# 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
- Written programs vs Python interpreter

# 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
```

operator

# 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
- Function as they normally do

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

# Operators – Multiplication & Division

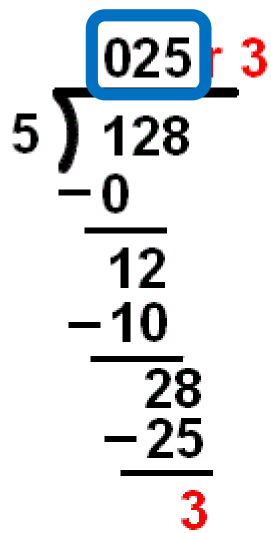
- Higher priority in the order of operations than addition and subtraction
- Function as they normally do
- Examples:
  1. `tax = subtotal * 0.06`
  2. `area = PI * (radius * radius)`
  3. `totalDays = hours / 24`

# 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 (//)

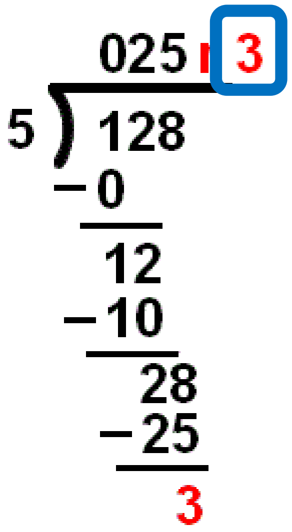
- Examples:
  1. `7 /  5       = 1.4`
  2. `7 // 5       = 1`
  3. `2 /  8       = 0.25`
  4. `2 // 8       = 0`
  5. `4 // 17 // 5 =  0`

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. `16 % 6     = 4`
  4. `23 % 4     = 3`
  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`

no more than the divisor minus 1

no less than zero

# 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!

# Floating Point Errors

# Division: Floats and Integers

- Floats (decimals) and integers (whole numbers) behave in two different ways in Python
  - And in many other programming languages

- Biggest difference is how their division works
  - Python 3 automatically performs decimal division
    - For both integers and floats
  - Have to explicitly call integer division

# Division Examples

- What do the following expressions evaluate to?
  1. `4 / 3` = `1.3333333333333333`
  2. `4 // 3` = `1`
  3. `8 / 3` = `2.6666666666666667`
  4. `8 / 2` = `4.0`
  5. `5 / 7` = `0.7142857142857143`
  6. `5 // 7` = `0`

# Rounding Errors

- Sometimes we need to approximate the representation of numbers
  - 0.66666666666666666666666667…
  - 3.14159265358979323846264338328…
- We know that this can lead to incorrect answers when doing calculations later
  - Something similar happens when numbers are stored in a computer's memory

# Float Arithmetic Examples

- What do the following expressions evaluate to?
  1. `8 / 3 = 2.6666666666666667`
  2. `5 / 7 = 0.7142857142857143`
  3. `1.99 + 0.12 = 2.11`
  4. `0.99 + 0.12 = 1.1099999999999999`
  5. `1.13 * 1.19 = 1.3446999999999998`

What's going on here???

Because computers store floats differently than whole numbers, they sometimes run into different kinds of rounding errors

# Handling Floating Point Errors

- How to fix floating point errors?
  - You can't!
    ¯_(ツ)_/¯
  - They're present in every single programming language that uses the float data type
- Just be aware that the problem exists
  - Don't rely on having exact numerical representations when using floats in Python

# Assignment Operators

# Basic Assignment

- All assignment operators
  - Contain a single equal 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
doubling = doubling * 2
```

  - By combining the arithmetic and assignment

```
count    += 1
doubling *= 2
```

- You can do this with any arithmetic operator

# Combined Assignments

- These shortcuts assume that the variable is the first thing after the assignment operator

```
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

# Overview

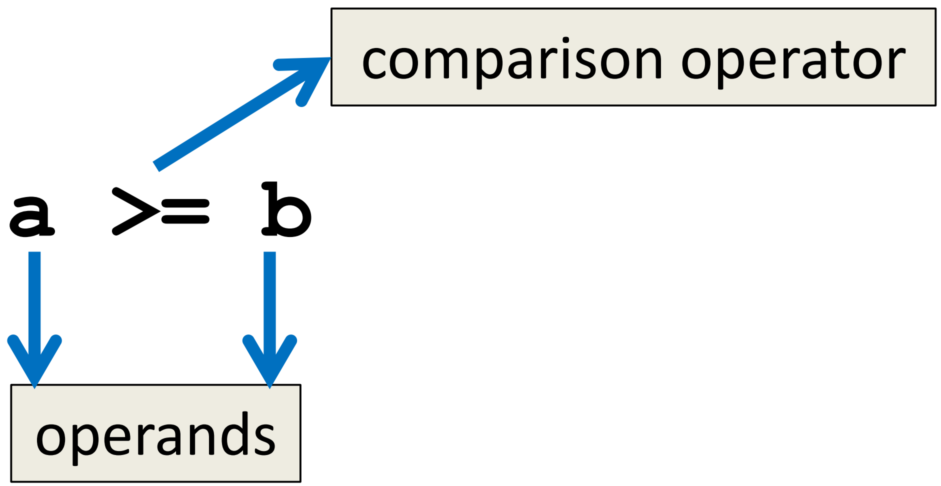
- Comparison operators
- Relational operators
- Equality operators
  - Are all the same thing

- 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`** less than or equal to **`b`**?
  - Is **`10`** less than or equal to **`20`**?
  - **`True`**

# 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?
  - Assigns **`a`** the value stored in **`b`**
  - Changes **`a`**'s value to the value of **`b`**

- What does **`a == b`** do?
  - Checks if **`a`** is equivalent to **`b`**
  - Does <u>not</u> 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`**

  `4.0 == 4` evaluates to **`True`**

# "Value" of Boolean Variables

- When we discuss Boolean outputs, we use

  **`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

# Logical Operators

- Sometimes also called Boolean operators
- There are three logical operators:
  - **`and`**
  - **`or`**
  - **`not`**

- They let us build 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` | |

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

# 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

# Practice with `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)
```

output:

```
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` | |

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

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

# 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)`**
  - Then computes **`a and`** the result

# Practice with Comparisons

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

output:

**False True True False**

```
bool1 = True and (a > b)
bool2 = (not True) or (b != c)
bool3 = (True and (not False)) or (a > b)
bool4 = (a % b == 2) and ((not True) or False)

print (bool1, bool2, bool3, bool4)
```

# Order of Operations (All)

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

# Daily emacs Shortcut

- **`CTRL+K`**
  - "Kill" from the cursor to the end of the line
    - Cuts the text (saves it to the "kill ring")
  - Hit twice to get the "enter" at the end too

- **`CTRL+Y`**
  - "Yank" the killed text back from the dead
    - Pastes the text (from the "kill ring")
  - Press multiple times to paste the text again

# Announcements

- Your discussions start this week!
  - Go to your scheduled location and time

- HW 1 is due Friday, Sept 14th at 8:59:59 PM
  - You must first complete the Syllabus and Course Website Quiz to see it