Introductory Scientific Computing with Python

Introduction, IPython and Plotting

FOSSEE

Department of Aerospace Engineering
IIT Bombay

SciPy India, 2015
December, 2015

Acknowledgement

FOSSEE group (`fossee.in`)
based at
IIT Bombay
and funded by
The National Mission on Education
through ICT,
Ministry of HRD, India

Outline

1. Checklist
2. Starting up IPython
3. Breaking out of loops
4. Plotting
   - Drawing plots
   - Decoration
   - More decoration
5. Multiple plots
6. Scripts – Saving & Running

Checklist

1. IPython
2. Editor
3. Data files:
   - `pendulum.txt`
   - `sslc.txt`
4. Images
   - `bird.png`

About the Tutorial

Intended Audience

- Engg., Mathematics and Science researchers with a reasonable programming background.

Goal: Successful participants will be able to

- Start using Python as plotting, computational tool.
- Use the basic libraries and tools for scientific computing with Python.

Outline

1. Checklist
2. Starting up IPython
3. Breaking out of loops
4. Plotting
   - Drawing plots
   - Decoration
   - More decoration
5. Multiple plots
6. Scripts – Saving & Running

Starting up . . .

Terminal

```
$ ipython -pylab
# OR
$ jupyter console -pylab
```

Running IPython

```
In []: print("Hello, World!")
Hello, World!
```

Exiting on the terminal

```
In []: ^D(Ctrl-D)
Do you really want to exit([y]/n)? y
```

Or hit `Return` or `Ctrl-D` again

Outline

1. Checklist
2. Starting up IPython
3. Breaking out of loops
4. Plotting
   - Drawing plots
   - Decoration
   - More decoration
5. Multiple plots
6. Scripts – Saving & Running

Breaking out of Loops

Breaking out of loops

```
In []: while True:
   ...:     print("Hello, World!")
   ...:
Hello, World!
Hello, World!^C(Ctrl-C)
------------------------------------
KeyboardInterrupt
```

10 m

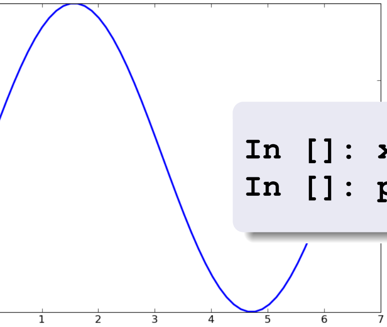
Outline

1. Checklist
2. Starting up IPython
3. Breaking out of loops
4. Plotting
   - Drawing plots
   - Decoration
   - More decoration
5. Multiple plots
6. Scripts – Saving & Running

Outline

1 Checklist
2 Starting up IPython
3 Breaking out of loops
4 Plotting
- Drawing plots
- Decoration
- More decoration
5 Multiple plots
6 Scripts – Saving & Running

First Plot



```
In []: x = linspace(0, 2*pi, 50)
In []: plot(x, sin(x))
```

Walkthrough

`x = linspace(start, stop, num)`

returns **`num`** evenly spaced points, in the interval [**`start`**, **`stop`**].

```
x[0] = start
x[num - 1] = end
```

`plot(x, y)`

plots **`x`** and **`y`** using default line style and color

Outline

1 Checklist

2 Starting up IPython

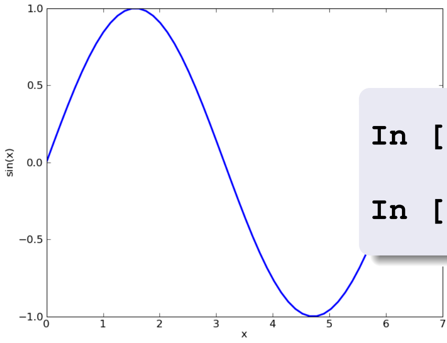
3 Breaking out of loops

4 Plotting
- Drawing plots
- Decoration
- More decoration

5 Multiple plots

6 Scripts – Saving & Running

Adding Labels



```
In []: xlabel('x')

In []: ylabel('sin(x)')
```

Another example

```
In []: clf()
```

Clears the plot area.

```
In []: y = linspace(0, 2*pi, 50)
In []: plot(y, sin(2*y))
In []: xlabel('y')
In []: ylabel('sin(2y)')
```

IPython tips . . .

- Use **`TAB`** to complete command

History

- Accesses history (also from past sessions)
- Up and down arrows (**`Ctrl-p`**/**`Ctrl-n`**)
- Search: **`Ctrl-r`** and start typing
- **`Ctrl-a`**: go to start of line
- **`Ctrl-e`**: go to end of line
- **`Ctrl-k`**: kill to end of line

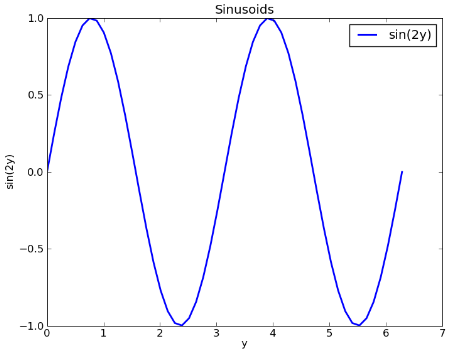
Outline

1 Checklist
2 Starting up IPython
3 Breaking out of loops
4 Plotting
- Drawing plots
- Decoration
- More decoration

5 Multiple plots
6 Scripts – Saving & Running

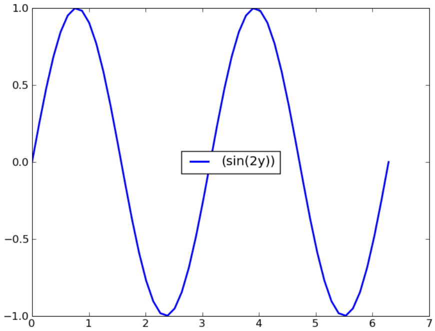
Title and Legends

```
In []: title('Sinusoids')
In []: legend(['sin(2y)'])
```



Legend Placement

```
In []: legend(['sin(2y)'], loc = 'center')
```

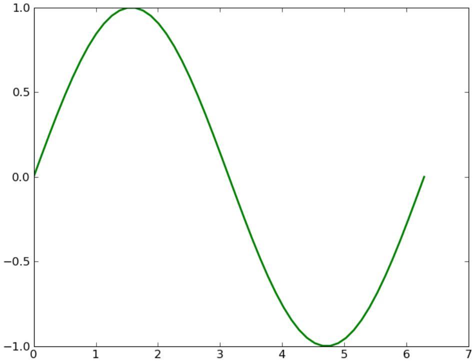


```
'best'
'right'
'center'
```

Showing it better

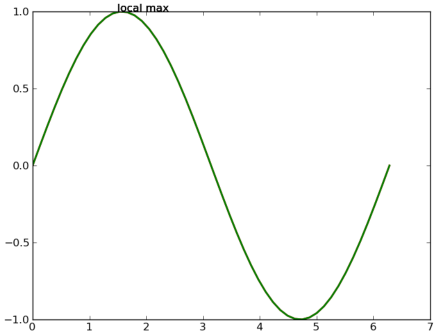
```
In []: plot(y, cos(y), 'r')

In []: clf()
In []: plot(y, sin(y), 'g', linewidth=2)
```



Annotating

```
In []: annotate('local max', xy=(1.5, 1))
```



Saving & Closing

```
In []: savefig('sin.png')

In []: close()
```

Supported formats to store images:

- png
- eps - Easy to embed in LaTeX files
- pdf
- raw
- rgba
- svg

Outline

1 Checklist
2 Starting up IPython
3 Breaking out of loops
4 Plotting
- Drawing plots
- Decoration
- More decoration
5 Multiple plots
6 Scripts – Saving & Running

Overlaid Plots

```
In []: clf()
In []: plot(y, sin(y))
In []: plot(y, cos(y))
In []: xlabel('y')
In []: ylabel('f(y)')
In []: legend(['sin(y)', 'cos(y)'])
```

By default plots would be overlaid!

Plotting separate figures

```
In []: clf()
In []: figure(1)
In []: plot(y, sin(y))
In []: figure(2)
In []: plot(y, cos(y))
In []: savefig('cosine.png')
In []: figure(1)
In []: title('sin(y)')
In []: savefig('sine.png')
In []: close()
In []: close()
```

Axes lengths

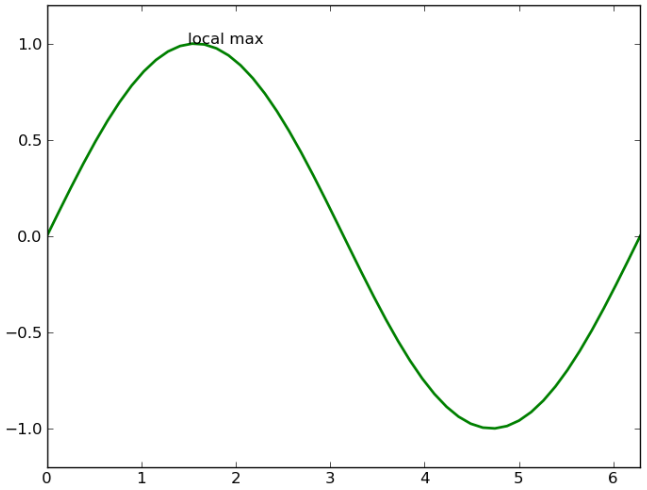
Getting axes lengths

```
In []: xmin, xmax = xlim()
In []: ymin, ymax = ylim()
In []: print xmin, xmax
```

Set the axes limits

```
In []: xlim(xmin, 2*pi )
In []: ylim(ymin-0.2, ymax+0.2)
```

Axes lengths



IPython tips . . .

- Try:

  ```
  In []: plot?
  ```

  to get more information on `plot`

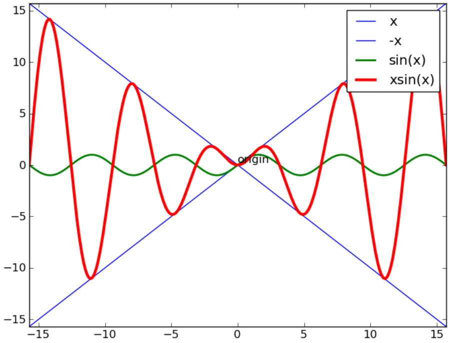
- Try:

  ```
  In []: plot??
  ```

  to see the source code for `plot`
- Note: exit pager with “q” or “ESC”

Review Problem

1. Plot x, -x, sin(x), xsin(x) in range -5π to 5π
2. Add a legend
3. Annotate the origin
4. Set axes limits to the range of x



Review Problem . . .

Plotting . . .

```
In []: x = linspace(-5*pi, 5*pi, 500)
In []: plot(x, x, 'b')
In []: plot(x, -x, 'b')
In []: plot(x, sin(x), 'g', linewidth=2)
In []: plot(x, x*sin(x), 'r',
            linewidth=3)
```

⋮

Review Problem . . .

Legend & Annotation. . .

```
In []: legend(['x', '-x', 'sin(x)',
                 'xsin(x)'])
In []: annotate('origin', xy = (0, 0))
```

Setting Axes limits. . .

```
In []: xlim(-5*pi, 5*pi)
In []: ylim(-5*pi, 5*pi)
```

Outline

1 Checklist
2 Starting up IPython
3 Breaking out of loops
4 Plotting
- Drawing plots
- Decoration
- More decoration
5 Multiple plots
6 Scripts – Saving & Running

Command History

Use the `%hist` magic command of IPython

```
In []: %hist
```

This displays all the commands typed in so far aka Command History.

Careful about errors!

`%hist` will contain the errors as well.

Magic Commands?

Magic commands are commands provided by IPython to make our life easier.

Command History

Use the **`%hist`** magic command of IPython

```
In []: %hist
```

This displays all the commands typed in so far aka Command History.

Careful about errors!

`%hist` will contain the errors as well.

Magic Commands?

Magic commands are commands provided by IPython to make our life easier.

Saving commands into script

Use the `%save` magic command of IPython

```
%save script_name line_numbers
```

Line numbers can be specified individually separated by spaces or as a range separated by a dash.

```
%save four_plot.py 16 18-27
```

This saves from the history the commands entered on line numbers 16, 18, 19, 20, . . . 27

Python Scripts. . .

Now, four_plot.py is called a Python Script.

- run the script in IPython using
  `%run four_plot.py`

```
NameError: name 'linspace' is not defined
```

To avoid this, run using `%run -i four_plot.py`

You may need to do `show()` to see a plot window

Python Scripts. . .

Now, four_plot.py is called a Python Script.

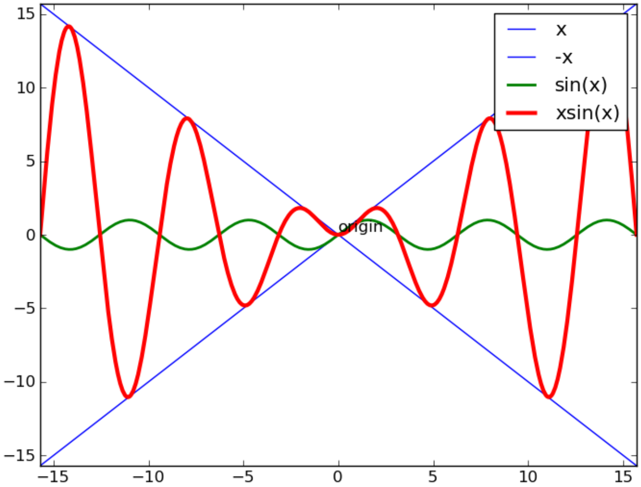
- run the script in IPython using
  `%run four_plot.py`

```
NameError: name 'linspace' is not defined
```

To avoid this, run using `%run -i four_plot.py`

You may need to do `show()` to see a plot window

Result graph



What did we learn?

- Starting up IPython
- Creating simple plots
- Adding labels and legends
- Annotating plots
- Changing the looks: size, linewidth
- Accessing history, documentation
- `%hist` - History of commands
- `%save` - Saving commands
- Running a script using `%run -i`

40 m