

Teaching Plan: DSE courses for B.A. (Prog.) /B.Sc. (Physical Sc.) with Mathematics, and Generic Electives, Semester-5

DSE-1(iii)/DSE-3(ii)/GE-5(ii): Mathematical Python

Weeks 1 and 2: Review of Python fundamentals; Drawing diverse shapes using code and Turtle.

[2]: Chapter 1 (Review: Fundamentals of Python).

[1]: Chapters 1 to 3.

Weeks 3 and 4: Using matplotlib and NumPy for data organization, Structuring and plotting lines, bars, markers, contours and fields, managing subplots and axes; Pyplot and subplots.

[3]: Chapter 2 (up to page 45).

- <https://patrickwalls.github.io/mathematicalpython/scipy/numpy/>
- <https://patrickwalls.github.io/mathematicalpython/scipy/matplotlib/>
- https://matplotlib.org/stable/gallery/lines_bars_and_markers/index.html
- https://matplotlib.org/stable/gallery/images_contours_and_fields/index.html
- https://matplotlib.org/stable/gallery/subplots_axes_and_figures/index.html
- <https://matplotlib.org/stable/tutorials/introductory/pyplot.html>

Week 5: Animations of decay, Bayes, Random walk.

[3]: Chapter 5 (Generating random numbers, pages 134 to 139; page 136 is optional).

- <https://matplotlib.org/stable/gallery/animation/index.html>
- https://matplotlib.org/stable/gallery/animation/animate_decay.html
- https://matplotlib.org/stable/gallery/animation/bayes_update.html
- https://matplotlib.org/stable/gallery/animation/random_walk.html

Week 6: NumPy for scalars and linear algebra on n -dimensional arrays; Computing eigenspace.

[2]: Chapter 4 (pages 226 to 229).

- <https://numpy.org/numpy-tutorials/content/tutorial-svd.html>
- <https://patrickwalls.github.io/mathematicalpython/linear-algebra/eigenvalues-eigenvectors/>

Week 7: Solving dynamical systems on coupled ordinary differential equations, Functional programming update fundamentals using NumPy.

- <https://patrickwalls.github.io/mathematicalpython/differential-equations/first-order/>
- <https://patrickwalls.github.io/mathematicalpython/differential-equations/systems/>
- <https://realpython.com/python-functional-programming/>

Weeks 8 and 9: Symbolic computation and SymPy: Differentiation and integration of functions, Limits.

[3]: Chapter 4 (up to page 96), and Chapter 7.

- <https://docs.sympy.org/latest/guides/index.html>
- <https://docs.sympy.org/latest/tutorials/intro-tutorial/calculus.html>

Week 10: Solution of ordinary differential equations, Computation of eigenvalues, Solution of expressions at multiple points (lambdify).

- <https://docs.sympy.org/latest/guides/solving/solve-ode.html>
- <https://docs.sympy.org/latest/tutorials/intro-tutorial/matrices.html>
- <https://docs.sympy.org/latest/modules/utilities/lambdify.html>

Week 11: Simplification of expressions, Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.

[3]: Chapter 4

[2]: Chapter 5.

[1]: Chapter 6, and 10.

- <https://docs.sympy.org/latest/modules/solvers/solvers.html>

Weeks 12 and 13: Pretty printing using SymPy; Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MSExcel, OpenDocument, and other such formats.

[3]: Chapter 4 (pages 97-100).

- <https://docs.sympy.org/latest/tutorials/intro-tutorial/printing.html>

[2]: Chapter 2 (pages 73-83).

- https://pandas.pydata.org/docs/user_guide/io.html

Week 14 and 15: PyLaTeX and writing document files from Python with auto-computed values, Plots and visualizations.

- <https://pypi.org/project/PyLaTeX/>
- <https://matplotlib.org/stable/tutorials/text/usetex.html>
- https://pandas.pydata.org/docs/user_guide/visualization.html

Essential Readings

1. Farrell, Peter (2019). Math Adventures with Python. No Starch Press. ISBN Number: 978- 1-59327-867-0.
2. Farrell, Peter et al. (2020). The Statistics and Calculus with Python Workshop. Packet Publishing Ltd. ISBN: 978-1-80020-976-3.
3. Saha, Amit (2015). Doing Math with Python. No Starch Press. ISBN: 978-1-59327-640-9

Computer Lab work:

Weeks 1 to 4:

- Spyder Environment preparation with download, installation of required components.
- Implementation of turtle draw for polygonal shapes.
- Using lists and loops for common functions.
- List manipulation.
- Animating objects.
- Interactive grid.
- Drawing complex patterns.

Week 5: Animated plots for solution of problems: decay function w. r. t. time, conditional probability and bayes rule, random walk.

Week 6: Solution of linear algebra problems: Systems of equations, eigenvalues and eigenvectors.

Week 7: Newton's law of cooling, Coupled ODEs with initial conditions.

Weeks 8 and 9: Examples of limits, differentiation and integration of functions.

Weeks 10 to 15: Examples from text references, and similar to those from online sources.