CMSC201
Computer Science I for Majors

Lecture 03 – Operators

Last Class We Covered

- Variables
  - Rules for naming
  - Different types
  - How to use them
- Printing output to the screen
- Getting input from the user
  - Mad Libs

Any Questions from Last Time?

Today's Objectives

- To learn Python's operators
  - Arithmetic operators
    - Including mod and integer division
  - Assignment operators
  - Comparison operators
  - Boolean operators

- To understand the order of operations

Pop Quiz!

- Which of the following examples are correct?
  1. `500 = numStudents`
  2. `numStudents = 500`
  3. `numCookies * cookiePrice = total`
  4. `mpg = miles_driven / gallons_used`
  5. `"Hello World!" = message`
  6. `_CMSC201_doge_ = "Very learning"`
  7. `60 * hours = days * 24 * 60`

Pop Quiz!

- Which of the following examples are correct?

✗ 1. `500 = numStudents`

✓ 2. `numStudents = 500`

✗ 3. `numCookies * cookiePrice = total`

✓ 4. `mpg = miles_driven / gallons_used`

✗ 5. `"Hello World!" = message`

✓ 6. `_CMSC201_doge_ = "Very learning"`

✗ 7. `60 * hours = days * 24 * 60`

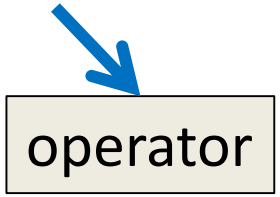
Python's Operators

Python Basic Operators

- ***Operators*** are the constructs which can manipulate and evaluate our data

- Consider the expression:

```
num = 4 + 5
```



Types of Operators in Python

- Arithmetic Operators
- Assignment Operators
- Comparison Operators
- Logical Operators
- Membership Operators
- Bitwise Operators
- Identity Operators

focus of today's lecture

Operators – Addition & Subtraction

- "Lowest" priority in the order of operations
  - Can only change this with parentheses
- Function as they normally do

- Examples:
  1. `cash = cash - bills`
  2. `(5 + 7) / 2`
  3. `( ((2 + 4) * 5) / (9 - 6) )`

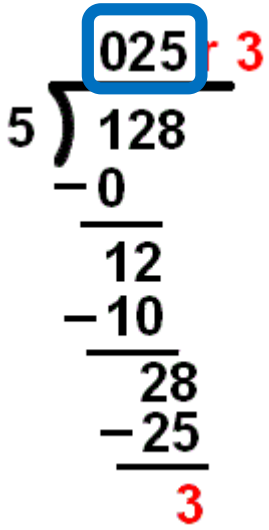
Operators – Multiplication & Division

- Higher priority in the order of operations than addition and subtraction
- Function as they normally do

- Examples:
  1. `tax = subtotal * 0.06`
  2. `area = PI * (radius * radius)`
  3. `totalDays = hours / 24`

Operators – Integer Division

- Reminder: integers (or ints) are **whole numbers**
  - What do you think integer division is?
- Remember division in grade school?
- Integer division is
  - Division done without decimals
  - And the remainder is discarded



Examples: Integer Division

- Integer division uses double slashes (`//`)

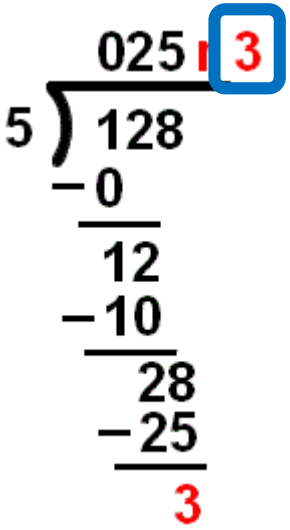
- Examples:

1. `7 /  5    = 1.4`
2. `7 // 5    = 1`
3. `2 /  8    = 0.25`
4. `2 // 8    = 0`
5. `4 // 17 // 5 = 0`

evaluate from left to right

Operators – Mod

- Also called “modulo” or “modulus”
- Example: `17 % 5 = 2`
  - What do you think mod does?
- Remember division in grade school?
- Modulo gives you the remainder
  - The “opposite” of integer division



Examples: Mod

- Mod uses the percent sign (%)

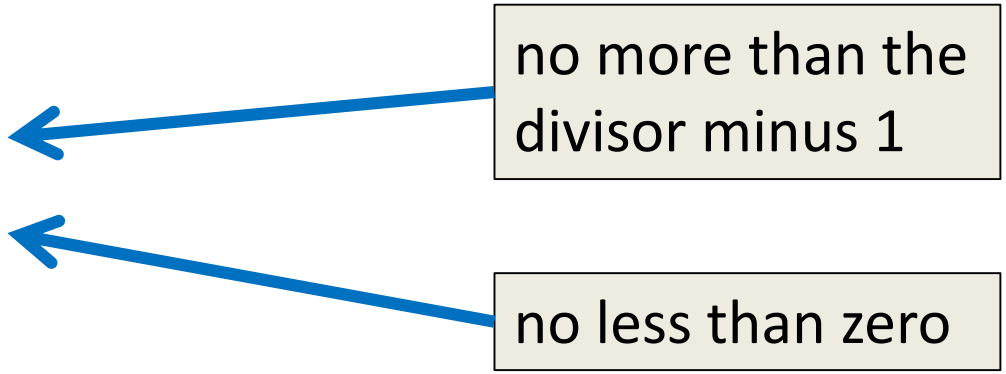
- Examples:

1. `7 % 5 = 2`
2. `5 % 9 = 5`
3. `17 % 6 = 5`
4. `22 % 4 = 2`
5. `48692451673 % 2 = 1`

Modulo Answers

- Result of a modulo operation will always be:
  - Positive
  - No less than 0
  - No more than the divisor minus 1

- Examples:
  1. `8 % 3 = 2`
  2. `21 % 3 = 0`
  3. `13 % 3 = 1`



Operators – Exponentiation

- "Exponentiation" is just another word for raising one number to the power of another

- Examples:

1. `binary8 = 2 ** 8`
2. `squareArea = length ** 2`
3. `cubeVolume = length ** 3`
4. `squareRoot = num ** 0.5`

Arithmetic Operators in Python

Operator	Meaning
+	Addition
–	Subtraction
*	Multiplication
/	Division
//	Integer division
%	Modulo (remainder)
**	Exponentiation

Order of Operations (Arithmetic)

- Expressions are evaluated from left to right

Operator(s)	Priority
**	highest
* / // %	
+ -	lowest

- What can change this ordering?
  - Parentheses!

Assignment Operators

Basic Assignment

- All assignment operators
  - Contain a single equals sign
  - Must have a variable on the left side

- Examples:

1. `numDogs = 18`
2. `totalTax = income * taxBracket`
3. `numPizzas = (people // 4) + 1`

Combining with Arithmetic

- You can simplify statements like these

```
count       = count + 1
amountLeft = amountLeft // 2
```

  – By combining the arithmetic and assignment

```
count       += 1
amountLeft //= 2
```

- You can do this with any arithmetic operator

Combined Assignments

- These operators work only if the variable is the first thing to the right of the assignment

```
percent = int(input("Enter percent: "))
# convert the percentage to a decimal
percent /= 100
```

- The last line is the same as this line

```
percent = percent / 100
```

Comparison Operators

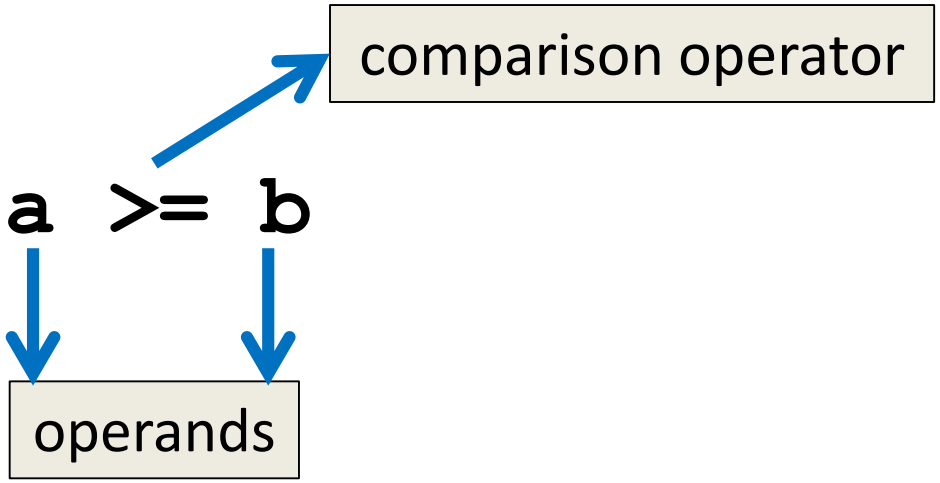
Vocabulary

- Comparison operators
- Relational operators
- Equality operators
  - Are all the same thing

- Include things like **>**, **>=**, **<**, **<=**, **==**, **!=**

Comparison Operators

- Always return a Boolean result
  - **`True`** or **`False`**
  - Indicates whether a relationship holds between their operands



Comparison Examples

- What are the following comparisons asking?

  `a >= b`

  – Is `a` greater than or equal to `b`?

  `a == b`

  – Is `a` equivalent to `b`?

Comparison Operators in Python

Operator	Meaning
<	Less than (exclusive)
<=	Less than or equal to (inclusive)
>	Greater than (exclusive)
>=	Greater than or equal to (inclusive)
==	Equivalent to
!=	Not equivalent to

Comparison Examples (Continued)

- What do these evaluate to if `a = 10` and `b = 20`?

  `a >= b`

  - Is `a` greater than or equal to `b`?
  - Is `10` greater than or equal to `20`?
  - **FALSE**

Comparison Examples (Continued)

- What do these evaluate to if `a = 10` and `b = 20`?

  `a == b`

  - Is `a` equivalent to `b`?
  - Is `10` equivalent to `20`?
  - **FALSE**

Comparison vs Assignment

- A common mistake is to use the assignment operator (=) in place of the relational (==)
  - This is a very common mistake to make!

- This type of mistake will trigger an error in Python, but you may still make it on paper!

Equals vs Equivalence

- What does **`a = b`** do?
  - Sets **`a`** equal to **`b`**
  - Changes **`a`**'s value to the value of **`b`**

- What does **`a == b`** do?
  - Checks if **`a`** is equivalent to **`b`**
  - Does not change the value of **`a`** or **`b`**

Evaluating to Boolean Values

Comparison Operators and Simple Data Types

- Examples:

`8 < 15`	evaluates to	**`True`**
`6 != 6`	evaluates to	**`False`**
`2.5 > 5.8`	evaluates to	**`False`**
`5.9 <= 7.5`	evaluates to	**`True`**

"Value" of Boolean Variables

- When we discuss Boolean outputs, we think

  `True` and **`False`**

- We can also think of it in terms of

  `1` and `0`

- **`True  = 1`**
- **`False = 0`**

"Value" of Boolean Variables

- Other data types can also be seen as "**`True`**" or "**`False`**" in Python

- Anything empty or zero is **`False`**
  - `""` (empty string), `0`, `0.0`
- Everything else is **`True`**
  - `81.3`, `77`, `-5`, `"zero"`, `0.01`
  - Even `"0"` and `"False"` evaluate to **`True`**

Logical Operators

Vocabulary

- Logical operators
- Boolean operators
  - Are the same thing

- Include **`and`**, **`or`**, and **`not`**

Logical Operators

- There are three logical operators:
  - `and`
  - `or`
  - `not`
- They allow us to build more complex Boolean expressions
  - By combining simpler Boolean expressions

Logical Operators – `and`

- Let's evaluate this expression

```
bool1 = a and b
```

Value of `a`	Value of `b`	Value of `bool1`
`True`	`True`	
`True`	`False`	
`False`	`True`	
`False`	`False`	

Logical Operators – `and`

- Let's evaluate this expression

```
bool1 = a and b
```

Value of `a`	Value of `b`	Value of `bool1`
`True`	`True`	`True`
`True`	`False`	`False`
`False`	`True`	`False`
`False`	`False`	`False`

- For `a and b` to be `True`, both `a` and `b` must be true

Examples of **and**

```
a = 10
b = 20
c = 30

ex1 = a < b
ex2 = a < b and b < c
ex3 = a + b == c and b - 10 == a
      and c / 3 == a

print (ex1, ex2, ex3)
```

Prints:

```
True True True
```

Logical Operators – `or`

- Let's evaluate this expression

```
bool2 = a or b
```

Value of `a`	Value of `b`	Value of `bool2`
`True`	`True`	
`True`	`False`	
`False`	`True`	
`False`	`False`	

Logical Operators – `or`

- Let's evaluate this expression

```
bool2 = a or b
```

Value of `a`	Value of `b`	Value of `bool2`
`True`	`True`	`True`
`True`	`False`	`True`
`False`	`True`	`True`
`False`	`False`	`False`

- For `a or b` to be `True`, either `a` or `b` must be true

Logical Operators – `not`

- Let's evaluate this expression

```
bool3 = not a
```

Value of `a`	Value of `bool3`
`True`	
`False`	

Logical Operators – `not`

- Let's evaluate this expression

```
bool3 = not a
```

Value of `a`	Value of `bool3`
`True`	`False`
`False`	`True`

- `not a` calculates the Boolean value of `a` and returns the opposite of that

Complex Expressions

- We can put multiple operators together!

```
bool4 = a and (b or c)
```

- What does Python do first?
  - Computes **`(b or c)`**
  - Computes **`a and`** the result

Order of Operations (All)

Operator(s)	Priority
`**`	highest
`*` `/` `//` `%`	
`+` `-`	
`<` `<=` `>` `>=` `!=` `==`	
`not`	
`and`	
`or`	lowest

Announcements

- Your discussions start this week!
  - Go to your scheduled location and time
- HW 0 is due by *Wednesday* at 8:59:59 PM
- HW 1 is out on Blackboard now
  - You must complete a Quiz to see it
  - Due by Friday (Feb 10th) at 8:59:59 PM