EP305 Computer Physics

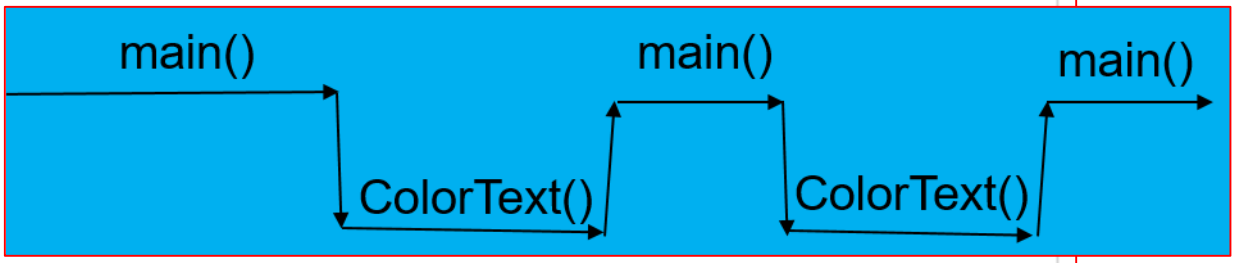
Laboratory 5

Objectives for 5th laboratory

- Getting information on functions available in numpy
- User defined functions – parameter passing
- Simple examples and structure of a user-defined function
- Local versus global variables
- Activity - write a number of programs that makes use of a user defined functions
  - to calculate the surface area of a cylinder, a cone, etc.
  - to convert polar to Cartesian coordinates & vice versa
  - to convert decimal degrees to deg, min, sec
- Homework – calculate the roots of a quadratic equation using two user-defined functions.
- Preparation for Homework to be submitted through Moodle

Example of a user-defined function

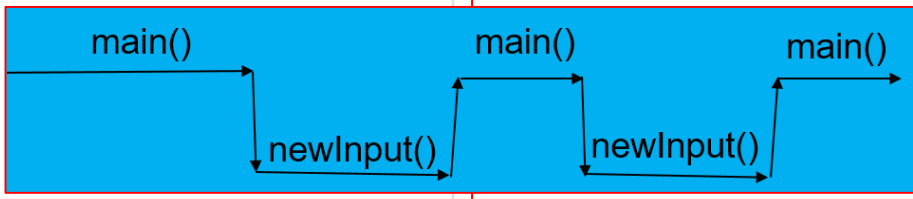
```
7   #------------------------------ ColorText() -------------------------------#
8   def ColorText(text, color):
9       CEND      = '\033[0m'
10      CBOLD     = '\033[1m'
11      CBLACK    = '\033[0m'
12      CRED      = '\033[31m'
13      CGREEN    = '\033[32m'
14      CYELLOW   = '\033[33m'
15      CBLUE     = '\033[34m'
16      CVIOLET   = '\033[35m'
17      CBEIGE    = '\033[36m'
18      if color == 'red':
19          return CRED + CBOLD + text + CEND
20      elif color == 'green':
21          return CGREEN + CBOLD + text + CEND
22      elif color == 'yellow':
23          return CYELLOW + text + CEND
24      elif color == 'blue':
25          return CBLUE + text + CEND
26      elif color == 'voilet':
27          return CVIOLET + text + CEND
28      elif color == 'beige':
29          return CBEIGE + text + CEND
30      else:
31          return CBLACK + text + CEND
32
33  #------------------------- main program starts here ------------------------#
34  print('\n') # skip a line
35
36  colour = 'red'
37  message = 'This is red'
38  print(ColorText(message, colour))
39
```



This line calls the function ColorText()

Another example of a user-defined function

```
1   # -*- coding: utf-8 -*-
2   """
3   Created on Tue Feb 19 18:12:41 2019
4
5   @author: Joe Bloggs (Python 3.6)
6
7   Description: for_loop_2 example: calculates values
8                function in n equally spaced steps in
9   """
10
11  import numpy as np   # needed for pi, sin(), cos()
12
13  # --------------------------- Handling exceptions ---------------------------#
14  # Handling exceptions
15  def newInput(message):
16      num = input(message)
17      try:  # attempt to parse the number as an integer
18          num = int(num)
19          return num
20      except ValueError:
21          print(CRED + CBOLD + 'You did not enter an integer!  \
22  Please try again' + CEND)
23          print('\a') # make a beep
24          return newInput(message)
25  # ------------------------ end Handling exceptions ---------------------------#
26
27  #-------------------------- main program starts here -------------------------
28  # inform the user what is happening
29  print('\nThis programme calculates values of the sine() and cosine() function \
30  in n equally spaced steps in the range [0, 2*pi].  \
31  n is a user entered integer value')
```



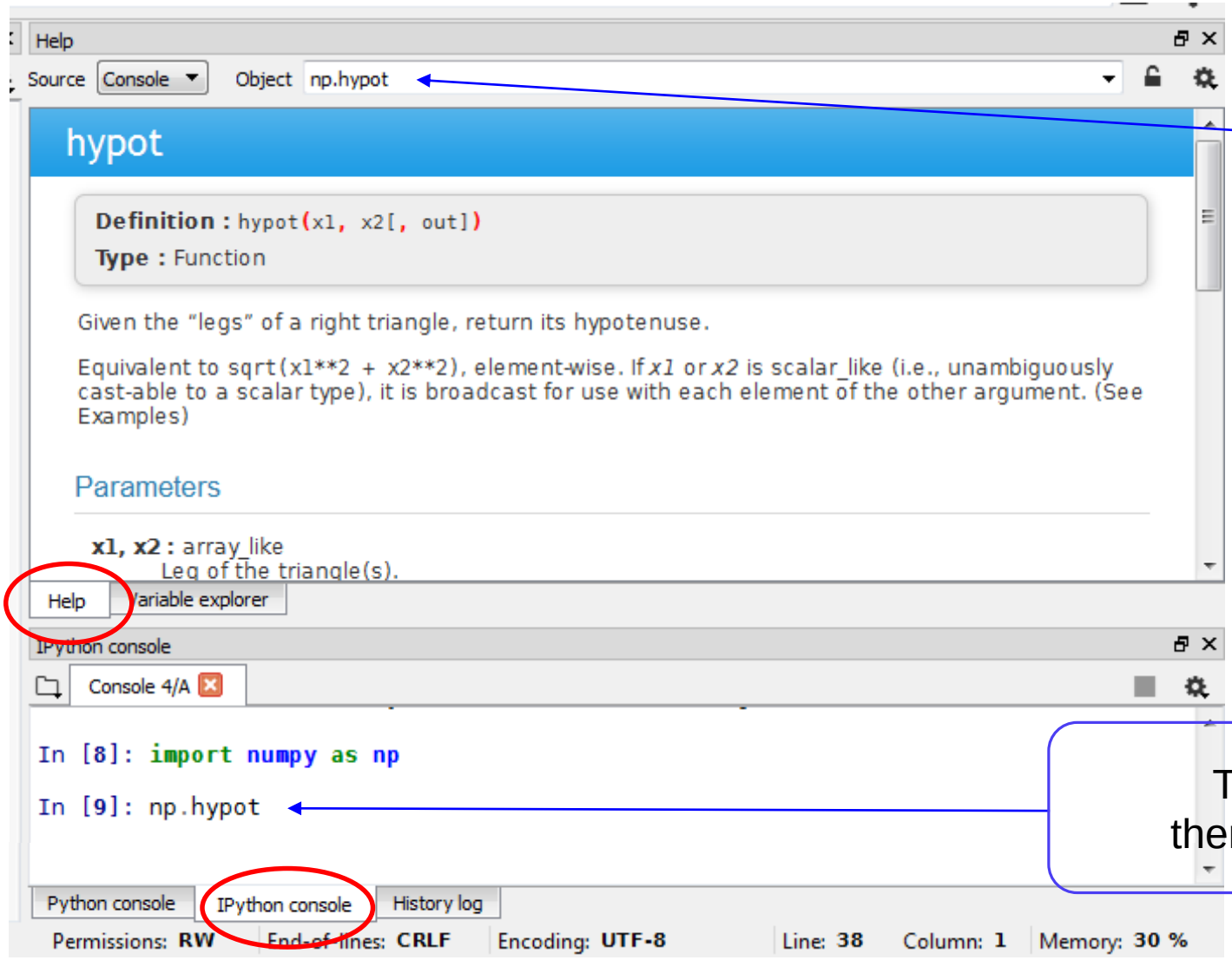

```
38  # Prompt the user to enter the number of intervals required
39  message = 'Please enter an INTEGER value n (e.g. 12) : '
40  n = newInput(message)  # validate the input
41
```

This line calls the function newInput()

Checking available functions in Numpy 2

Let us have a look at the function `np.hypot()`

In the `IPython console` window, type `np.hypot` then type `<Cntrl-I>`



The `Help` window displays information on the `np.hypot` object if it exists

Type np.hypot then type <Cntrl-I>

User-defined functions

`numpy` provides us with **the function hypot(x, y)**

It **receives** two parameters (x and y) and **returns** a value (sqrt(x**2 + y**2))

As our first example of a user-defined function we will define a function which **receives** two arguments - the radius and height of a cylinder -
and **returns** the volume of the cylinder.

We need a **name** for our function – we will call it **cylinder_volume()**

It will receive two **parameters** – the radius, r, and the height, h.

It will calculate a value equal to $\pi r^2 h$ and it will **return** this value.

defining and calling user defined functions

A Python function is a set of statements that are grouped together and named so that they can be run more than once in a program

Advantages:

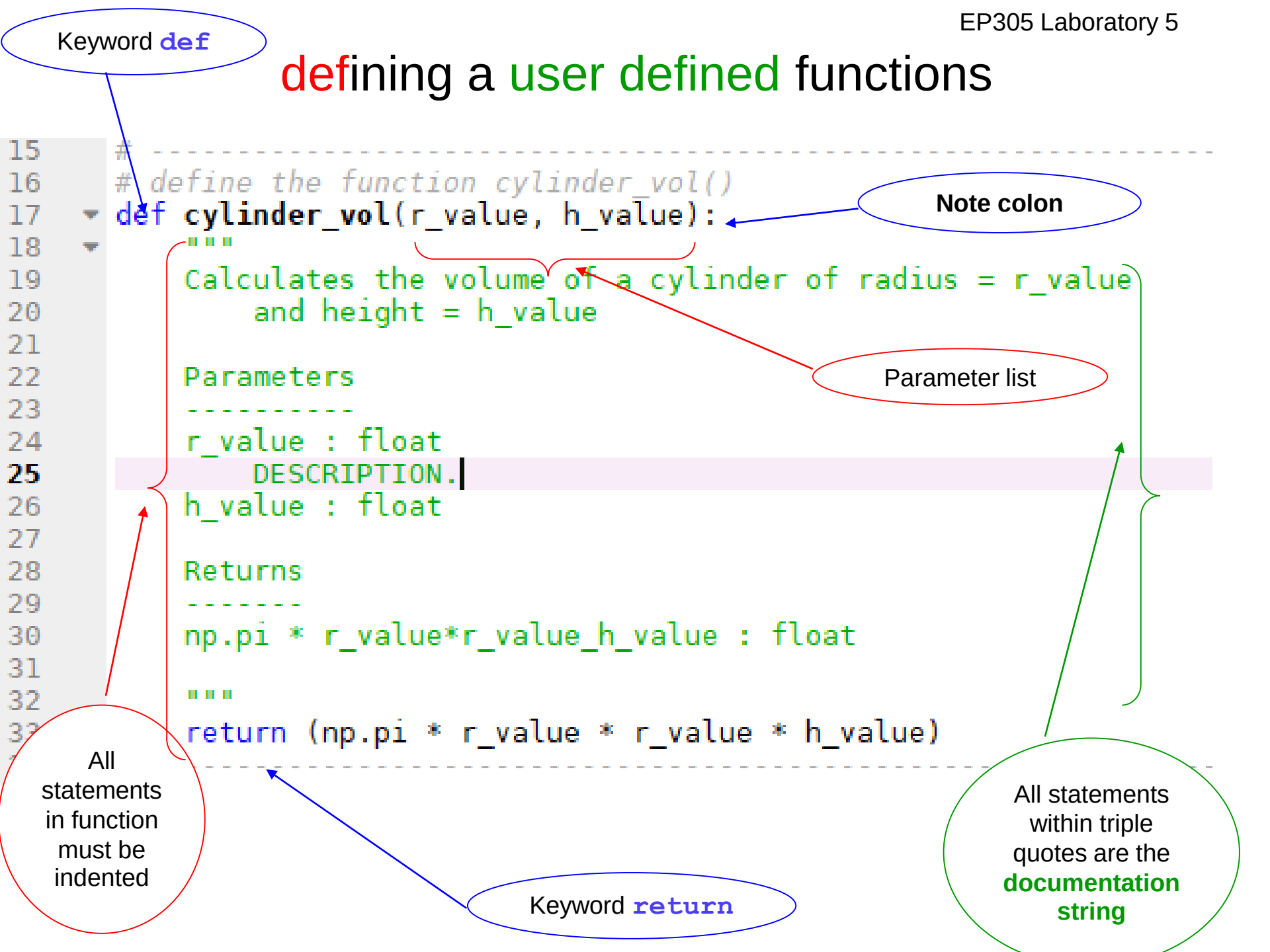
- They enable code to be reused without having to be replicated in different parts of the program;
- They enable complex tasks to be broken into separate parts with each implemented by its own function.

The def statement defines a function, gives it a name and lists the arguments (if any) that the function expects to receive when called.

A function must be defined before it can be called.

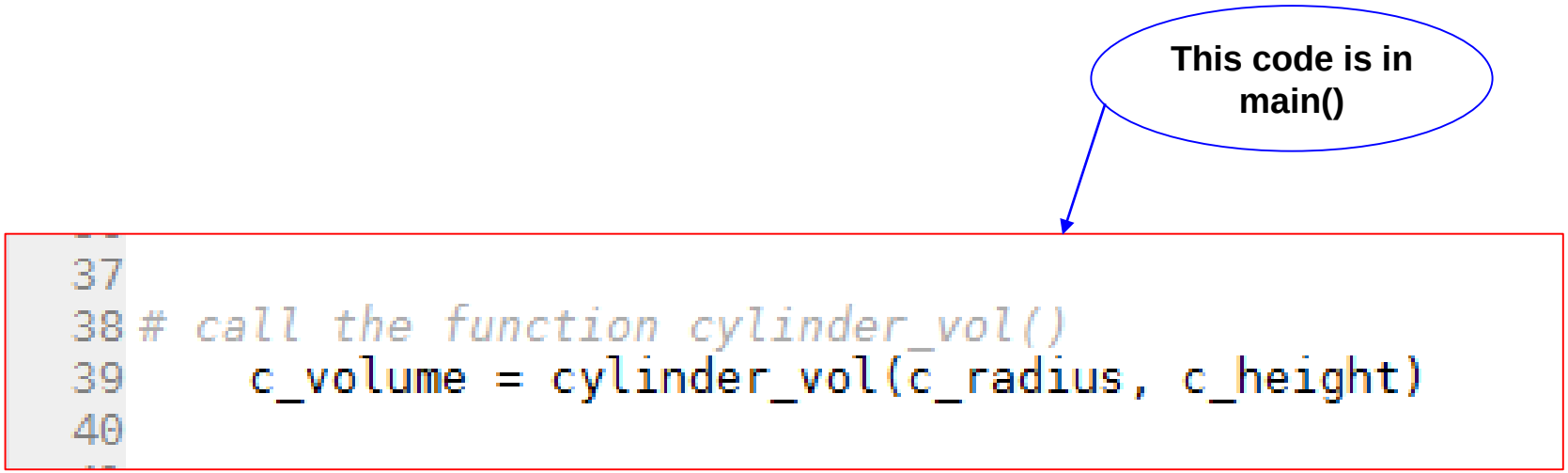
We generally declare a function **before** main() – its **scope** is then **global** – every other function, including **main()**, knows about it.

defining a user defined functions




```
15  # ------------------------------------------------------------------
16  # define the function cylinder_vol()
17  def cylinder_vol(r_value, h_value):
18      """
19      Calculates the volume of a cylinder of radius = r_value
20          and height = h_value
21
22      Parameters
23      ----------
24      r_value : float
25          DESCRIPTION.
26      h_value : float
27
28      Returns
29      -------
30      np.pi * r_value*r_value_h_value : float
31
32      """
33      return (np.pi * r_value * r_value * h_value)
    ------------------------------------------------------------------
```

Structure of function call



1. Call the function (by its name);
2. pass the variables (`c_radius` and `c_height`) to it;
3. Assign the result to the variable `c_volume`
4. The name and variables (`c_radius` , and `c_height and c_volume`) **must correspond exactly** with the function definition

cylinder_volume() function example

```
# -*- coding: utf-8 -*-
"""
Created on Tue Feb 19 18:12:41 2019

@author: Frank Mulligan (Python 3.6)

Description: returns the volume of a cylinder given its radius and height
"""

# This programme calculates the volume of a cylinder given the radius
# and length of the cylinder

import numpy as np   # needed for pi

#-------------------------------------------------------------------------#
# define the function cylinder_vol()
def cylinder_vol(r_value, h_value):
    return (np.pi * r_value * r_value * h_value)
#-------------------------------------------------------------------------#

# main program starts here

# inform the user what is happening
print('\nThis programme calculates the volume of a cylinder of radius, r, \
and height, h.   \
\nIt uses a USER DEFINED function')

ans = 'Y' # use the program at least once
while ans == 'Y':
# prompt the user for the radius
    c_radius = float(input('\nEnter the radius of the cylinder in meters \
(e.g., 2.1) : '))
# and the height
    c_height = float(input('Enter the height of the cylinder in meters \
(e.g., 3.4) : '))

# call the function cylinder_vol()
    c_volume = cylinder_vol(c_radius, c_height)

# Output the results
    print('\nThe volume of the cylinder is ', \
      '{0:>10.3f}'.format(c_volume), ' meters\xb3')

    ans = input('\nDo you want to try another cylinder (Y/N) ')
```

Note colon

`r_value`, and `h_value` are local variables in cylinder_vol**()**. They are not in scope outside function cylinder_vol()

`c_radius` and `c_height` are local variables in **main()**. **`cylinder_vol()`** does not know about them.

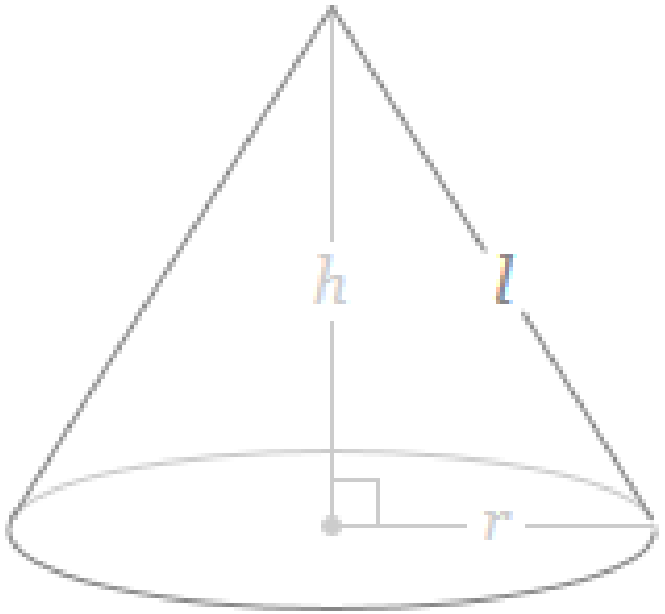
Output of `cylinder_volume.py`

```
In [15]: runfile('C:/Documents Previous computer/fmulligan/Teaching/EP305_FJM/
Python/Python Progs/cylinder_volume.py', wdir='C:/Documents Previous computer/
fmulligan/Teaching/EP305_FJM/Python/Python Progs')

This programme calculates the volume of a cylinder of radius, r, and height, h.
It uses a USER DEFINED function


Enter the radius of the cylinder in meters (e.g., 2.1) : 2.1

Enter the height of the cylinder in meters (e.g., 3.4) : 3.4

The volume of the cylinder is      47.105  meters³


Do you want to try another cylinder (Y/N) N

In [16]:
```

Python console | IPython console | History log

Permissions: **RW** | End-of-lines: **CRLF** | Encoding: **UTF-8** | Line: **33** | Column: **17** | Memory: **31 %**

Area of a cone



$$A = \pi r l + \pi r^2$$

$$l = \sqrt{r^2 + h^2}$$

Lab Activity

- Write a program called `cone_surface_area.py`
- Which employs one simple user defined function called `cone_area()`
- to calculate the surface area (including the base area) of a cone
  - Pass the **radius** and **height** of the cone to your function
  - Return the total surface area to the main() program
- Print out the results, radius, height and total surface area
- Make your program “user-friendly”!

Output of `cone_surface_area.py`

```
This programme calculates the surface area of a cone of radius r and height
h.  The area includes the curved surface and the base.
It uses a USER DEFINED function


Enter the radius of the cone base in meters     (e.g., 2.1) : 2.1

Enter the height of the cone in meters     (e.g., 3.4) : 3.4

The surface area of the cone is       40.22  meters²


Do you want to try another cone (Y/N) n
```

Lab Activity 2

- Write a program called `polar_to_Cart.py`
- Which employs one simple user defined function called `polar_2_Cart()`
- to calculate values of x and y for given values of r and θ
- Pass of r and θ to your function (θ in degrees)
  - Return the two values x, y to the main() program
- Print the results in a suitable format
- Make your program “user-friendly”!
- Write a program called `Cart_to_polar.py`

Lab Activity 3

- Write a program called `deg_to_dms.py`
- Which employs one simple user defined function called `deg_2_dms()`
- to calculate the angle (in degrees, minutes and seconds) given the angle in decimal degrees
  - Pass the **angle** to your function in decimal degrees
  - Return the three values **d**, **m**, **s** to the main() program
- Print out the angle in decimal degrees and degs, mins and seconds
- Make your program “user-friendly”!

Homework problem

- Write a program called **quadratic_roots.py**
- Which employs two simple user defined functions called root1() and root2()
- to calculate the roots of a quadratic of the form

$$Ax^2+Bx+C = 0$$

$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

  - Pass A, B and C to each function **root1()** and **root2()**
  - Return the appropriate root to the main() program

- Print out the results in a format that makes sense!
- Test your program on values of A, B and C that give known real roots.
- Allow for the possibility that the roots are complex !!

quadratic_roots.py

Example output – real roots only

```
In [40]: runfile('C:/Documents Previous computer/fmulligan/Teaching/EP305_FJM/
Python/Python Progs/Quadratic_roots1.py', wdir='C:/Documents Previous computer/
fmulligan/Teaching/EP305_FJM/Python/Python Progs')

Programme to determine the roots of a quadratic equation of the form
      Ax² + Bx + C = 0.

It uses two USER DEFINED functions.

Enter the value of A (float): 1

Enter the value of B (float): -4.1

Enter the value of C (float): -26.6

The equation  1.0 x² +  -4.1 x +  -26.6  = 0 has roots at
    x =  7.600  and x = -3.500

Do you want to try another equation (Y/N) N

In [41]:
```

Python console | IPython console | History log

Permissions: RW | End-of-lines: CRLF | Encoding: UTF-8 | Line: 59 | Column: 16 | Memory: 42 %

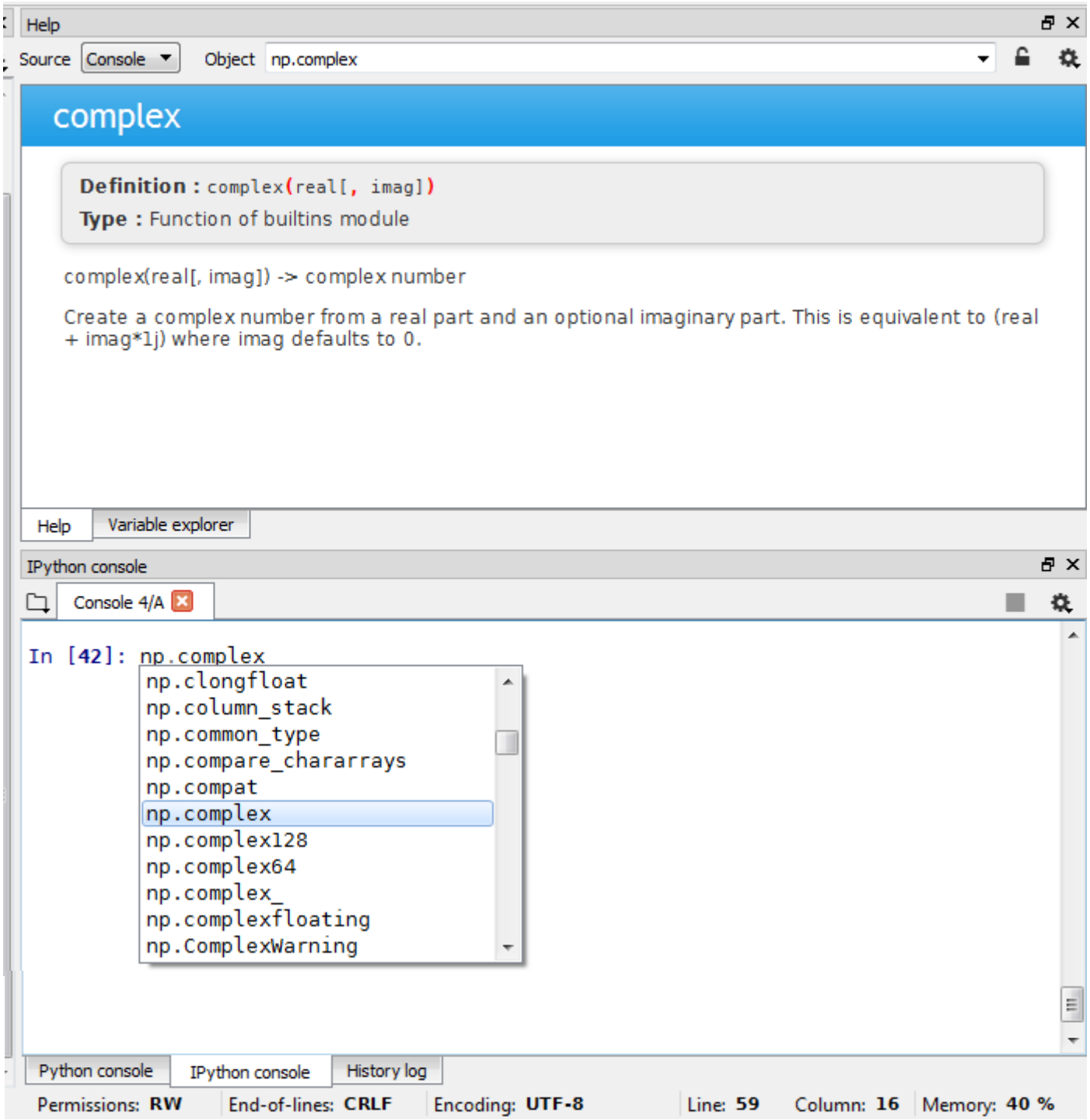
quadratic_roots.py

Example output – complex roots

```
In [41]: runfile('C:/Documents Previous computer/fmulligan/Teaching/EP305_FJM/
Python/Python Progs/Quadratic_roots1.py', wdir='C:/Documents Previous computer/
fmulligan/Teaching/EP305_FJM/Python/Python Progs')

Programme to determine the roots of a quadratic equation of the form
      Ax² + Bx + C = 0.

It uses two USER DEFINED functions.

Enter the value of A (float): 23

Enter the value of B (float): 34

Enter the value of C (float): 56

The equation  23.0 x² +  34.0 x +  56.0  = 0 has roots at
    x =  -0.739+1.374j  and x = -0.739-1.374j

Do you want to try another equation (Y/N) N

In [42]:
```

Python console | IPython console | History log

Permissions: RW | End-of-lines: CRLF | Encoding: UTF-8 | Line: 59 | Column: 16 | Memory: 42 %



Recall Python has a type complex. See image here.