



# PROGRAMMING, DATA STRUCTURES AND ALGORITHMS USING PYTHON

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**INTENDED AUDIENCE** : Students in any branch of mathematics/science/engineering, 1st year

**PRE-REQUISITES** : School level mathematics.

**INDUSTRIES APPLICABLE TO** : This course should be of value to any company requiring programming skills.

### COURSE OUTLINE :

This course is an introduction to programming and problem solving in Python. It does not assume any prior knowledge of programming. Using some motivating examples, the course quickly builds up basic concepts such as conditionals, loops, functions, lists, strings and tuples. It goes on to cover searching and sorting algorithms, dynamic programming and backtracking, as well as topics such as exception handling and using files. As far as data structures are concerned, the course covers Python dictionaries as well as classes and objects for defining user defined datatypes such as linked lists and binary search trees.

### ABOUT INSTRUCTOR :

Prof. Madhavan Mukund studied at IIT Bombay (BTech) and Aarhus University (PhD). He has been a faculty member at Chennai Mathematical Institute since 1992, where he is presently Professor and Director. His main research area is formal verification. He has active research collaborations within and outside India and serves on international conference programme committees and editorial boards of journals.

He has served as President of both the Indian Association for Research in Computing Science (IARCS) (2011-2017) and the ACM India Council (2016-2018). He has been the National Coordinator of the Indian Computing Olympiad since 2002. He served as the Executive Director of the International Olympiad in Informatics from 2011-2014.

In addition to the NPTEL MOOC programme, he has been involved in organizing IARCS Instructional Courses for college teachers. He is a member of ACM India's Education Committee. He has contributed lectures on algorithms to the Massively Empowered Classroom (MEC) project of Microsoft Research and the QEEE programme of MHRD

### COURSE PLAN:

#### Week 1:

Informal introduction to programming, algorithms and data structures  
Downloading and installing Python  
gcd in Python: variables, operations, control flow - assignments, condition-als, loops, functions

#### Week 2:

Python: types, expressions, strings, lists, tuples  
Python memory model: names, mutable and immutable values  
List operations: slices etc  
Binary search  
Inductive function definitions: numerical and structural induction  
Elementary inductive sorting: selection and insertion sort  
In-place sorting

#### Week 3:

Basic algorithmic analysis: input size, asymptotic complexity,  $O()$  notation  
Arrays vs lists  
Merge sort  
Quicksort  
Stable sorting

#### Week 4:

Dictionaries  
More on Python functions: optional arguments, default values  
Passing functions as arguments  
Higher order functions on lists: map, lter, list comprehension

#### Week 5:

Exception handling  
Basic input/output  
Handling files  
String processing

#### Week 6:

Backtracking: N Queens, recording all solutions  
Scope in Python: local, global, nonlocal names  
Nested functions  
Data structures: stack, queue  
Heaps

#### Week 7:

Abstract datatypes  
Classes and objects in Python  
"Linked" lists: find, insert, delete  
Binary search trees: find, insert, delete  
Height-balanced binary search trees

#### Week 8:

Efficient evaluation of recursive definitions: memoization  
Dynamic programming: examples  
Other programming languages: C and manual memory management  
Other programming paradigms: functional programming