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Algorithms & Abstraction

Algorithms: procedures that specify how to do a task or solve a problem
Abstraction: changing the level of detail used to represent/interact with a system

Designing algorithms:
Little abstraction: assume no prior knowledge, need to define everything
Moderate abstraction: assume user has some basic knowledge already
Heavy abstraction: can make a lot more assumptions about incoming knowledge

Programming Basics

Integer (`int`): whole numbers (`14`)
Floating point number (`float`): numbers with a fractional part (`5.735`)
String (`str`): text in quotes (`"Sup all"`)
Boolean (`bool`): truth value (`True`)

Number operations: `+`, `-`, `*`, `/`, `**`, `%`, `//`
Text operations: `+`, `*`, `in`
Comparison ops: `<`, `>`, `<=`, `>=`, `==`, `!=`

Expression: code that evaluates to a data value
Statement: code that can change the state of the program
Variable assignment: `x = expr` stores the value of `expr` in the variable `x`
Variables: `x` evaluates to the value stored in the variable `x`

When dealing with an error:
1. Look for the line number
2. Look at the error type
3. For `SyntaxError`s, look for the inline arrow
4. For other errors, read the error message

Data Representation

Number system: a way of representing a number using symbols. Currency, decimal, etc

Binary numbers: numbers in the base 2 system, composed of 0s and 1s.
Bit: a single digit in binary
Byte: eight bits interpreted together

Translate binary to decimal: add together the powers of 2 represented by the 1s. The first eight powers of 2 are 1, 2, 4, 8, 16, 32, 64, and 128.

Translate decimal to binary: repeatedly look for the largest power of 2 that fits in the decimal and remove it

Interpret binary as color: represent a single color with RGB (Red-Green-Blue). Each color component is represented by three bytes- intensity of red, then green, then blue.

Interpret binary as text: make a lookup table (like ASCII) that maps characters to numbers. Convert each byte to a number and look it up in the table.

Function Calls

Function: an algorithm implemented abstractly in Python that can be called on specific inputs

Arguments: input values to function call
Returned value: evaluated result, the output. If no output, defaults to `None`

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Side effect: visible things that happen as the function runs (printing, graphics, etc)

`print(expr)` - show `expr` in interpreter
`abs(num)` - absolute value of `num`
`pow(x, y)` - raises `x` to power of `y`
`round(x, y)` - round `x` to `y` sig. digits
`type(expr)` - type of evaluated `expr`
`input(msg)` - accepts user input
`ord(c)` - ASCII value of `c`
`chr(x)` - character of ASCII value `x`

Library: a collection of functions that need to be imported to be used

```
import libraryName
```

`math.ceil(x)` - ceiling of `x`
`math.log(x, y)` - log of `x` with base `y`
`math.radians(x)` - degrees to radians
`math.pi` - pi (to some number of digits)

`random.randint(x, y)` - random int in range [`x`, `y`]
`random.random()` - random float in range [0, 1)

`canvas.create_rectangle(a,b,c,d)` - draw a rectangle from point (`a`, `b`) to point (`c`, `d`)

```
canvas.create_rectangle(a,b,c,d,
                        fill="blue")
```

- fill in the rectangle with the color blue

Function Definitions

Function definition: abstract implementation of an algorithm. Provides input with *parameters* (abstract variables), produces a result with a *return statement*.

```
def funName(args):
    # body
    return result
```

Local scope: variables in function definitions (including parameters) are only accessible within that function.

Global scope: variables at the global (top) level are accessible at the top-level, and by any function.

Function Call Tracing: Python keeps track of the functions it is currently calling in nested function calls. When Python reaches a return statement, it returns the value to the most recent function that called the current function.

Booleans, Conditionals, & Errors

Logical operators: `and`, `or`, `not`

Short circuit evaluation: Python only evaluates the second half of a logical operation if it needs to

Conditional statement: control structure that allows you to make choices in a program.

```
if booleanExpr:
    ifBody
elif booleanExpr:
    elifBody
else:
    elseBody
```

Syntax Error: an error that occurs when Python cannot tokenize or structure code.

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Examples: `SyntaxError`, `IndentationError`, Incomplete Error

Runtime Error: an error that occurs when Python encounters a problem while running code. Examples: `NameError`, `TypeError`, `ZeroDivisionError`

Logical Error: an error that occurs when code runs properly but does not produce the intended result. Often (but not always) caused by a failed test case with `AssertionError`

```
assert(funName(input) == output)
```

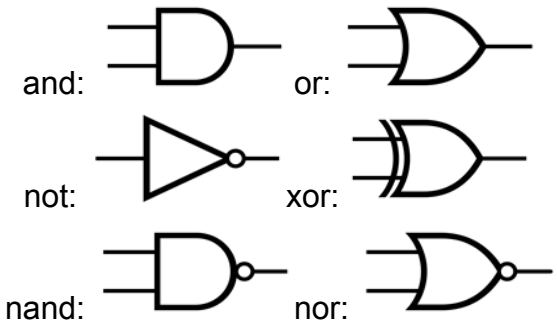
Circuits and Gates

Circuit: a hardware component that manipulates bits to compute an algorithmic result. Can also be simulated with an abstract version.

Gate: an abstract component of a circuit. Takes some number of bits as input and outputs a bit.

Gates: ∧ (and), ∨ (or), ¬ (not), ⊕ (xor); also nand and nor (no special symbols)

Gates (in circuits):



Truth table: a table that lists all possible input bit combinations and the resulting output for a particular gate or circuit

Half-adder: a circuit that takes two one-digit binary numbers, adds them, and outputs two digits as the result

Full adder: a circuit that takes two one-digit binary numbers and a carried-in digit, adds all three, and outputs two digits as the result

N-bit adder: a circuit that takes two n-bit numbers, adds them together by chaining together n full adders, and outputs a n+1-digit result

While Loops

While loop: a control structure that lets you repeat actions while a given Boolean expression is `True`

```
while booleanExpr:
    whileBody
```

Infinite loop: a while loop that never exits due to the state of the program

Loop control variable: a variable used to manipulate the number of times a loop iterates. Requires a start value, update action, and continuing condition.

For Loops

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For loop: a control structure that lets you repeat actions a specific number of times

```
for var in range(rangeArgs):
    forBody
```

Range: a function that generates values for the loop control variable in a for loop. Can take 1-3 inputs.

```
range(end) # [0, end)
range(start, end) # [start, end)
range(start, end, step)
# step provides the increment
```

Strings

Index: access a specific value in a sequence based on its position. Positions start at `0` and end at `len(seq)-1`. Non-existent indexes result in `IndexError`.

```
strExpr[index]
```

Slice: access a subsequence of a larger sequence based on a given start, end (not inclusive), and step

```
strExpr[start:end:step] # slice
strExpr[start:end] # also slice
# default to 0:len(strExpr):1
```

Looping over strings: use range and indexing to access one character at a time.

```
for i in range(len(strExpr)):
    something with strExpr[i]
```

Common string methods:

`strExpr.islower()` - returns `True` if all characters in `strExpr` are lowercase
`strExpr.isupper()` - returns `True` if all characters in `strExpr` are uppercase
`strExpr.count(x)` - return the number of times the subpart `x` occurs in `strExpr`
`strExpr.index(x)` - return the index of the subpart `x` in `strExpr`, or raise an error if it does not occur in the value

`strExpr.lower()` - returns a new string with all character in `strExpr` lowercase
`strExpr.upper()` - returns a new string with all characters in `strExpr` uppercase

General Control Structures

Control flow chart: chart that designates how a program steps through commands. Uses branches for conditional checks and arrows leading back to previous commands for loops.

Nesting: a control structure can be included in the body of another control structure through use of indentation.

Nested loop: a loop with another loop in its body. The inner loop is fully executed for each iteration of the outer loop.