Thonny Shell & Program Window

ECE 476 Advanced Embedded Systems

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Please visit Bison Academy for corresponding
lecture notes, homework sets, and solutions

Introduction:

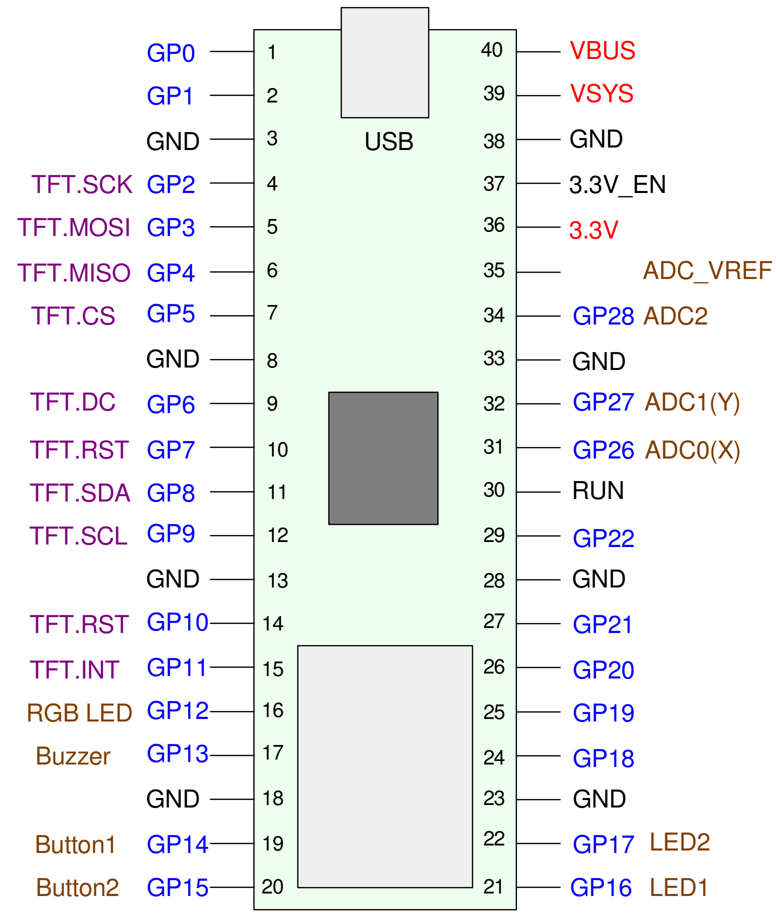
The Raspberry Pi-Pico is a microcontroller version of the Raspberry Pi

It can be programmed in

- Assembler
- C
- Python
- Other...

In ECE 476, we'll be using MicroPython

- A subset of Python
- Designed for microcontrollers

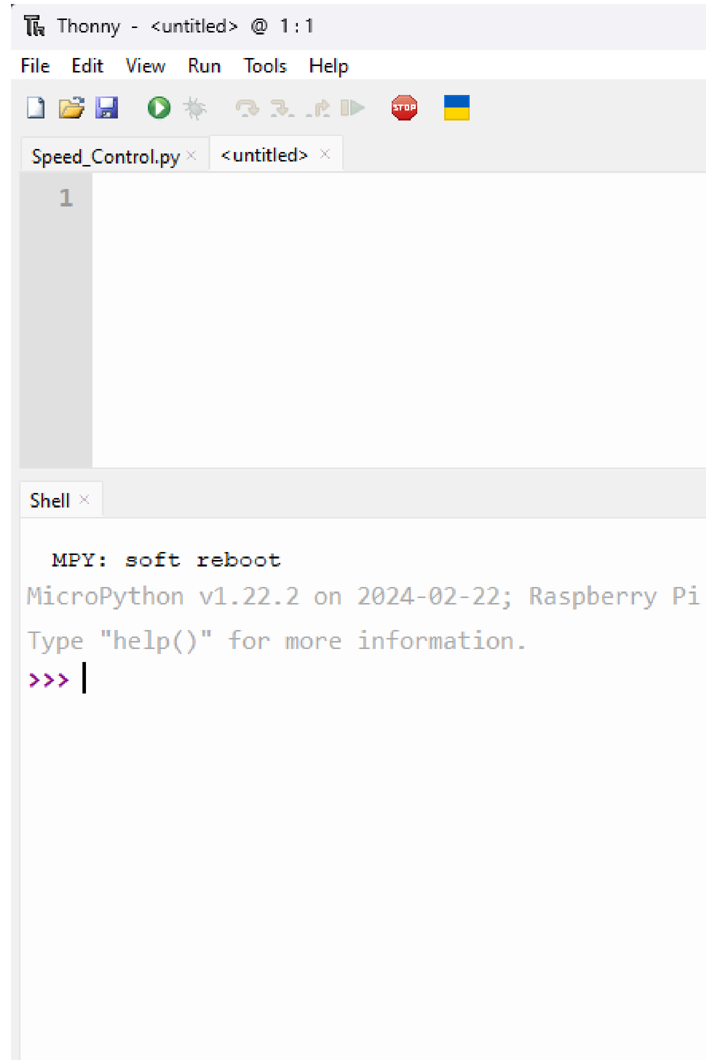


Thonny, MicroPython, & Matlab

MicroPython is similar to Matlab

- Can be used as a calculator
- Works with complex numbers
- Has similar syntax
- Has windows (program, command)
- Is a programming language

This lecture goes over using MicroPython in this fashion

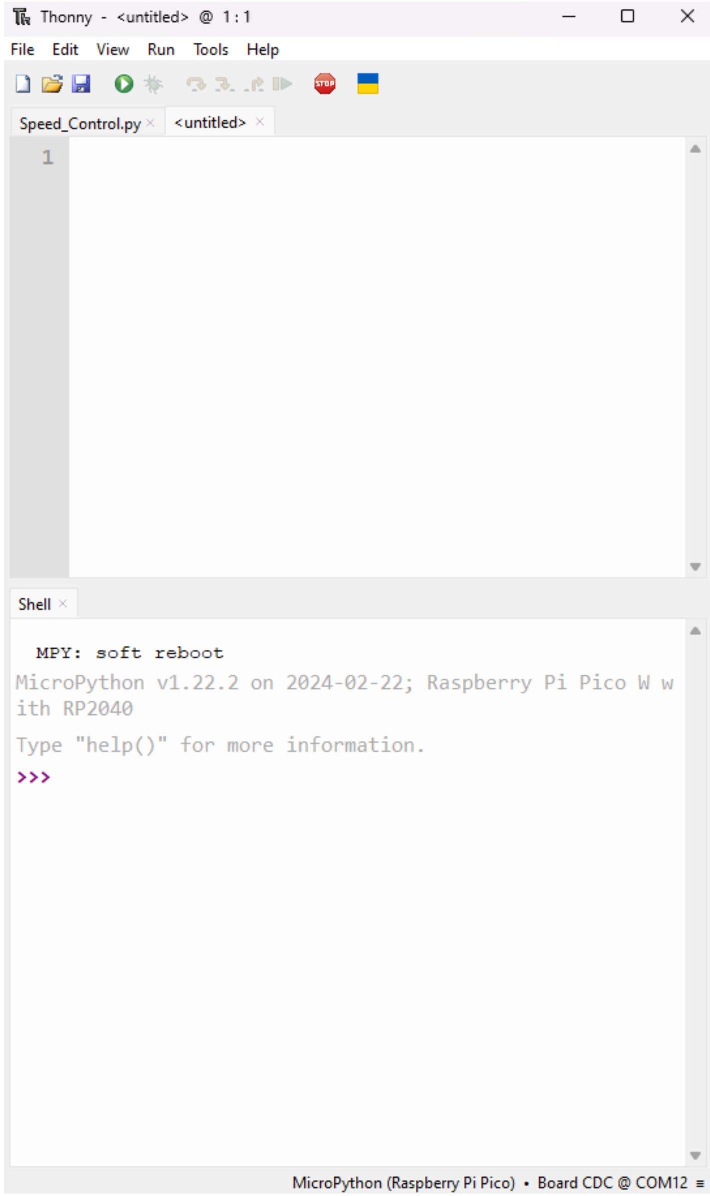


Installing Thonny

- Locate Thonny 4.1.4
- Download to PC
- Connect to Pico board
- Install Micropython

Click on the lower-right corner

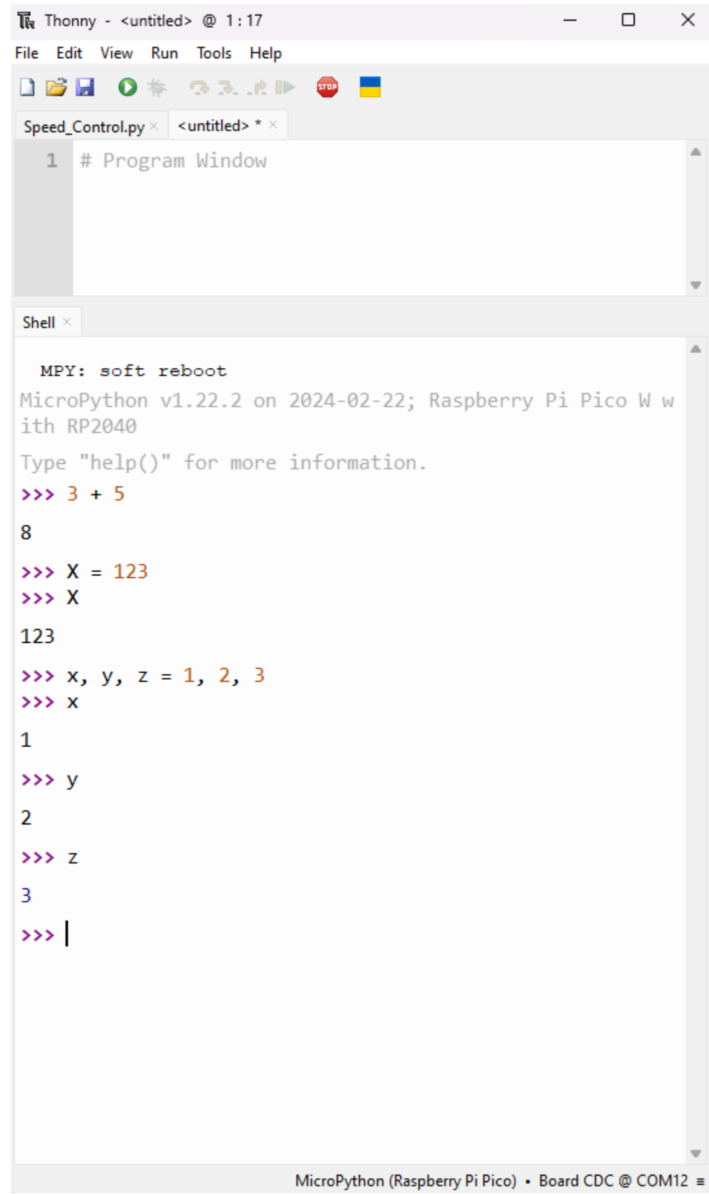
- Select your Pi-Pico chip
- It will prompt you to install MicroPython if this is the first time using your chip



Thonny: Command Window

Once Thonny is installed and you're connected to your Pico chip, you're ready to start running Python code. Thonny looks very much like Matlab:

- There is a script window (top window) where you can write and run programs.
- There is command window (shell) where you can type in code directly and see the result



Python is an interpretive language.

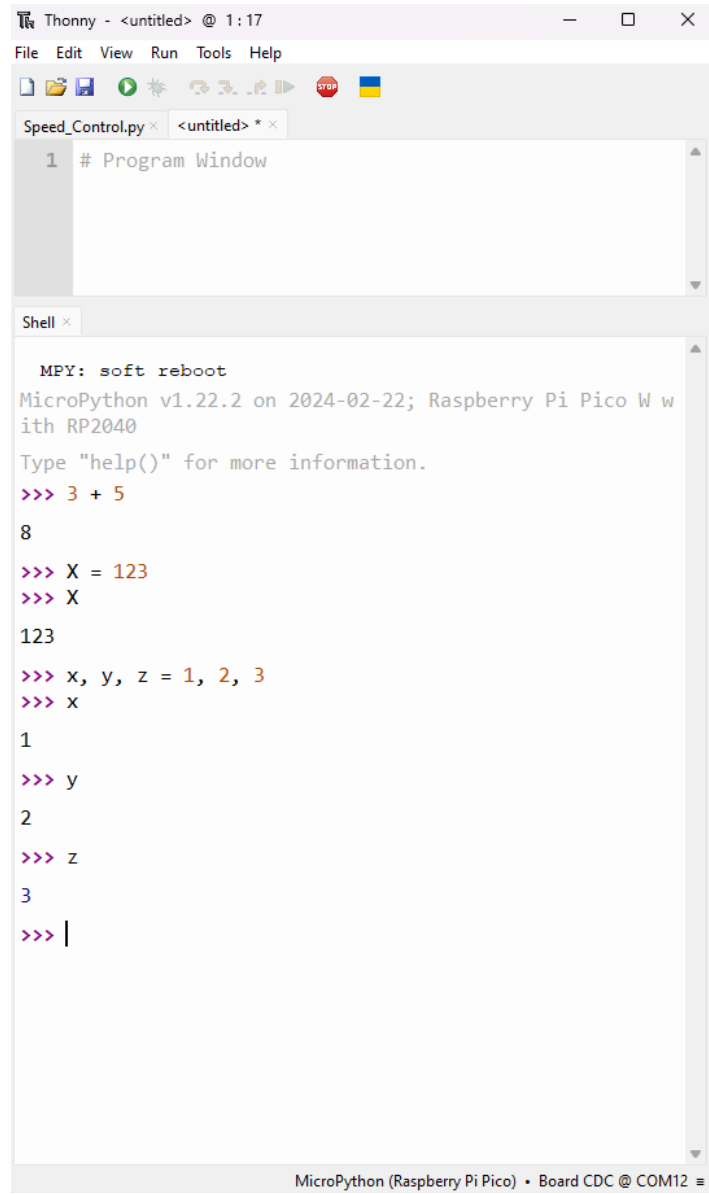
- Similar to Matlab
- Each line of code is executed as you type
- Allows you to see each result

Python is slower than C code.

- C is 3-10x slower than assembler
- Python is 3-10x slower than C

In return, you get a language which is

- Easier to use,
- Easier to modify, and
- Easier to build upon.



What language is best?

It depends.

- If you really need speed and size, use assembler.
- If speed, number crunching, and reusable code is needed, use C
- If incorporating features such as graphics displays, touch-screens, web interfaces, etc. are needed, use Python.

In short, programming languages are tools.

- If the tool helps you do your job, use it.
- If the tool makes your life hard, don't use it.

Thonny & Shell Window

- Command Window in Matlab-Speak

You can type commands in the shell.

Python act like a calculator, very much like Matlab

At the command line you can do calculations such as

```
>>> 3 + 5
8

>>>(2 + 3)*(7 + 8)
75

>>>1/(1/50 + 1/60 + 1/70)
19.6262
```

Variable Names in Python

Variables are valid in Python

To be valid

- The first character must be a letter or an underscore (_)
- The following characters can *only* be letters, underscores, or digits

`>>> Pi.Value = 3.14159`	*invalid decimal points are not allowed*
`>>> Pi Value = 3.14159`	*invalid spaces are not allowed*
`>>> Pi_Value = 3.14159`	*valid variable name*

Case Sensitivity

MicroPython is case sensitive.

The following code creates two different variables

```
>>> Name = 'Jake'
>>> name = 'Bill'
```

You *cannot* use the following words as variable names

```
and, as, assert, break, class, continue, def
del, elif, else, except, finally, for, from, global
if, import, in, is, lambda, nonlocal, not, or, pass,
 raise, return, try, while, with, yield, False, None, True
```

MicroPython Syntax

Assigning values to variables:

```
X = 123              decimal 123
X = 0x123            hex 123
x, y, z = 1, 2, 3
X = [1,2,3,4,5]    matrix or array
X = range(1,6)       same matrix
X = [[1,2],[3,4]]    2x2 matrix
```

Operations

```
+    add
-    subtract
*    multiply
/    divide (result is usually a float)
//   divide and round down (result is integer)
%    modulus (remainder)
**   raise to the power

X.append(6)   append 6 to the end of array X
```

Logic Operations

```
&    logical AND (bitwise)
|    logical OR (bitwise)
^    logical XOR (bitwise)
>>   shift right
<<   shift left
```

comment statement

```
# this is a comment statement
```

Conditionals:

```
X > Y
X < Y
X >= Y
X == Y
X != Y
```

Converting variable types:

```
int(X)    convert to an integer, round down
round(X)  round to nearest integer
float(X)  convert to a floating point number
```

Declaring Variables:

Python allows you to create new variables on the fly

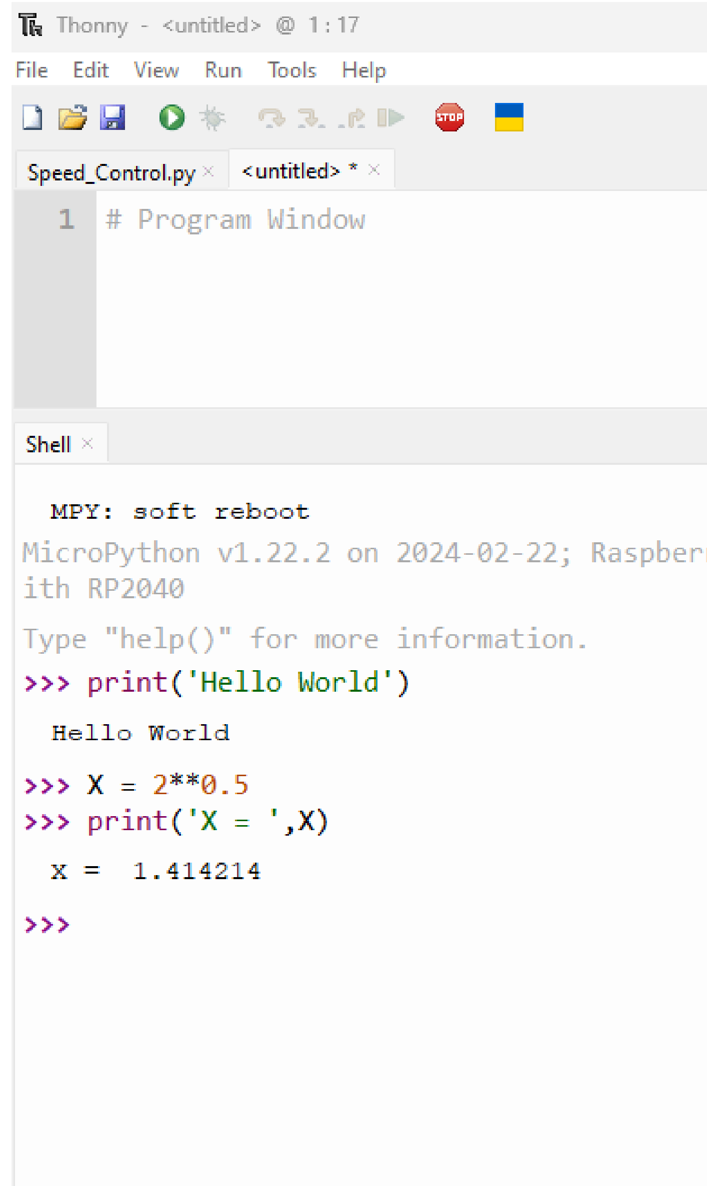
- You don't have to declare all of your variables at the start of a program

Python automatically adjusts variable types

```
>>> X = 3             X is automatically treated like an integer

>>> Y = 4             Y is automatically treated like an integer

>>> Z = X/Y           Z becomes a float  (0.75)

>>> Z = X//Y          Z is an integer (0)
```

print() Information can be sent to the shell window using a *print()* statement

```
>>> print('Hello World')
Hello World

>>> X = 2**0.5
>>> print('X = ',X)
X =  1.414214
```



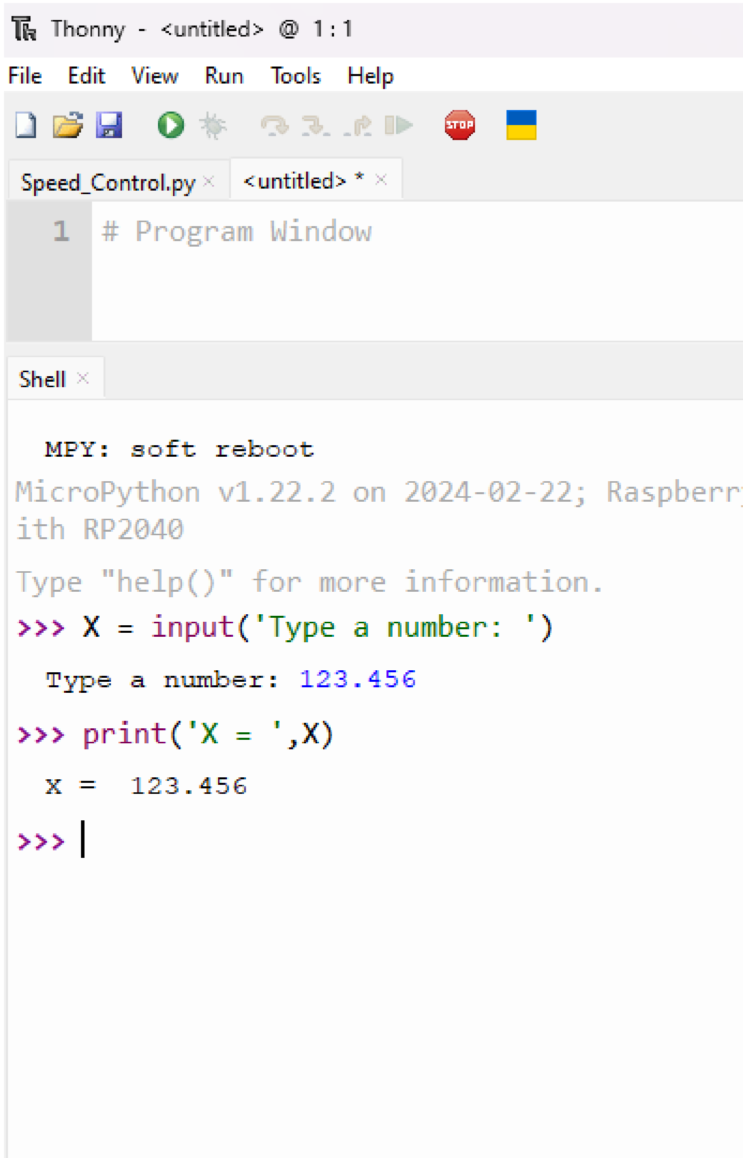
X = input()

- Prompts user for an input

Pythons interprits this as a string

- Convert to an integer or float

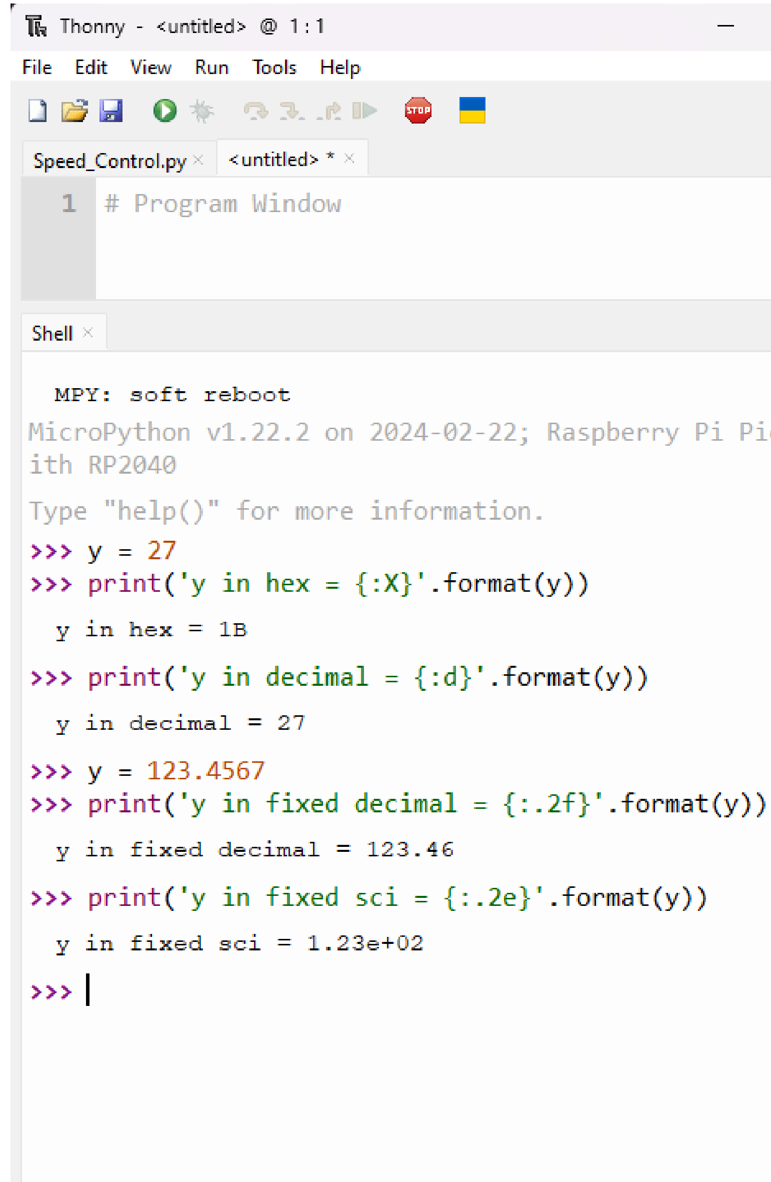
```
X = int( input('Type in a number') )

X = float( input('Type in a number') )
```



Formatting Output

Makes output prettier

- X hexadecimal
- d decimal
- 2f two fixed decimal places
- 2e two decimal in scientific notation

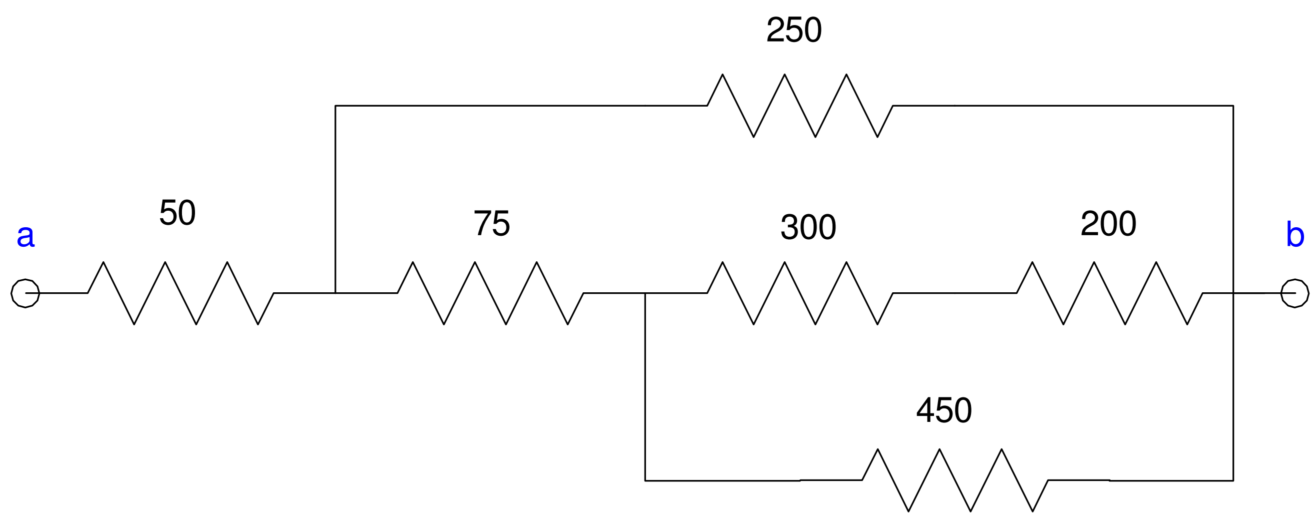


Command Window & Scripts Examples

Like Matlab, MicoPython can be used like a calculator.

Example 1: Find the resistance Rab:

- Resistors add in series as $R_s = R_1 + R_2$
- Resistors in parallel as $R_p = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$

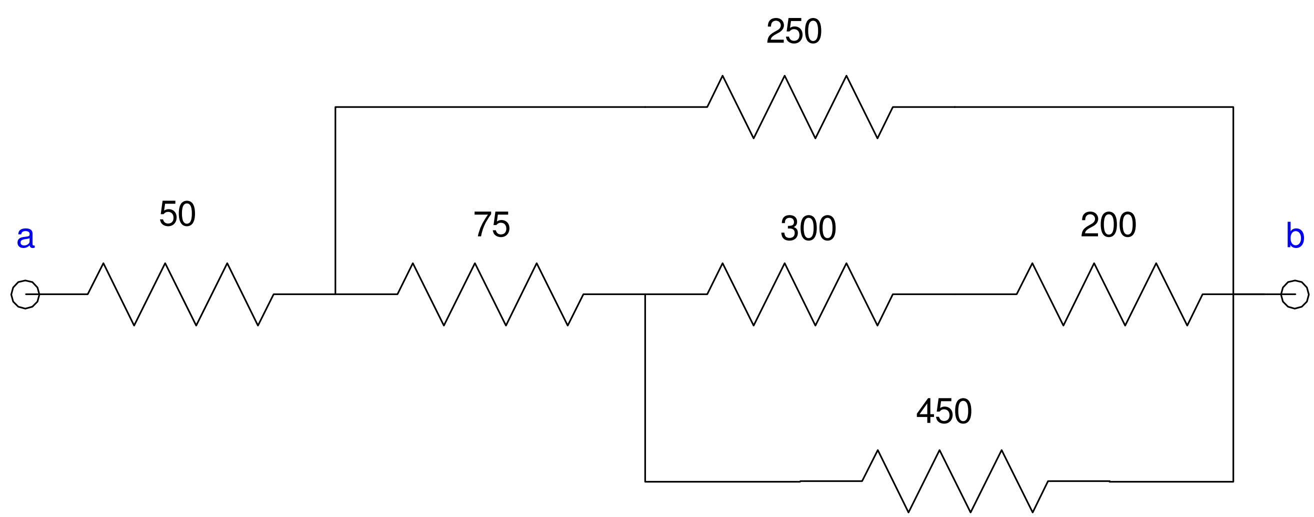


Example, the 200 Ohm and 300 Ohm are in series

$$R_{net} = 200 + 300 = 500\Omega$$

This is in parallel with 450 Ohms

$$450||500 = \left(\frac{1}{450} + \frac{1}{500}\right)^{-1} = 236.84\Omega$$

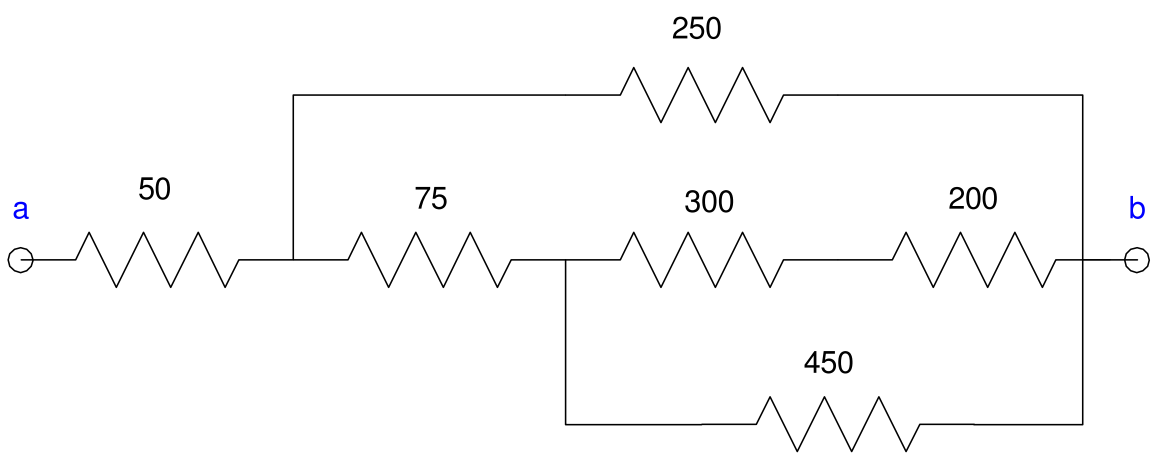


In the shell window, you can solve for Rab:


```
# program window
```

Shell Window

```
>>> R1 = 200 + 300
>>> R2 = 1 / (1/R1 + 1/450)
>>> R3 = R2 + 75
>>> R4 = 1 / (1/R3 + 1/250)
>>> Rab = 50 + R4
>>> Rab

188.7588
```



Python Programs:

- Place the code in the program window (top)
- Allows you to run the program over and over


```
R = float(input('Value of R = '))
R1 = 200 + R
R2 = 1 / (1/R1 + 1/450)
R3 = R2 + 75
R4 = 1 / (1/R3 + 1/250)
R5 = 50 + R4
print('Rab = ',R5)
```

Shell Window

```
>>>
```

Hit the *run* icon to execute the program

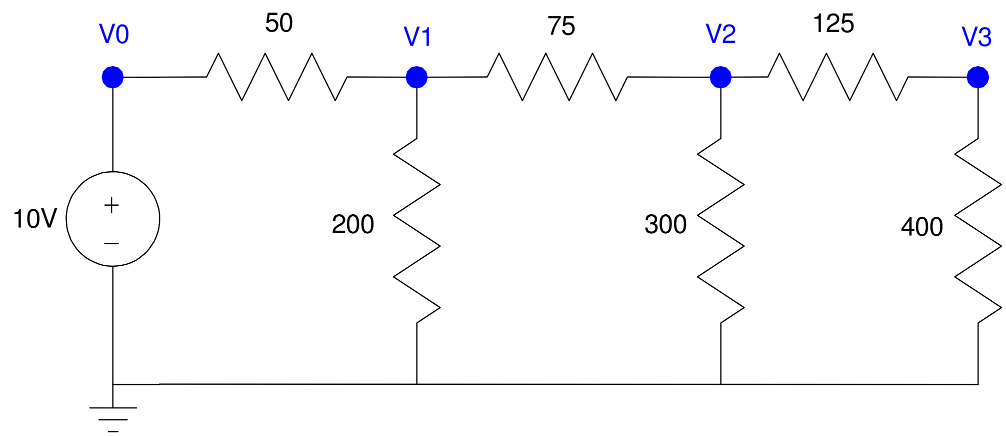
- Prompts you for an input in the shell window
- The program computes and displays Rab
- Presssing *run* repeats the process


```
R = float(input('Value of R = '))
R1 = 200 + R
R2 = 1 / (1/R1 + 1/450)
R3 = R2 + 75
R4 = 1 / (1/R3 + 1/250)
R5 = 50 + R4
print('Rab = ',R5)
```

Shell Window

```
>>>
Value of R = 300
Rab =  188.7588

Value of R = 123.45
Rab =  178.2118
```

Example 2: As a second example, compute the voltages {V1, V2, V3} using voltage division:



From Circuits I

$$V_3 = \left(\frac{400}{400+125}\right) V_2$$

$$V_2 = \left(\frac{R_{20}}{R_{20}+75}\right) V_1$$

$$V_1 = \left(\frac{R_{10}}{R_{10}+50}\right) V_0$$

R20 is the resistance at node 2 to ground looking right

$$R_{20} = 300 || (400+125)$$

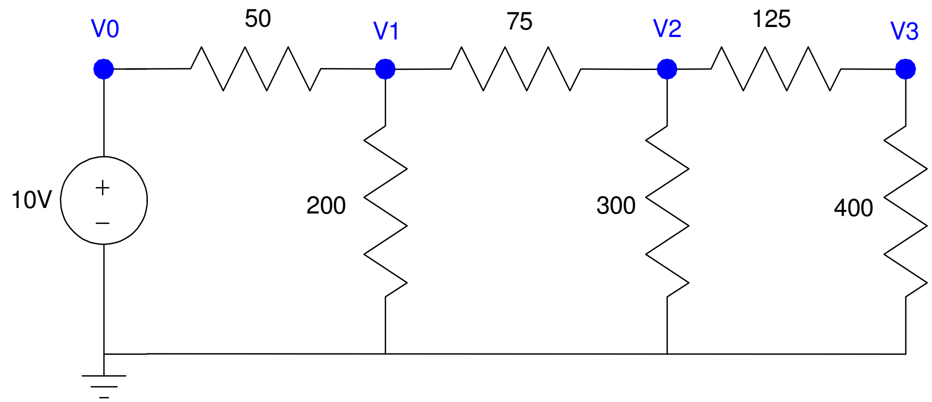
R10 is the resistance at node 1 to ground looking right

$$R_{10} = 200 || (75+R_{20})$$

From the Shell (lower window):

Shell Window

```
>>> # Finding voltages using votlage division
>>> R20 = 1 / (1/300 + 1/525)
>>> R10 = 1 / (1/200 + 1/(75+R23))
>>> V1 = R10 / (R10 + 50)*10
>>> V2 = R20 / (R20 + 75) * V1
>>> V3 = 400 / (400 + 125) * V2
>>> print(V1,V2,V3)

6.953938 4.992571 3.803864
```



Place the instructions in the program window

- Lets you run over and over again


```
R30 = int(input('Value of R30 = '))
R20 = 1 / (1/300 + 1/(125 + R30))
R10 = 1 / (1/200 + 1/(75+R20))
V1 = R10 / (R10 + 50)*10
V2 = R20 / (R20 + 75) * V1
V3 = 400 / (400 + 125) * V2
print('V1 = ', V1)
print(' V2 = ', V2)
print(' V3 = ', V3)
```

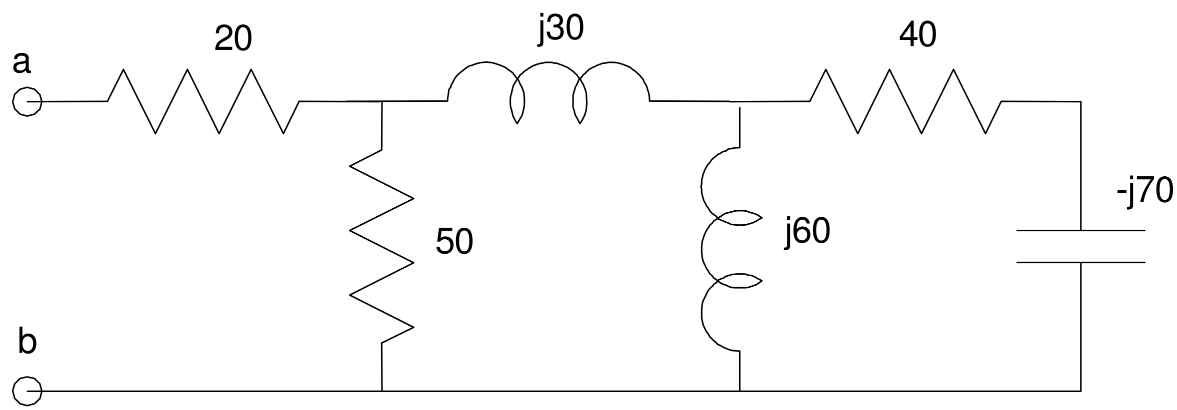
Shell Window

```
>>>
Value of R30 = 400
V1 =    6.9539
V2 =   4.9926
V3 =   3.8039

Value of R30 = 123.45
V1 = 6.7246
V2 = 4.3332
V3 = 3.3015
```

Example 3: Complex Numbers Impedance.

Thonny can also handle complex numbers similar to Matlab.

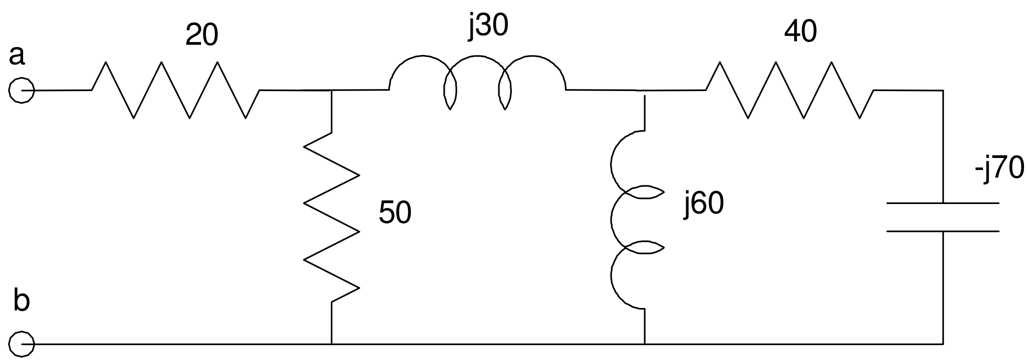
For example, find the impedance Zab:



In the Shell window:

Shell Window

```
>>> j = (-1) ** 0.5
>>> Z3 = - j*70
>>> Z2 = 1 / ( 1/(j*60) + 1/(40 + Z3))
>>> Z1 = 1 / ( 1/50 + 1 / (j*30 + Z2))
>>> Z0 = 20 + Z1
>>> print('Zab = ',Z0)

Zab =  (58.96067+9.111071j)
```



In the Program Window:

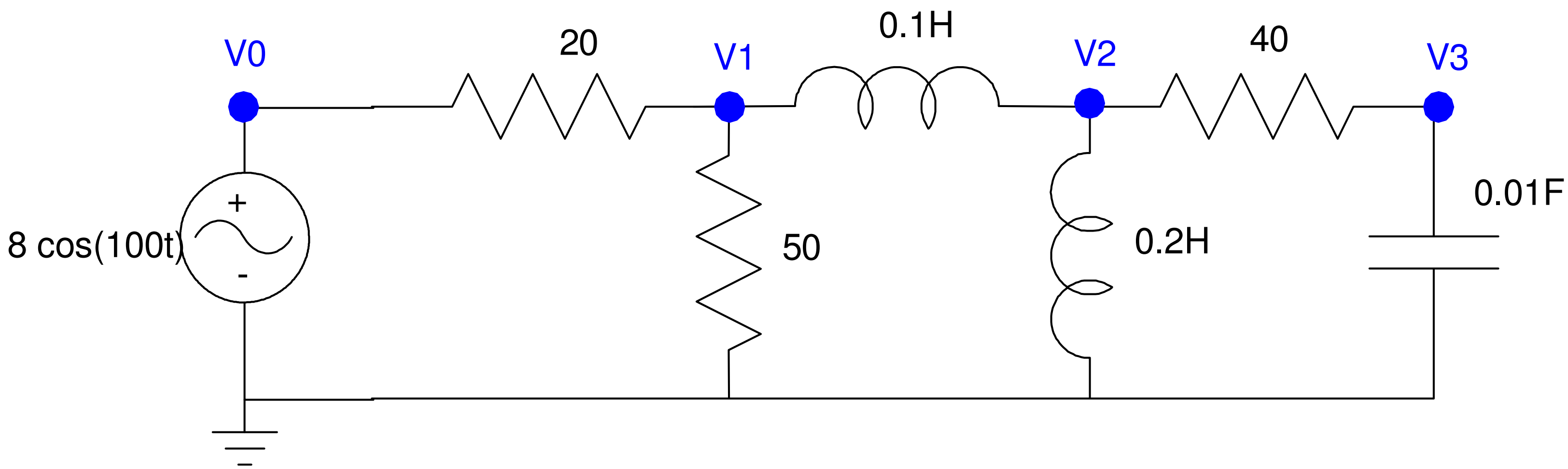

```
j = (-1) ** 0.5
X = float(input('Impedance of C3: -j'))
Z3 = -j*X
Z2 = 1 / ( 1/(j*60) + 1/(40 + Z3))
Z1 = 1 / ( 1/50 + 1 / (j*30 + Z2))
Z0 = 20 + Z1
print('Zab = ',Z0)
```

Shell Window

```
>>>
Impedance of C3: -j70
Zab =  (58.96067+9.111071j)

Impedance of C3: -j45.678
Zab =  (54.26275+7.450337j)
```

Example 4: Finally, this also works with voltage division.

Find {V1, V2, and V3} using MicroPython:



Recall from Circuits I, the AC impedance of inductors, resistors, and capacitors are:

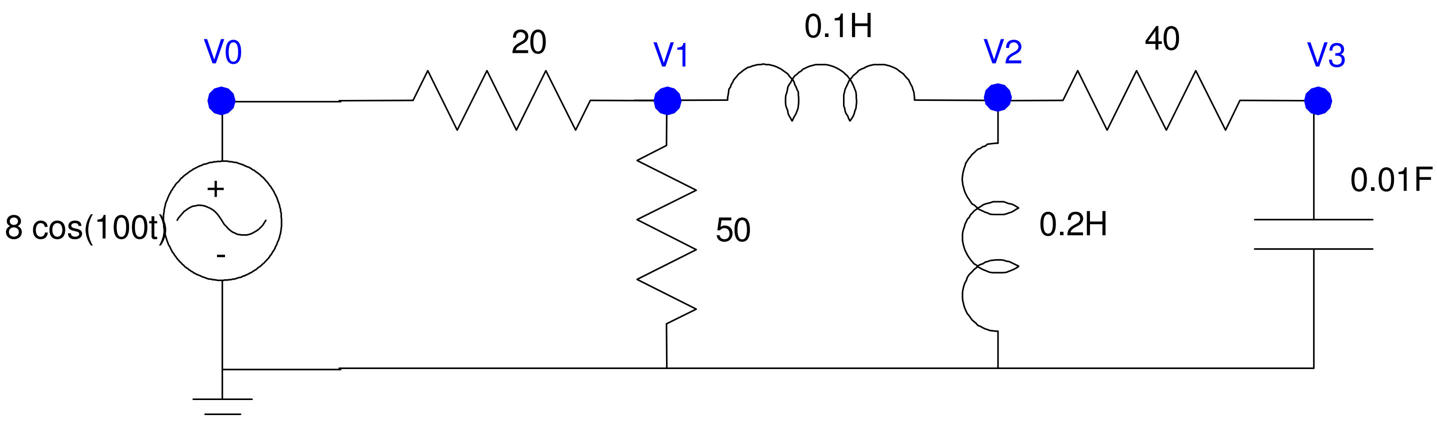
$$R \rightarrow R$$

$$L \rightarrow j\omega L$$

$$C \rightarrow \frac{1}{j\omega C}$$

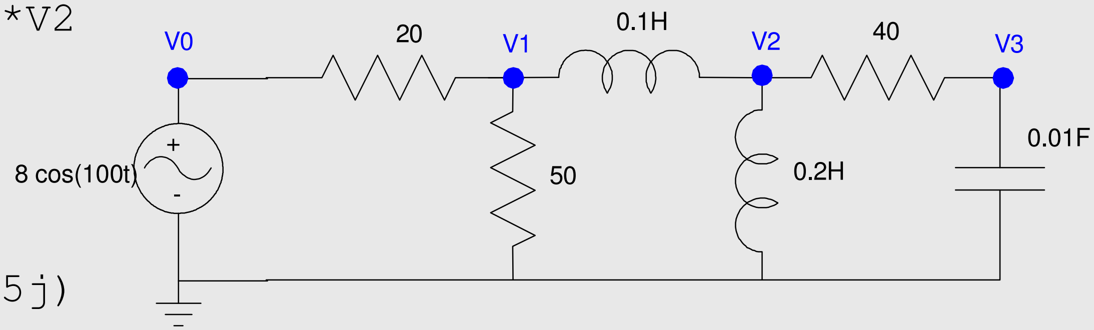
and voltages convert as

$$V = a\cos(\omega t) + b\sin(\omega t) \rightarrow a - jb$$



In the Shell window:

```
>>> w = 100
>>> Z30 = 1 / (j*w*0.01)
>>> Z20 = j*w*0.2
>>> Z12 = j*w*0.1
>>> Z3 = Z30
>>> Z2 = 1 / (1/Z20 + 1/(40 + Z30))
>>> Z1 = 1 / (1/50 + 1/(Z12 + Z20))
>>> V0 = 8 + j*0
>>> V1 = Z1 / (20 + Z1)*V0
>>> V2 = Z2 / (Z12 + Z2)*V1
>>> V3 = Z3 / (40 + Z3)*V2

>>> print('V0 = ',V0)
V0 =  (8+0j)

>>> print('V1 = ',V1)
V1 =  (4.658041+2.218115j)

>>> print('V2 = ',V2)
V2 =  (3.27509+0.937138j)

>>> print('V3 = ',V3)
V3 =  (0.02545947-0.08124077j)
```



You can also place this in the program window and run it as a program:


```
C3 = float(input('Value of C3 (F) = '))
w = 100
Z30 = 1 / (j*w*C3)
Z20 = j*w*0.2
Z12 = j*w*0.1
Z3 = Z30
Z2 = 1 / (1/Z20 + 1/(40 + Z30))
Z1 = 1 / (1/50 + 1/(Z12 + Z20))
V0 = 8 + j*0
V1 = Z1 / (20 + Z1)*V0
V2 = Z2 / (Z12 + Z2)*V1
V3 = Z3 / (40 + Z3)*V2
print('V0 = ',V0)
print('V1 = ',V1)
print('V2 = ',V2)
print('V3 = ',V3)
```

Shell Window

```
Value of C3 (F) = 0.01
V0 =  (8+0j)
V1 =  (4.658041+2.218115j)
V2 =  (3.27509+0.937138j)
V3 =  (0.02545947-0.08124077j)
```

Differences Between Matlab and MicroPython

Matlab and MicroPython are different

- Matlab was written for engineers and scientists
- MicroPython was written for the general public

More specifically:

- Matlab is a matrix language
- MicroPython is not

Example:

- Matlab treats variables as matrices
- Python treats them as strings

Matlab Command Window

```
>> A = [1,2;3,4]
A =
     1    2
     3    4

>> B = 2 * A
B =
     2    4
     6    8

>> C = A*A
C =
     7   10
    15   22
```

Thonny Shell

```
>>> A = 'Hello'
>>> A
'Hello'

>>> B = 2*A
'HelloHello'

>>> A = [1, 2]
>>> A
[1, 2]

>>> B = 2*A
>>> B
[1, 2, 1, 2]

>>> C = A*A
Error - unsupported file type
```

Summary:

Thonny is very similar to Matlab

- You can use the Shell window like the command window in Matlab. It behaves like a calculator, typing in code and seeing the result after each instruction.
- You can use the program window like the script window in Matlab. Once code is written, you can execute the program