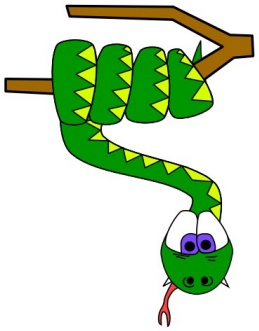

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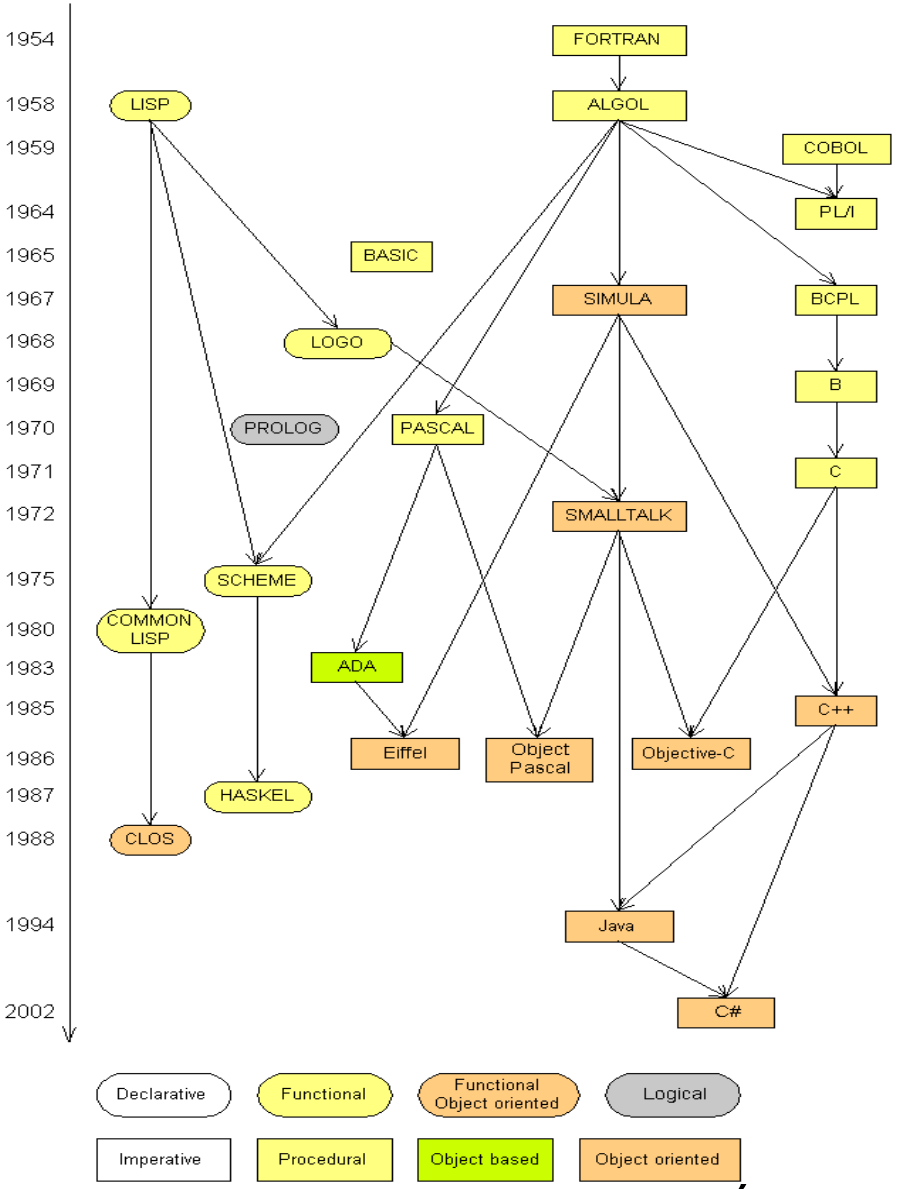
Introduction to Programming with Python

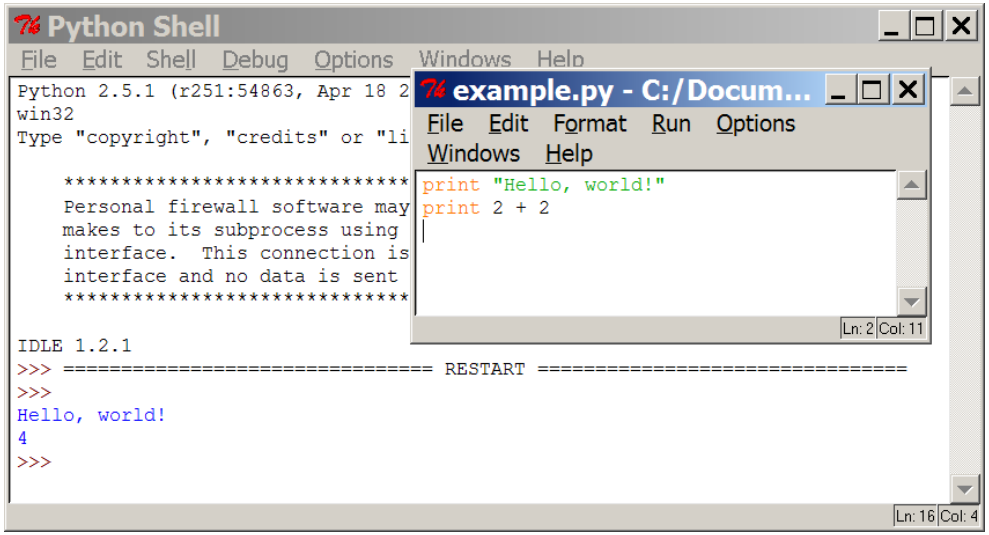
Languages

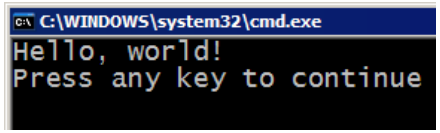
- Some influential ones:
  - FORTRAN
    - science / engineering
  - COBOL
    - business data
  - LISP
    - logic and AI
  - BASIC
    - a simple language



Programming basics

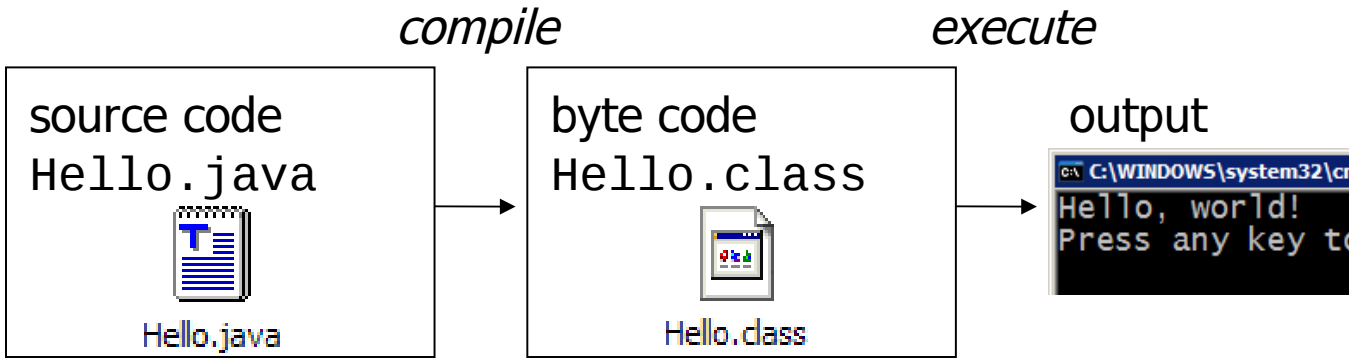
- **code** or **source code**: The sequence of instructions in a program.
- **syntax**: The set of legal structures and commands that can be used in a particular programming language.
- **output**: The messages printed to the user by a program.
- **console**: The text box onto which output is printed.
  - Some source code editors pop up the console as an external window, and others contain their own console window.



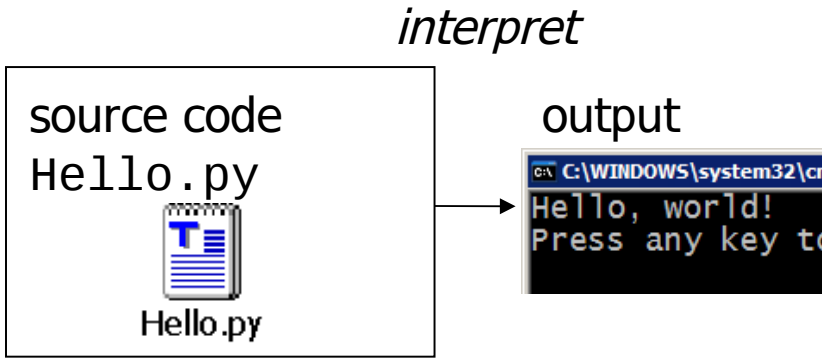


Compiling and interpreting

- Many languages require you to *compile* (translate) your program into a form that the machine understands.



- Python is instead directly *interpreted* into machine instructions.



Expressions

- **expression**: A data value or set of operations to compute a value.

  Examples: `1 + 4 * 3`

  `42`

- Arithmetic operators we will use:

`+ - * /`	addition, subtraction/negation, multiplication, division
`%`	modulus, a.k.a. remainder
`**`	exponentiation

- **precedence**: Order in which operations are computed.
  - `* / % **` have a higher precedence than `+ -`

    `1 + 3 * 4` is 13

  - Parentheses can be used to force a certain order of evaluation.

    `(1 + 3) * 4` is 16

Integer division

- When we divide integers with `/` , the quotient is also an integer.

```
     3                    52
  ____                 ____
4 ) 14              27 ) 1425
    12                   135
     2                     75
                           54
                           21
```

  - More examples:
    - `35 / 5` is `7`
    - `84 / 10` is `8`
    - `156 / 100` is `1`

- The `%` operator computes the remainder from a division of integers.

```
     3                    43
  ____                 ____
4 ) 14              5 ) 218
    12                   20
     2                    18
                          15
                           3
```

Real numbers

- Python can also manipulate real numbers.
  - Examples: `6.022  -15.9997  42.0  2.143e17`

- The operators `+ - * / % ** ( )` all work for real numbers.
  - The `/` produces an exact answer: `15.0 / 2.0` is **`7.5`**
  - The same rules of precedence also apply to real numbers: Evaluate `( )` before `* / %` before `+ -`

- When integers and reals are mixed, the result is a real number.
  - Example: `1 / 2.0` is `0.5`
  - The conversion occurs on a per-operator basis.

```
7 / 3 * 1.2 + 3 / 2
  2   * 1.2 + 3 / 2
    2.4     + 3 / 2
    2.4     +   1
        3.4
```

Math commands

- Python has useful commands for performing calculations.

Command name	Description
`abs(`***value***`)`	absolute value
`ceil(`***value***`)`	rounds up
`cos(`***value***`)`	cosine, in radians
`floor(`***value***`)`	rounds down
`log(`***value***`)`	logarithm, base *e*
`log10(`***value***`)`	logarithm, base 10
`max(`***value1***`, `***value2***`)`	larger of two values
`min(`***value1***`, `***value2***`)`	smaller of two values
`round(`***value***`)`	nearest whole number
`sin(`***value***`)`	sine, in radians
`sqrt(`***value***`)`	square root

Constant	Description
`e`	2.7182818...
`pi`	3.1415926...

- To use many of these commands, you must write the following at the top of your Python program:

```
from math import *
```

Variables

- **variable**: A named piece of memory that can store a value.
  - Usage:
    - Compute an expression's result,
    - store that result into a variable,
    - and use that variable later in the program.

- **assignment statement**: Stores a value into a variable.
  - Syntax:

    name = ***value***

  - Examples:

```
x = 5
gpa = 3.14
```

  - A variable that has been given a value can be used in expressions.
    x + 4 is 9

- **Exercise:** Evaluate the quadratic equation for a given *a*, *b*, and *c*.

print

- `print` : Produces text output on the console.
- Syntax:

  `print "`***Message***`"`

  `print` ***Expression***
  - Prints the given text message or expression value on the console, and moves the cursor down to the next line.

  `print` ***Item1***`,` ***Item2***`,` …`,` ***ItemN***
  - Prints several messages and/or expressions on the same line.

- Examples:

```
print "Hello, world!"
age = 45
print "You have", 65 - age, "years until retirement"
```

Output:

```
Hello, world!
You have 20 years until retirement
```

input

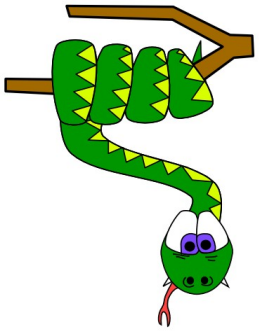
- `input` : Reads a number from user input.
  - You can assign (store) the result of `input` into a variable.
  - Example:

```
age = input("How old are you? ")
print "Your age is", age
print "You have", 65 - age, "years until retirement"
```

Output:

```
How old are you? 53
Your age is 53
You have 12 years until retirement
```

- **Exercise:** Write a Python program that prompts the user for his/her amount of money, then reports how many Nintendo Wiis the person can afford, and how much more money he/she will need to afford an additional Wii.



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Repetition (loops) and Selection (if/else)

The for loop

- **for loop**: Repeats a set of statements over a group of values.
  - Syntax:

```
for variableName in groupOfValues:
    statements
```

    - We indent the statements to be repeated with tabs or spaces.
    - ***variableName*** gives a name to each value, so you can refer to it in the ***statements***.
    - ***groupOfValues*** can be a range of integers, specified with the `range` function.

  - Example:

```
for x in range(1, 6):
    print x, "squared is", x * x
```

Output:

```
1 squared is 1
2 squared is 4
3 squared is 9
4 squared is 16
5 squared is 25
```

range

- The `range` function specifies a range of integers:
  - `range(`***start***`, `***stop***`)` - the integers between ***start*** (inclusive) and ***stop*** (exclusive)
  - It can also accept a third value specifying the change between values.
    - `range(`***start***`, `***stop***`, `***step***`)` - the integers between ***start*** (inclusive) and ***stop*** (exclusive) by ***step***
  - Example:

```
for x in range(5, 0, -1):
    print x
print "Blastoff!"
```

Output:

```
5
4
3
2
1
Blastoff!
```

  - **Exercise:** How would we print the "99 Bottles of Beer" song?

Cumulative loops

- Some loops incrementally compute a value that is initialized outside the loop. This is sometimes called a *cumulative sum*.

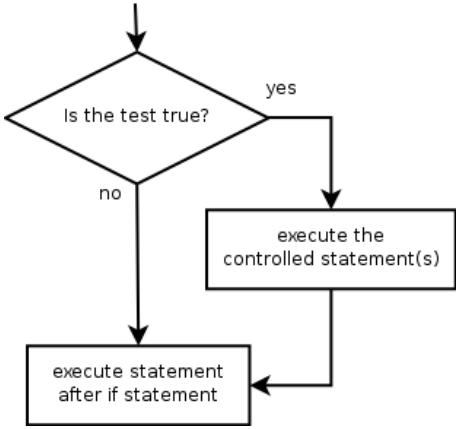
```
sum = 0
for i in range(1, 11):
    sum = sum + (i * i)
print "sum of first 10 squares is", sum

Output:
sum of first 10 squares is 385
```

- **Exercise:** Write a Python program that computes the factorial of an integer.

if

- **`if` statement**: Executes a group of statements only if a certain condition is true. Otherwise, the statements are skipped.
  - Syntax:

```
if condition:
    statements
```



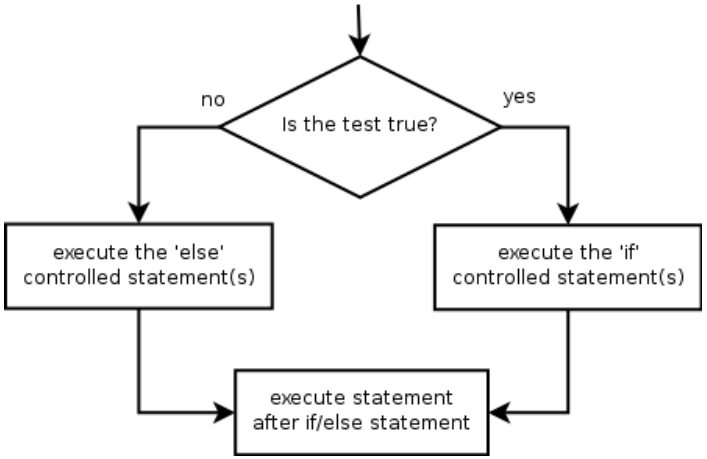
- Example:

```
gpa = 3.4
if gpa > 2.0:
    print "Your application is accepted."
```

if/else

- **`if/else` statement**: Executes one block of statements if a certain condition is True, and a second block of statements if it is False.
  - Syntax:

```
if condition:
    statements
else:
    statements
```

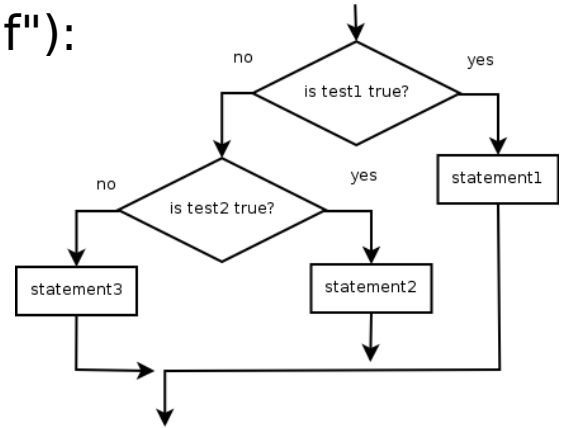


- Example:

```
gpa = 1.4
if gpa > 2.0:
    print "Welcome to Mars University!"
else:
    print "Your application is denied."
```

- Multiple conditions can be chained with `elif` ("else if"):

```
if condition:
    statements
elif condition:
    statements
else:
    statements
```



while

- **`while` loop**: Executes a group of statements as long as a condition is True.
  - good for *indefinite loops* (repeat an unknown number of times)

- Syntax:

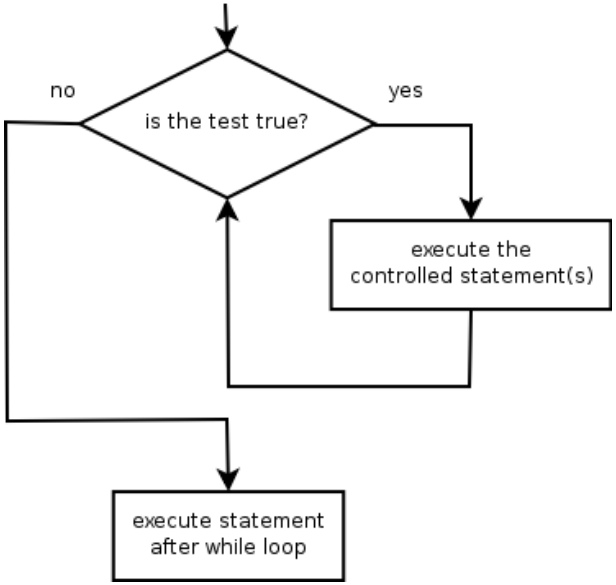
```
while condition:
    statements
```

- Example:

```
number = 1
while number < 200:
    print number,
    number = number * 2
```

  - Output:

```
1 2 4 8 16 32 64 128
```



Logic

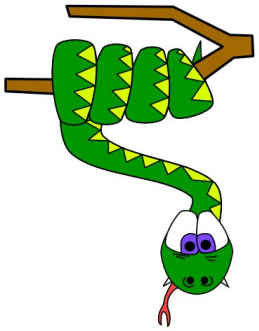
- Many logical expressions use *relational operators*:

Operator	Meaning	Example	Result
`==`	equals	`1 + 1 == 2`	`True`
`!=`	does not equal	`3.2 != 2.5`	`True`
`<`	less than	`10 < 5`	`False`
`>`	greater than	`10 > 5`	`True`
`<=`	less than or equal to	`126 <= 100`	`False`
`>=`	greater than or equal to	`5.0 >= 5.0`	`True`

- Logical expressions can be combined with *logical operators*:

Operator	Example	Result
`and`	`9 != 6 and 2 < 3`	`True`
`or`	`2 == 3 or -1 < 5`	`True`
`not`	`not 7 > 0`	`False`

- **Exercise:** Write code to display and count the factors of a number.



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Text and File Processing

Strings

- **string**: A sequence of text characters in a program.
  - Strings start and end with quotation mark `"` or apostrophe `'` characters.
  - Examples:

```
"hello"
"This is a string"
"This, too, is a string.   It can be very long!"
```

- A string may not span across multiple lines or contain a " character.

```
"This is not
a legal String."
"This is not a "legal" String either."
```

- A string can represent characters by preceding them with a backslash.
  - `\t` tab character
  - `\n` new line character
  - `\"` quotation mark character
  - `\\` backslash character
  - Example: `"Hello\tthere\nHow are you?"`

Indexes

- Characters in a string are numbered with *indexes* starting at 0:
  - Example:

```
name = "P. Diddy"
```

index	0	1	2	3	4	5	6	7
character	P	.		D	i	d	d	y

- Accessing an individual character of a string:
  variableName [***index***]
  - Example:

```
print name, "starts with", name[0]
```

Output:

```
P. Diddy starts with P
```

String properties

- `len(`***string***`)` - number of characters in a string (including spaces)
- `str.lower(`***string***`)` - lowercase version of a string
- `str.upper(`***string***`)` - uppercase version of a string

- Example:

```
name = "Martin Douglas Stepp"
length = len(name)
big_name = str.upper(name)
print big_name, "has", length, "characters"
```

Output:

```
MARTIN DOUGLAS STEPP has 20 characters
```

raw_input

- `raw_input` : Reads a string of text from user input.
  - Example:

```
name = raw_input("Howdy, pardner. What's yer name? ")
print name, "... what a silly name!"
```

Output:

```
Howdy, pardner. What's yer name? Paris Hilton
Paris Hilton ... what a silly name!
```

Text processing

- **text processing**: Examining, editing, formatting text.
  - often uses loops that examine the characters of a string one by one

- A `for` loop can examine each character in a string in sequence.
  - Example:

```
for c in "booyah":
    print c
```

Output:

```
b
o
o
y
a
h
```

Strings and numbers

- `ord(`***text***`)` - converts a string into a number.
  - Example: `ord("a")` is `97`, `ord("b")` is `98`, ...
  - Characters map to numbers using standardized mappings such as *ASCII* and *Unicode*.
- `chr(`***number***`)` - converts a number into a string.
  - Example: `chr(99)` is `"c"`
- **Exercise:** Write a program that performs a rotation cypher.
  - e.g. `"Attack"` when rotated by 1 becomes `"buubdl"`

File processing

- Many programs handle data, which often comes from files.

- Reading the entire contents of a file:

variableName `= open("`***filename***`").read()`

Example:

```
file_text = open("bankaccount.txt").read()
```

Line-by-line processing

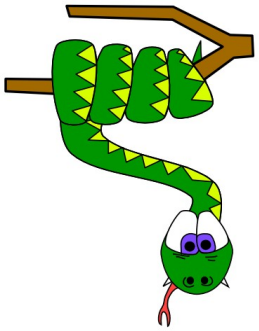
- Reading a file line-by-line:

```
for line in open("filename").readlines():
    statements
```

Example:

```
count = 0
for line in open("bankaccount.txt").readlines():
    count = count + 1
print "The file contains", count, "lines."
```

- **Exercise:** Write a program to process a file of DNA text, such as:
  `ATGCAATTGCTCGATTAG`
  - Count the percent of C+G present in the DNA.



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Graphics

DrawingPanel

- To create a window, create a `drawingpanel` and its graphical pen, which we'll call `g` :

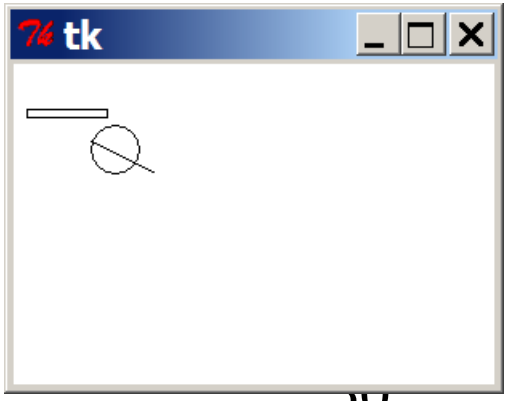
```
from drawingpanel import *
panel = drawingpanel(width, height)
g = panel.get_graphics()
```

... (draw shapes here) ...

```
panel.mainloop()
```

- The window has nothing on it, but we can draw shapes and lines on it by sending commands to `g` .
  - Example:

```
g.create_rectangle(10, 30, 60, 35)
g.create_oval(80, 40, 50, 70)
g.create_line(50, 50, 90, 70)
```



Graphical commands

Command	Description
`g.create_line(`***x1***, ***y1***, ***x2***, ***y2***`)`	a line between (***x1***, ***y1***), (***x2***, ***y2***)
`g.create_oval(`***x1***, ***y1***, ***x2***, ***y2***`)`	the largest oval that fits in a box with top-left corner at (***x1***, ***y1***) and bottom-left corner at (***x2***, ***y2***)
`g.create_rectangle(`***x1***, ***y1***, ***x2***, ***y2***`)`	the rectangle with top-left corner at (***x1***, ***y1***), bottom-left at (***x2***, ***y2***)
`g.create_text(`***x***, ***y***, `text="`***text***`")`	the given ***text*** at (***x***, ***y***)

- The above commands can accept optional outline and fill colors.

```
g.create_rectangle(10, 40, 22, 65, fill="red",
  outline="blue")
```

- The coordinate system is y-inverted:

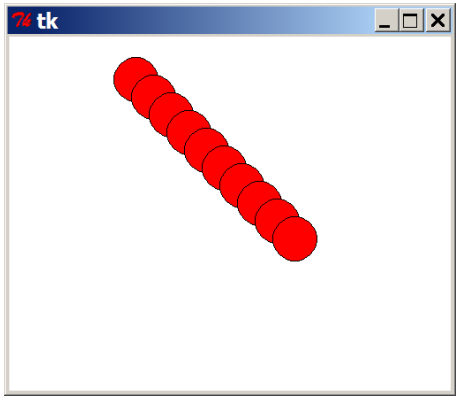
```
(0, 0)
```

```
(200, 100)
```

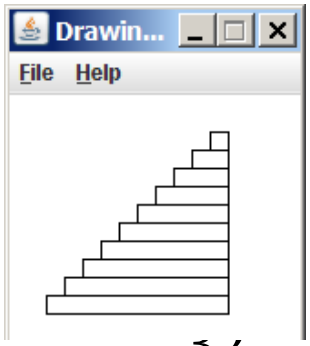
Drawing with loops

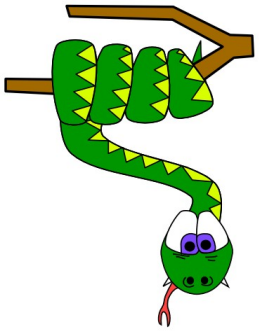
- We can draw many repetitions of the same item at different x/y positions with `for` loops.
  - The x or y assignment expression contains the loop counter, `i`, so that in each pass of the loop, when `i` changes, so does x or y.

```
from drawingpanel import *

window = drawingpanel(500, 400)
g = window.get_graphics()

for i in range(1, 11):
    x = 100 + 20 * i
    y = 5 + 20 * i
    g.create_oval(x, y, x + 50, y + 50, fill="red")

window.mainloop()
```



- **Exercise:** Draw the figure at right.





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What's Next?

Further programming

- Lab exercises
  - Let's go downstairs to the basement computer labs!
  - All resources are available at the following URL:
    - http://faculty.washington.edu/stepp/cs4hs/

- What next?
  - Arrays, data structures
  - Algorithms: searching, sorting, recursion, etc.
  - Objects and object-oriented programming
  - Graphical user interfaces, event-driven programming