# Variables
# Data Types



Lab OB

# What is a reference?

# What is a reference?

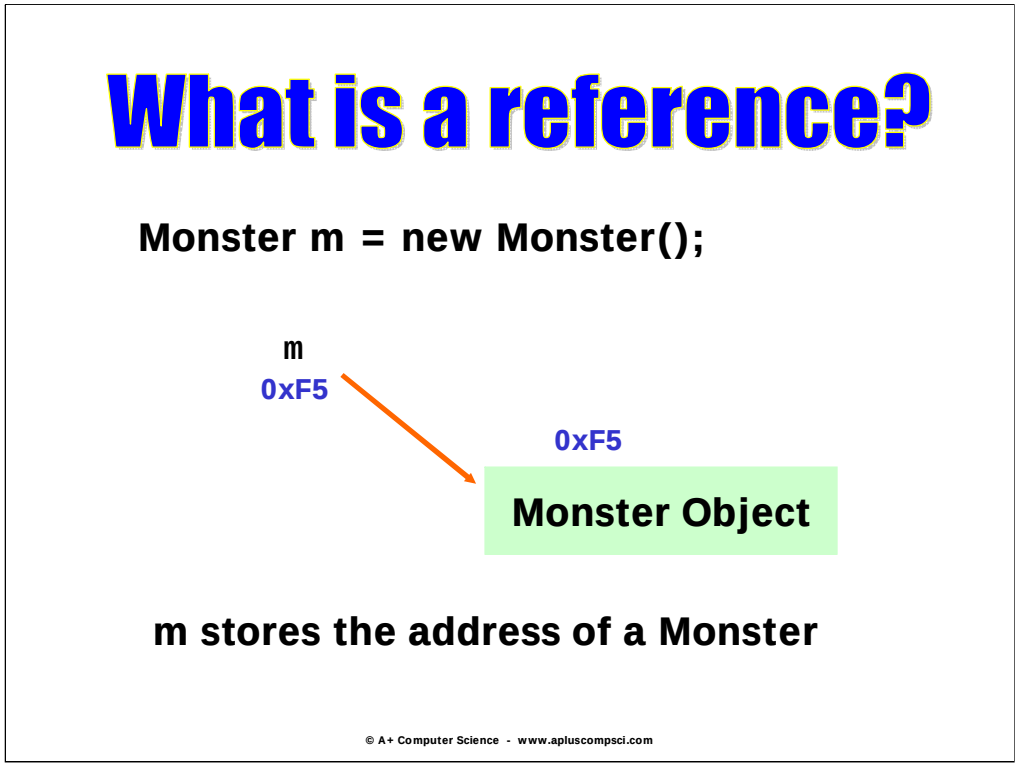
**A reference variable stores the memory address of an object.**

```
Monster fred = new Monster();
Monster sally = new Monster();
```



A reference variable is used to store the location of an Object. In most situations, a reference stores the actual memory address of an Object.

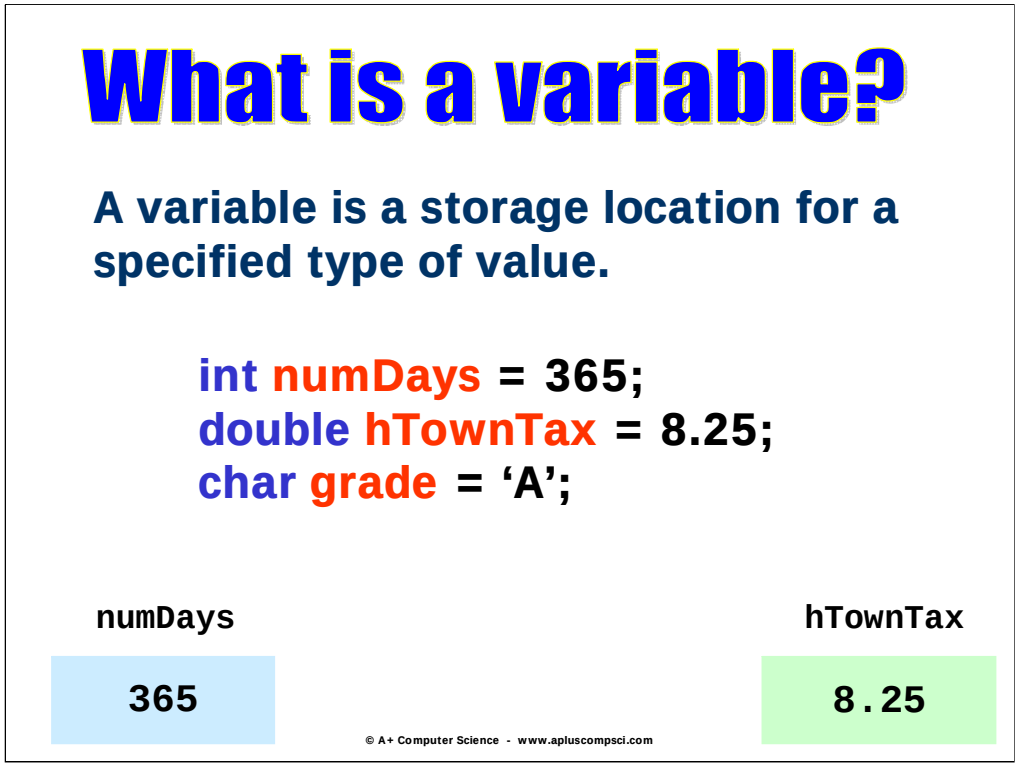
`fred` and `sally` store the location / memory address of two new Monster Objects.




A reference variable is used to store the location of an Object. In most situations, a reference stores the actual memory address of an Object.

`m` stores the location / memory address of a new Monster.

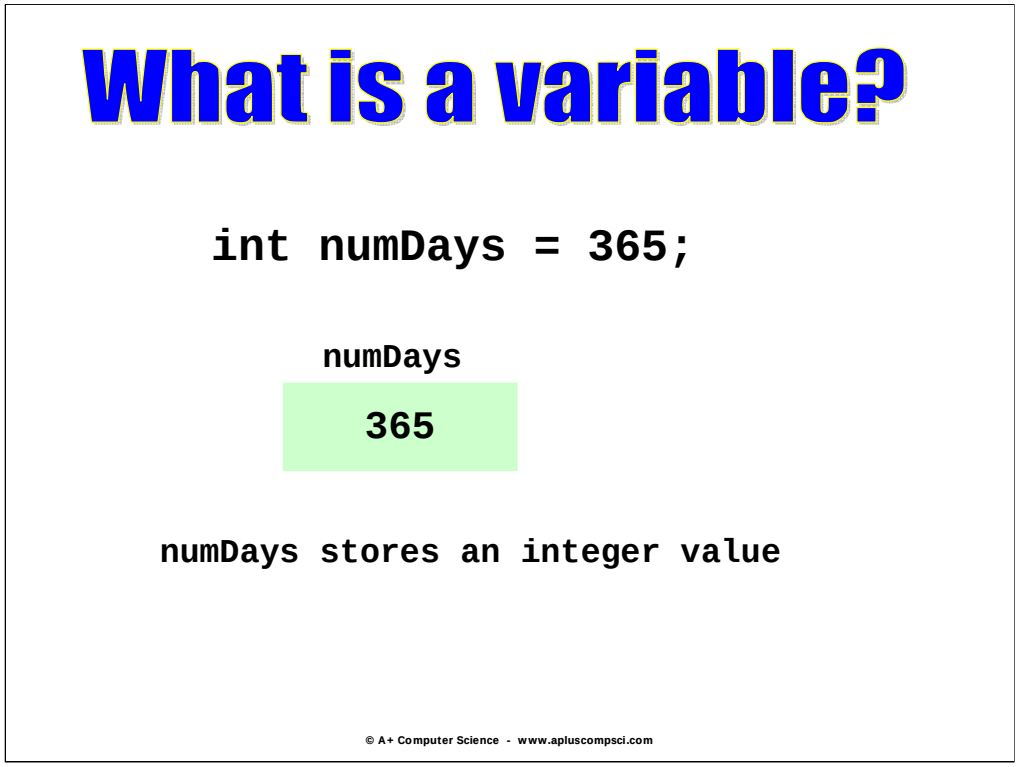
# What is a variable?




A non-reference variable is a storage location for a value.

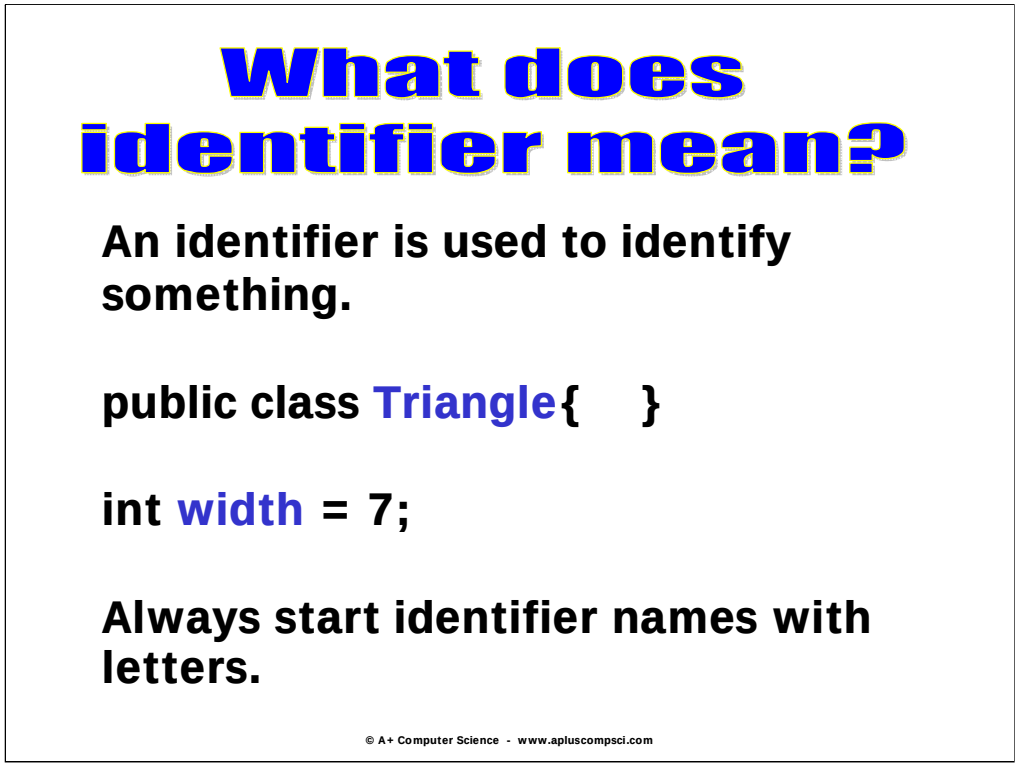
`numDays` is an integer primitive variable. `numDays` is not a reference variable. `numDays` stores an integer value.

`hTownTax` is a double primitive variable. `hTownTax` is not a reference variable. `hTownTax` stores a decimal value.




A variable is a box that stores a specific type of value. `numDays` stores an integer value. `numDays` is not a reference; thus, it does not store a location / memory address.

# Identifier Names




An identifier is used to identify something. Identifiers should begin with letters. Identifiers can contain symbols, letters, and numbers.

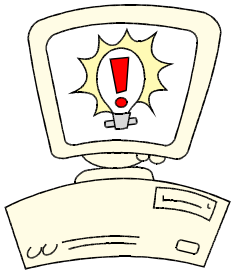
A box that will store integer numbers needs a name. The name should clearly identify what will be stored in the box. `width` clearly states that the box will contain the width of something.

`Triangle` is used to identify a class. The assumption is that the class will store information about Triangles.

# Identifiers

**Which of these would be legal identifiers?**

**1stYear**
**jump Up**
**feet2Inches**
**BigTriangle**
**SpaceInvaders**





`1stYear` is not legal. Identifiers cannot start with numbers.

`jump up` is not legal. Identifiers cannot contain spaces.

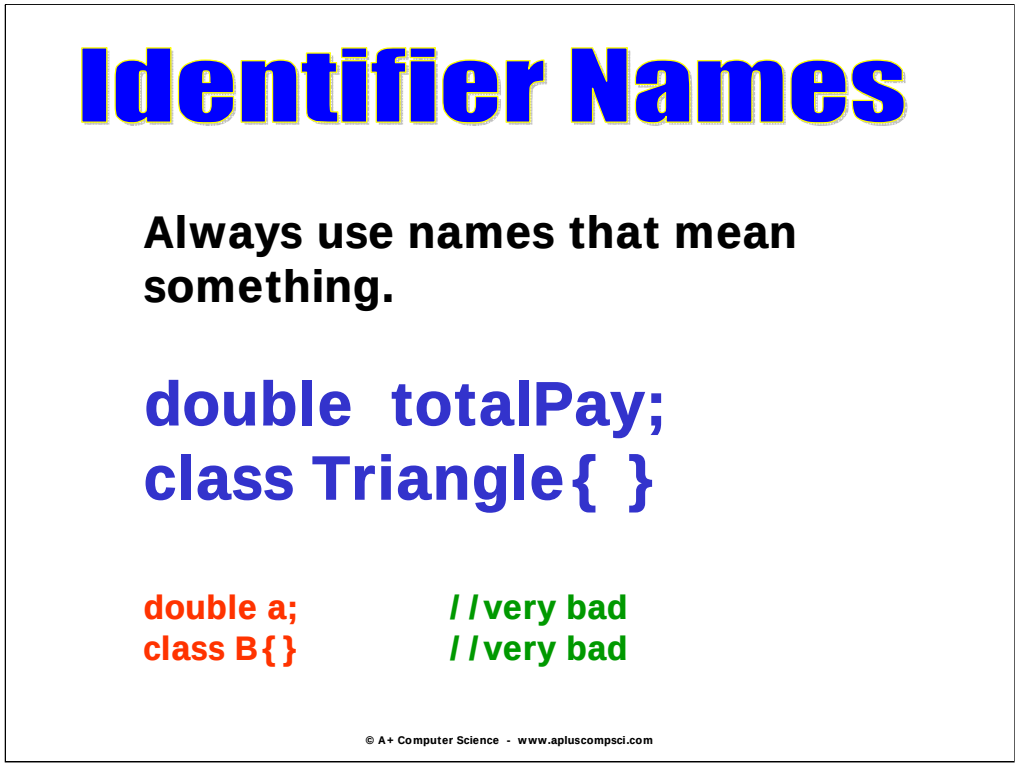
`feet2Inches` is legal.

`BigTriangle` is legal.

`SpaceInvaders` is legal.

`Space_Invaders` is legal.

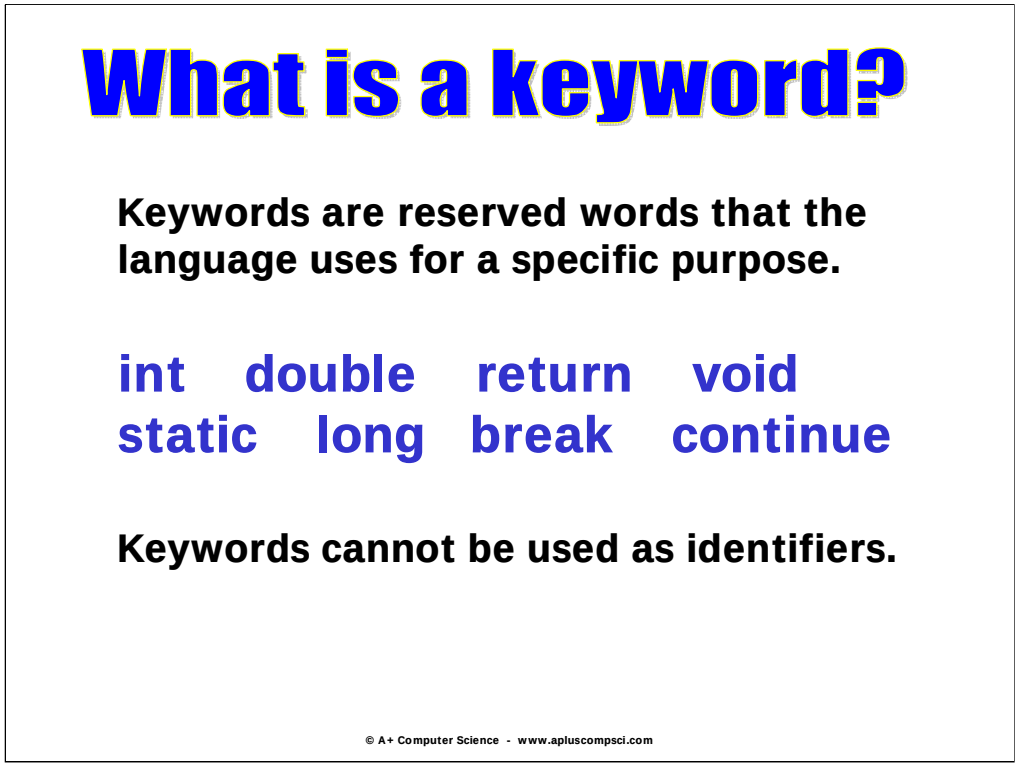
`_SpaceInvaders` is legal, but not a suggested naming style.



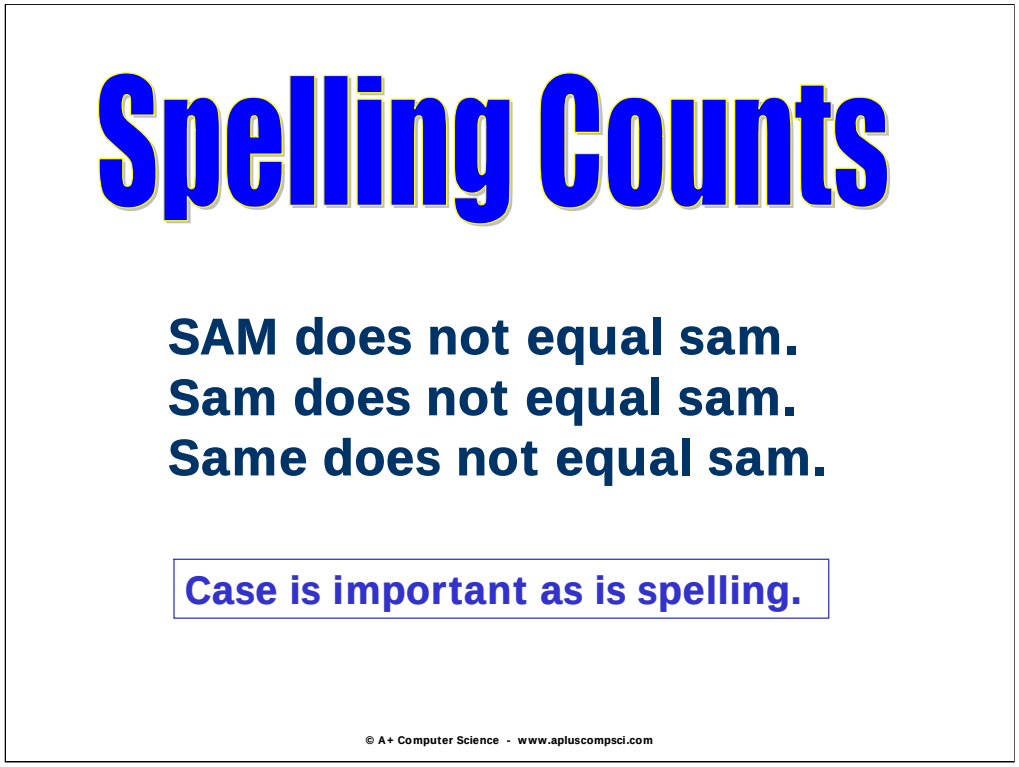

Use identifier names that are clear and informative.

The name `totalPay` seems to indicate the variable will store the total pay amount for someone or something.

```
double nationalDebt;
char firstLetterOfLastName;
long buildingHeight;
public class BlinkyBall{}
public class BlackJack{}
```




Keywords are words that have been assigned a special purpose in the language. Keywords cannot be used as identifier names.




Java is case sensitive.

# Open identifiers.java

# Types of Variables

# Data Types

**byte short int**
**long float double**

**int whole**
**double fraction**

**The type states how much and what kind of data the variable can store.**



When defining a variable, a data type must be provided. The data type describes what will be stored in the variable. A variable is a box where things will be stored. The data type states what kind of things can be placed in the box.

`int` can store non-decimal positive and negative numbers.

`double` can store decimal positive and negative numbers.

# All Data Types

| data type | memory usage | min .. max |
|---|---|---|
| byte | 8 bits | -128 to 127 |
| short | 16 bits | -32768 to 32767 |
| int | 32 bits | -2 billion to 2 billion |
| long | 64 bits | -big to +big |
| float | 32 bits | -big to +big |
| double | 64 bits | -big to +big |
| char | 16 bit unsigned | 0 - 65535 |
| reference | 32 bits | n/a |

**It is important to know all data types and what each one can store.**



This data type chart lists most data type's memory usage and range of storage values.

# Integers

# Integers

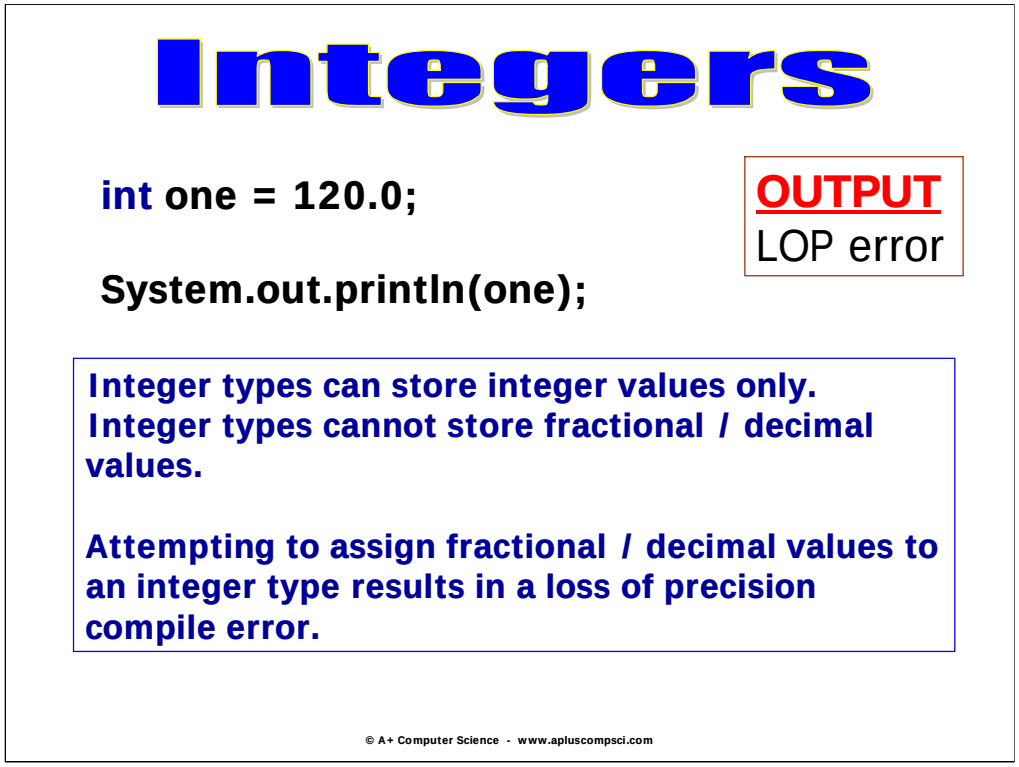
```
int one = 120;
int two = 987123;
byte bite = 99;
long longInt = 99234423;

System.out.println(one);
System.out.println(two);
System.out.println(bite);
System.out.println(longInt);
```

**OUTPUT**

120
987123
99
99234423



Integer types(`byte`, `short`, `int`, `long`, and `char`) can only store non-decimal values.

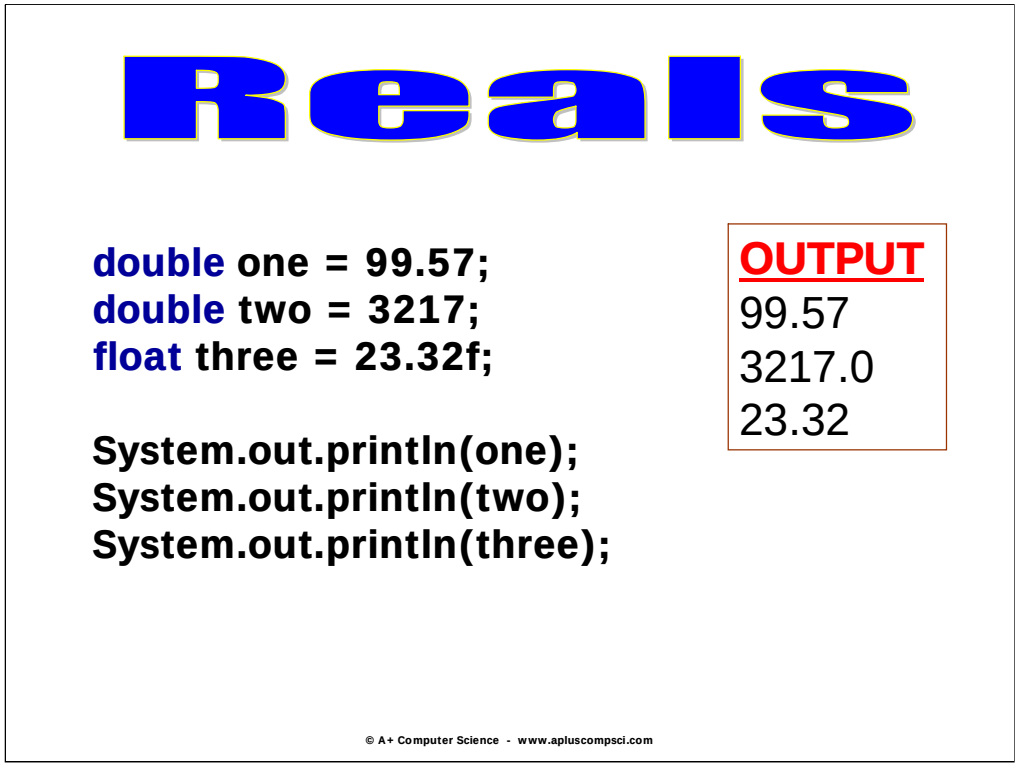



`int one = 120.0;` results in an error. `120.0` is a decimal value and integer types cannot store decimal values.

`int one = (int)120.0;` type casting temporarily converts the receiving value so that it can be stored in an integer storage location.

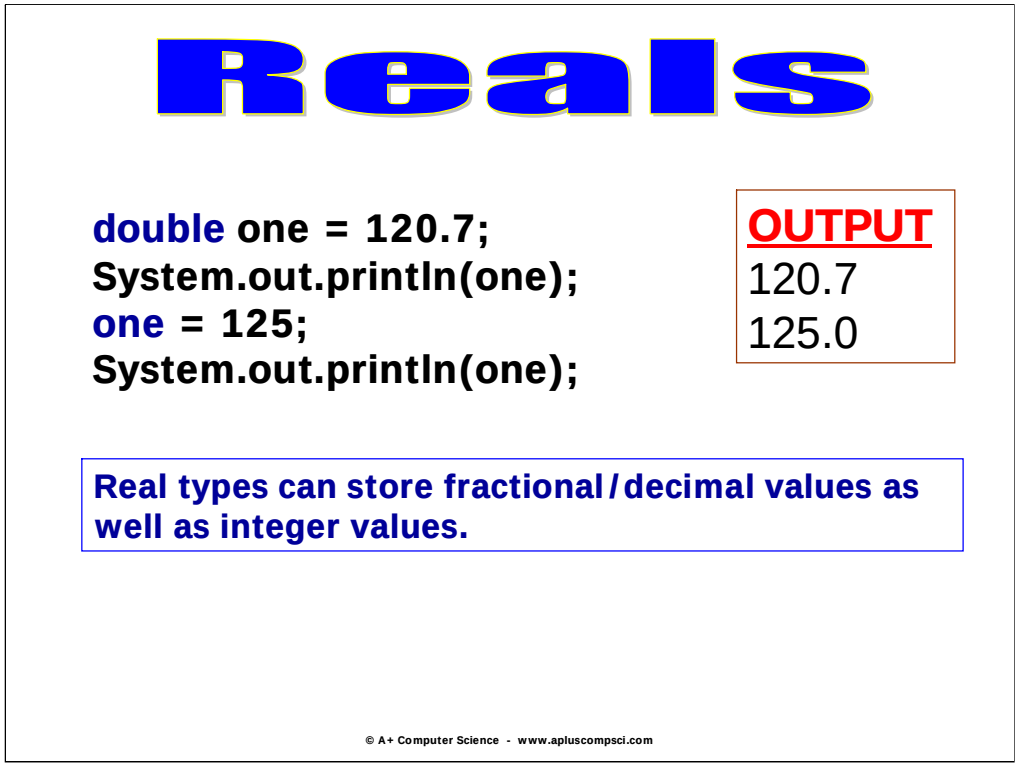
# Open integers.java integerslop.java

# Real Numbers
# Fractional Values




Real / decimal types (`float, double`) can store non-decimal values as well as decimal values.

```
double example = 456;
example = 456.323;
```




Real / decimal types (`float, double`) can store non-decimal values as well as decimal values.

```
double example = 456;
example = 456.323;
```

# Open reals.java

# Characters

# Characters

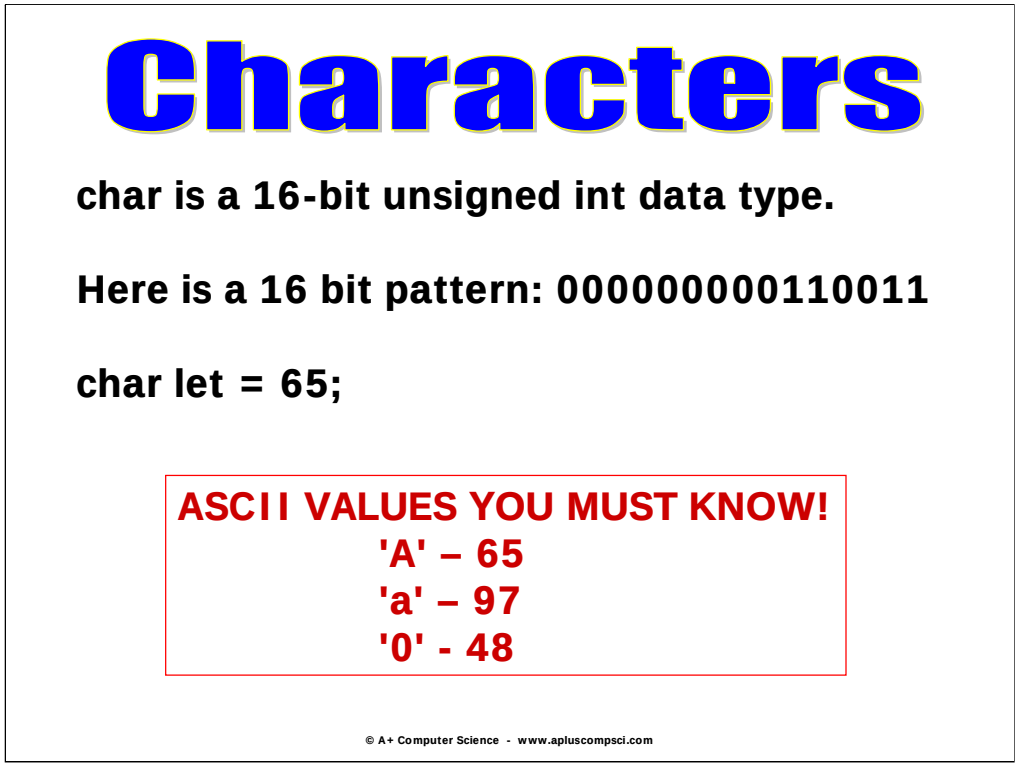
```
char let = 'A';
char fun = 65;

char test = 'a';
char go = 97;

char what = 48;
```

char variables are used to store a single letter.

char variables are actually integers.

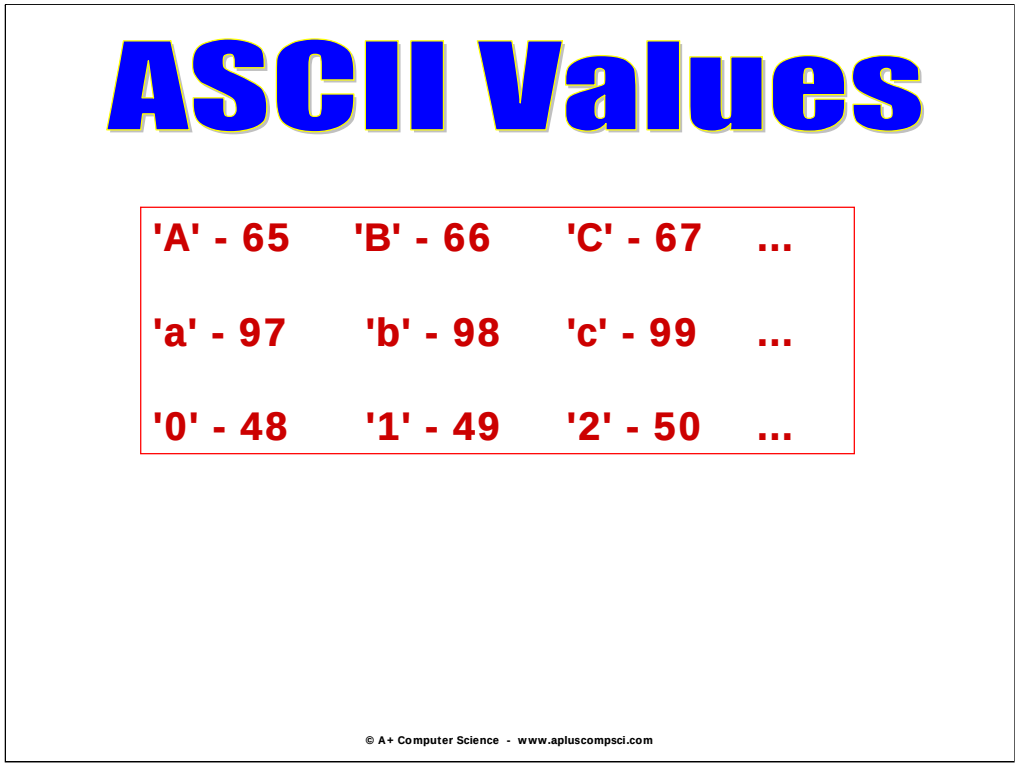


`char` is an integer data type.

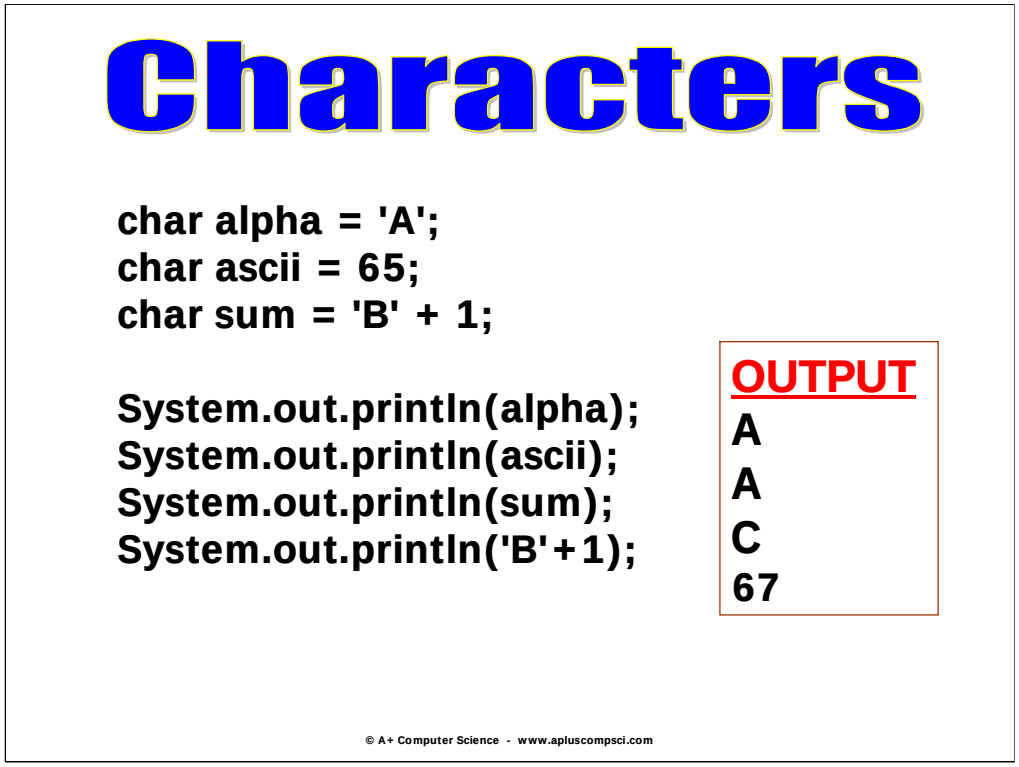



`char` is an unsigned(has no negative range) integer data type.

```
char letter = 97;
out.println(letter);            //outs a
letter = 'A';
out.println(letter);            //outs A
```




Once you memorize the starting value for ‘A’, ‘a’, and ‘0’, determining the ASCII values for most letters and numbers is pretty simple.




Because char is an integer data type, it is okay to store non-decimal values in a char. It is also okay to perform integer math operations on a char variable and to store math results in a char variable.

```
char example = 98;
out.prinltn(example);              //outs a  b

example = 'A'+5;
out.prinltn(example);              //outs a  F

out.prinltn('A'+5);                //outs a  70
                //outs a 70 because char + int nets an int
```

# Open chars.java

# Start work on Lab 0b

# Booleans

# Booleans

```
boolean go = true;
System.out.println(go);
boolean stop = false;
System.out.println(stop);
```

**OUTPUT**

true
false

**A boolean type can store true or false only.**



A `boolean` can store true or false. A `boolean` cannot store letters or numbers.

# Open booleans.java

# Strings

# Strings

```
String dude = "hello world";
String buddy = "whoot - \\\\\\\\\\\\";

System.out.println(dude);
System.out.println("buddy = " + buddy);
```

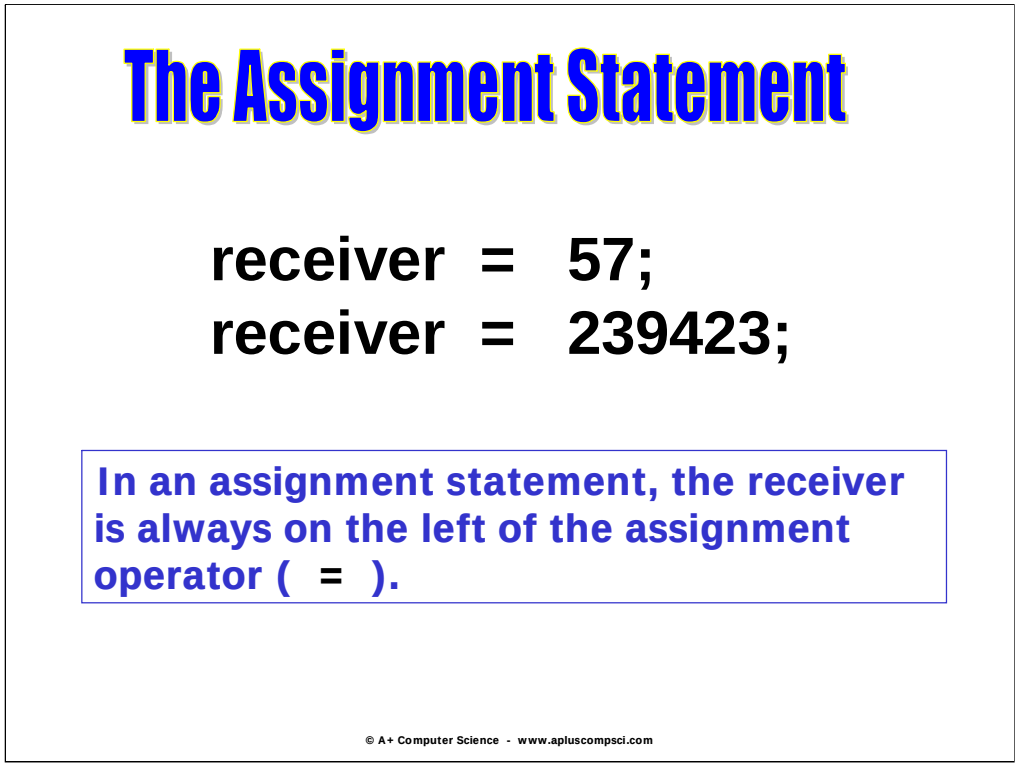
**OUTPUT**

```
hello world
buddy = whoot - \\\\\\
```

**A String type stores groups of characters.**

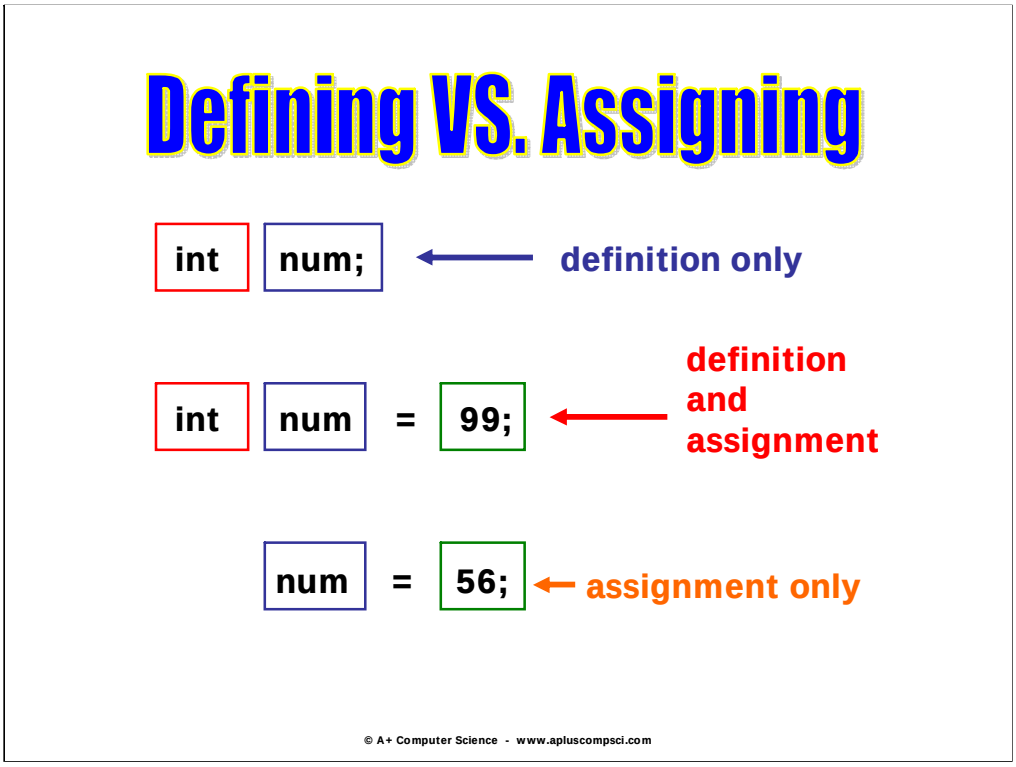
# Open strings.java

# Variable Assignment




The variable receiving the value is placed on the left of the assignment operator( = ).

57 is the value being placed in box receiver.




A data-type must be placed in front of/to the left of a variable name when that variable is defined.

When assigning a variable that has already been defined, only the name and the value are required.

# The Assignment Statement

```
int number = 75, bigNum=99;
double hTownTax = 8.25;
char bigA = 'A', littleA = 'a';
boolean isPrime = false;
String s = "abc";

System.out.println(number);
System.out.println(bigNum);
System.out.printf("%.2f\n",hTownTax);
System.out.println(bigA);
System.out.println(littleA);
System.out.println(isPrime);
System.out.println(s);
```

**OUTPUT**

```
75
99
8.25
A
a
false
abc
```



Variable definitions and assignments can be performed on one line.

```
int intFun=75;          //definition and assignment
```

More than one variable can be defined and assigned on the same line.

```
int go=3, stop=2, pause=1;   //separate with a comma
```

# Open assignment.java

# Data Type Ranges

# All Data Types

| data type | memory usage | min .. max |
|---|---|---|
| byte | 8 bits | -128 to 127 |
| short | 16 bits | -32768 to 32767 |
| int | 32 bits | -2 billion to 2 billion |
| long | 64 bits | -big to +big |
| float | 32 bits | -big to +big |
| double | 64 bits | -big to +big |
| char | 16 bit unsigned | 0 - 65535 |
| reference | 32 bits | n/a |

**It is important to know all data types and what each one can store.**



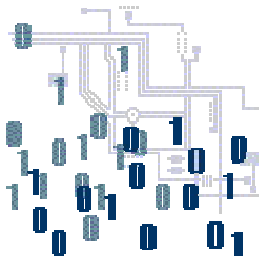
This data type chart lists most data type's memory usage and range of storage values.

# Memory

**Memory consists of bits and bytes.**

**8 bits = 1001 0010 = 1 byte**
**16 bits = 0101 1001 0100 1001 = 2 bytes**

**The more bits you have the more you can store.**

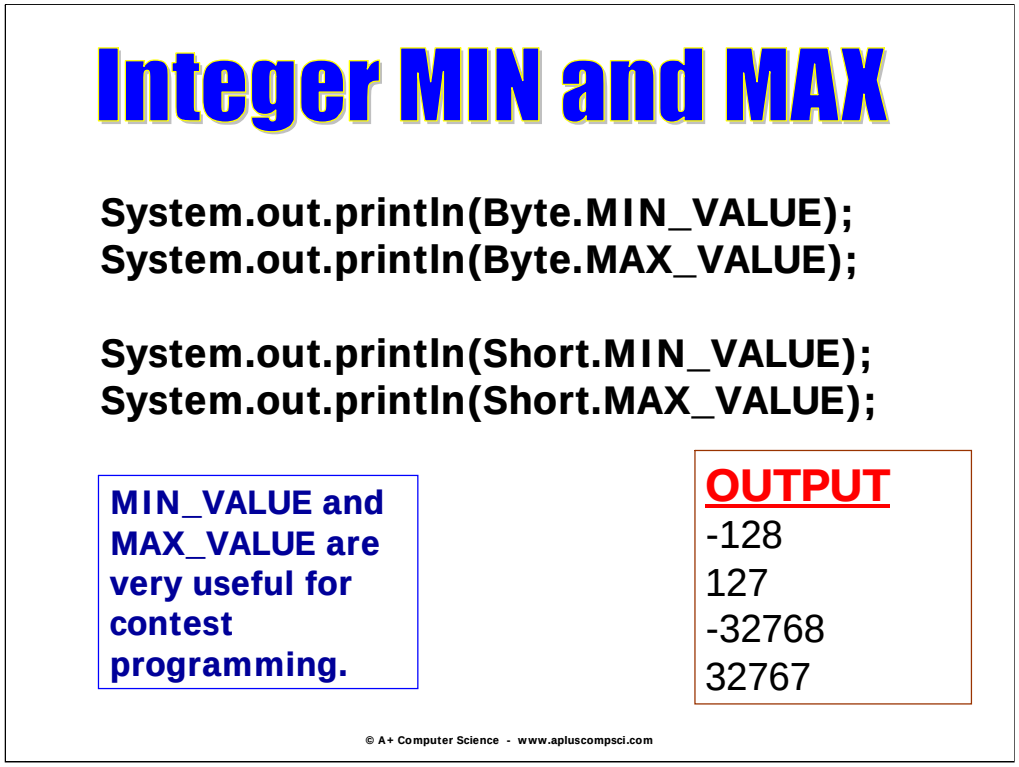


**1 byte = 8 bits**

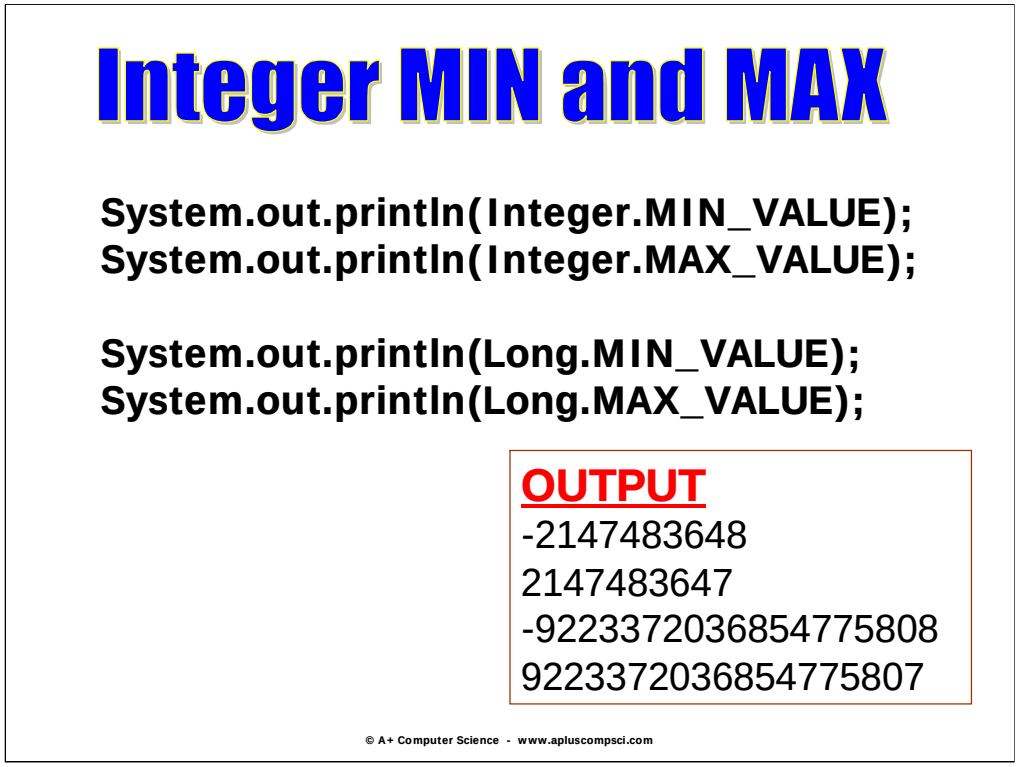


The more bits a data type has the more that data type can store. A 64 bit type has much more storage room than an 8 bit type.

| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | base 10 value of each binary digit |
|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 0 | 1 | 0 | = 10 in base 10 |
| | | | | 1 | 1 | 1 | 1 | = 15 in base 10(4 bit) |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | = 136 in base 10 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | = 255 in base 10(8 bit) |




The MIN_VALUE and MAX_VALUE fields store the minimum and maximum values that can be stored in a particular type.




The `MIN_VALUE` and `MAX_VALUE` fields store the minimum and maximum values that can be stored in a particular type.

# Overflow Errors

```
int num = Integer.MAX_VALUE;
num=num+1;
System.out.println(num);
num=num-1;
System.out.println(num);
```

**Why does adding 1 to MAX_VALUE give you the MIN_VALUE?**

**OUTPUT**

-2147483648
2147483647

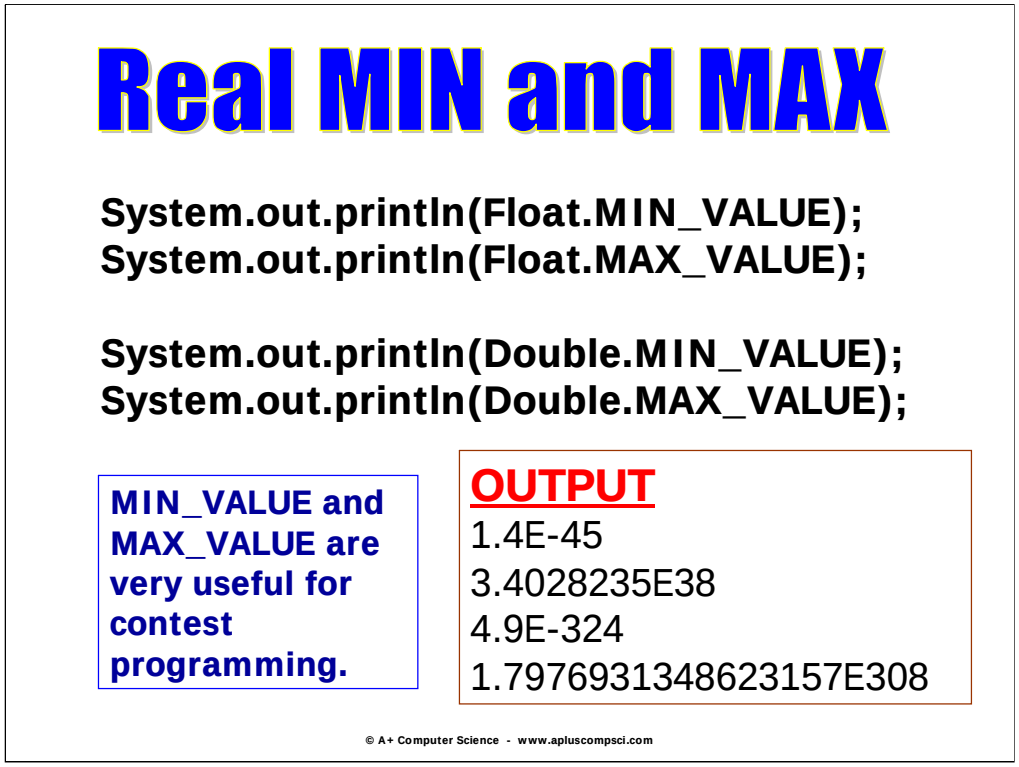


Overflow errors occur at run-time when a value is assigned to a variable that is too large. The resulting value is typically a negative value. The negative value occurs when the positive upper bound is overflowed into the negative range.

Attempting to assign a numeric constant that is too large to a variable is a syntax error. It is very easy for Java to determine that the value is too large for the data type.

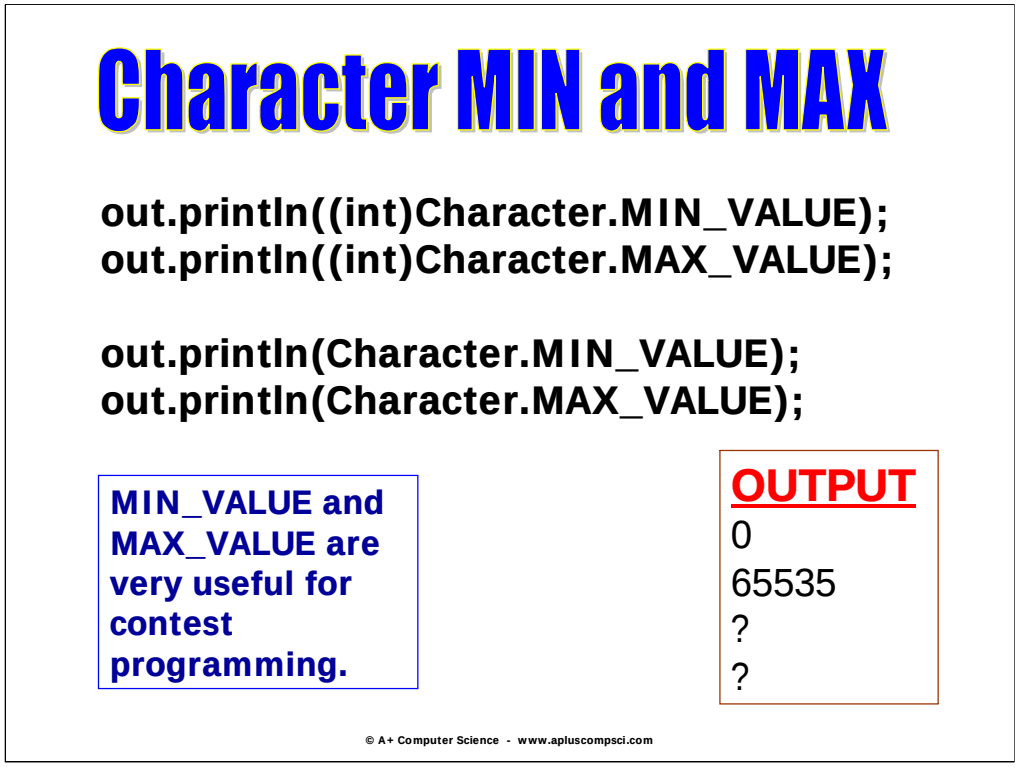
```
byte example = 128;   //compile error
```

# Open integersminmax.java




The `MIN_VALUE` and `MAX_VALUE` fields store the minimum and maximum values that can be stored in a particular type.

# Open realsminmax.java




The `MIN_VALUE` and `MAX_VALUE` fields store the minimum and maximum values that can be stored in a particular type.

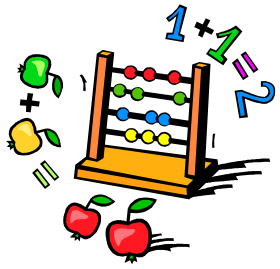
# Open charsminmax.java

# Mixing data

# Mixing Data

**Java is a strong typed language.**
**You must pay attention to a variable's type when assigning a value.**

```
int one=90;
char letter= 'A';
char let= 97;

one=letter;
letter=let;
one=let;
```






As Java is a strong-typed language, it is important to pay attention to data types when assigning values.

Integer types cannot store decimal values unless a cast is used.

Also, when assigning values from one variable to another, data types and data type sizes play an important part.

# Mixing Data

```
int one = 90;
double dec = 234;
char letter = 'A';

System.out.println( one );
one = letter;          //char to int
System.out.println( one );

one = 'A';             //char to int
System.out.println( one );

System.out.println( dec );
dec = one;             //int to double
System.out.println( dec );
```

**OUTPUT**

90
65
65
234.0
65.0

**Data type sizes often determine if assignment is legal.**

**32 bit == 32 bit**



When assigning values from one variable to another, data types and data type sizes play an important part.

Large size types can be assigned same size type and smaller type values.

Smaller size types cannot be assigned larger type values.

16 bit = 16 bit and smaller  //legal

8 bit = 16 bit and smaller  //illegal without a cast()

# open mixingdata.java

# Finish work on Lab 0b

# AutoBoxing
# AutoUnboxing



# References/Objects

**In JAVA, you have 8 primitive data types.**

**All other variables in Java are reference variables. References refer to objects.**

```
Monster m = new Monster();
```

# References/Objects

| primitive | object |
|---|---|
| byte | Byte |
| short | Short |
| int | Integer |
| long | Long |
| float | Float |
| double | Double |
| char | Character |
| boolean | Boolean |



For each of the primitive types, there is a corresponding wrapper class.

`int` has a corresponding wrapper class named `Integer`.

`int` stores a non-decimal value.

`Integer` stores the location / memory address of an `Integer` Object which stores an `int` value.

`double` has a corresponding wrapper class named `Double`.

`double` stores decimal and non-decimal values.

`Double` stores the location / memory address of a `Double` Object which stores a `double` value.

# Box/Unbox

**Before Java 5 added in autoboxing and autounboxing, you had to manually wrap primitives.**

```
Integer x = new Integer(98);
int y = 56;
x= new Integer(y);
```



Before autoboxing and autounboxing, a reference could only refer to a primitive if a Wrapper class was instantiated and the primitive passed to the constructor.

# Box/Unbox

**Java now wraps automatically.**

```
Integer numOne = 99;
Integer numTwo = new Integer(99);

=99;
=new Integer(99);
```

**These two lines are equivalent.**



`Integer numOne = 99;` is equivalent to

`Integer numOne = new Integer(99);`

With the introduction of Java 5, the `new Integer()` Object instantiation code happens in the background. Java takes care of these details, but does not show the work.

# Box/Unbox

**Java now wraps automatically.**

```
Double numOne = 99.1;
Double numTwo = new Double(99.1);
```

```
=99.1;
=new Double(99.1);
```

**These two lines are equivalent.**



`Double numOne = 99;` is equivalent to
`Double numOne = new Double(99);`

With the introduction of Java 5, the `new Double()` Object instantiation code happens in the background. Java takes care of these details, but does not show the work.

# Box/Unbox

**Before Java 5 added in autoboxing and autounboxing, you had to manually unwrap references.**

```
Integer ref = new Integer(98);
int y = ref.intValue();
```



Before autoboxing and autounboxing, a reference value could only be stored in a primitive if the corresponding reference get method was called to retrieve the primitive value from the reference.

# Box/Unbox

**Java now unwraps automatically.**

```
Integer num = new Integer(3);
int prim = num.intValue();
out.println(prim);
prim = num;
out.println(prim);
```

**OUTPUT**

```
3
3
```

```
prim=num.intValue();
prim=num;
```

**These two lines are equivalent.**



```
Integer numOne = new Integer(99);
int primInt = numOne;
```

is equivalent to

```
int primInt = numOne.intValue();
```

With the introduction of Java 5, the `intValue()` method call happens in the background. Java takes care of these details, but does not show the work.

# Box/Unbox

```
Double dub = 9.3;
double prim = dub;
out.println(prim);

int num = 12;
Integer big = num;
out.println(big.compareTo(12));
out.println(big.compareTo(17));
out.println(big.compareTo(10));
```

**OUTPUT**

```
9.3
0
-1
1
```



Before autoboxing and autounboxing, a reference could only refer to a primitive if a Wrapper class was instantiated and the primitive passed to the constructor.

Before autoboxing and autounboxing, a reference value could only be stored in a primitive if the corresponding reference get method was called to retrieve the primitive value from the reference.

With the introduction of Java 5, the wrapping and unwrapping / boxing and unboxing happens in the background. Java takes care of these details, but does not show the work.

# Open objects.java


GUI HELP
guihelp.java
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