evaluate to 2.

4. Evaluate the following Java expressions:

18 % 4 19 % 4 19 % 5 19 % 6

5. Describe what the % operator does. How are the / and % operators related?

6. Would it make sense to apply the % operator to floating-point numbers? Why or why not?

Model 2 Primitive Types

Keyword	Size	Min Value	Max Value
`byte`	1 byte	-128	127
`short`	2 bytes	$-32,768$	$32,767$
`int`	4 bytes	-2^{31}	$2^{31}-1$
`long`	8 bytes	-2^{63}	$2^{63}-1$
`float`	4 bytes	$\pm 3.4 \times 10^{-38}$	$\pm 3.4 \times 10^{38}$
`double`	8 bytes	$\pm 1.7 \times 10^{-308}$	$\pm 1.7 \times 10^{308}$
`boolean`	N/A	`false`	`true`
`char`	2 bytes	`'\u0000'`	`'\uffff'`

Note that 1 byte is 8 bits, i.e., eight "ones and zeros" in computer memory. Since there are only two options for each bit, with 8 bits you can represent $2^8 = 256$ possible values.

Questions (15 min) Start time: _____

7. Which of the primitive types are integers? Which are floating-point?

8. Why do primitive types have ranges of values? What determines the range of the data type?

9. Why can't computers represent every possible number in mathematics? Will they ever be able to do so?

10. Since a `byte` can represent 256 different numbers, why is its max value 127 and not 128?

11. What is the data type for each of the following values?

1.14159	7.2E-4	-128
0	0.0	false
-1.0F	-13L	true
123	'0'	"0"

12. Given the following variable declarations, which of the assignments are not allowed?

```
byte miles;
short minutes;
int checking;
long days;
float total;
double sum;
boolean flag;
char letter;
```

```
checking = 56000;
total = 0;
sum = total;
total = sum;
checking = miles;
sum = checking;
sum = days;
days = "0";
```

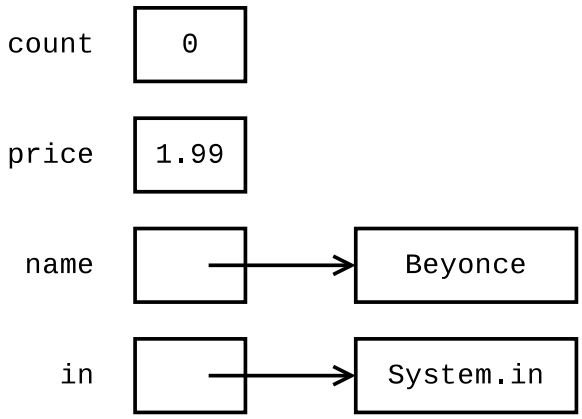
13. In general, when does Java allow you to assign one type of numeric variable to another?

14. Based on your answer to #13, list all possible assignments for `int`, `long`, `float`, and `double` values in this format: `long` ← `int`

Model 3 Reference Types

```
int count;
double price;
String name;
Scanner in;

count = 0;
price = 1.99;
name = "Beyonce";
in = new Scanner(System.in);
```



Java has eight primitive types (see Model 2). All other types of data are called *reference* types, because **their value is a memory address**. When drawing state diagrams, use an arrow to *reference* other memory locations (rather than make up integer values for the actual addresses).

Questions (15 min) Start time: _____

15. What are the reference types in the example above?

16. By convention, what is the difference between primitive and reference type names?

17. Variables in Java can use at most eight bytes of memory. Explain why `"Beyonce"` and `System.in` cannot be stored directly in the memory locations for `name` and `in`.

18. What is the value of the variable `count`? What is the value of the variable `price`?

19. What is the value of the variable `name`? What is the value of the variable `in`?

20. Carefully explain what it means to assign one variable to another. For example, what does the statement `price = count;` do in terms of memory?

21. Draw a state diagram for the following code. Make sure your answer is consistent with what you wrote for #20.

```
int width;
double score;
Scanner input;
String first;
String other;

width = 20;
score = 0.94;
input = new Scanner(System.in);
first = "Taylor";
score = width;
other = first;
```

22. What is the output of the following statements after running the code above? Explain your answer using the diagram.

```
first = "Swift";
System.out.println(other);
```