PET328: Computer Applications in Petroleum Engineering

(Python Programming with Petroleum Engineering Applications)

Dr. Olatunde Mosobalaje
with Ms Gift Aghaulor & Mr. Peter Ojegbile

Covenant University, Nigeria

FIRST-DAY PACKAGE

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APPETIZER

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- Python 3
- Jupyter Notebook
- GitHub

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DELIVERABLES

- Certifications
- Qualification for PDA_SIG
- Profile Enhancement
- Resources

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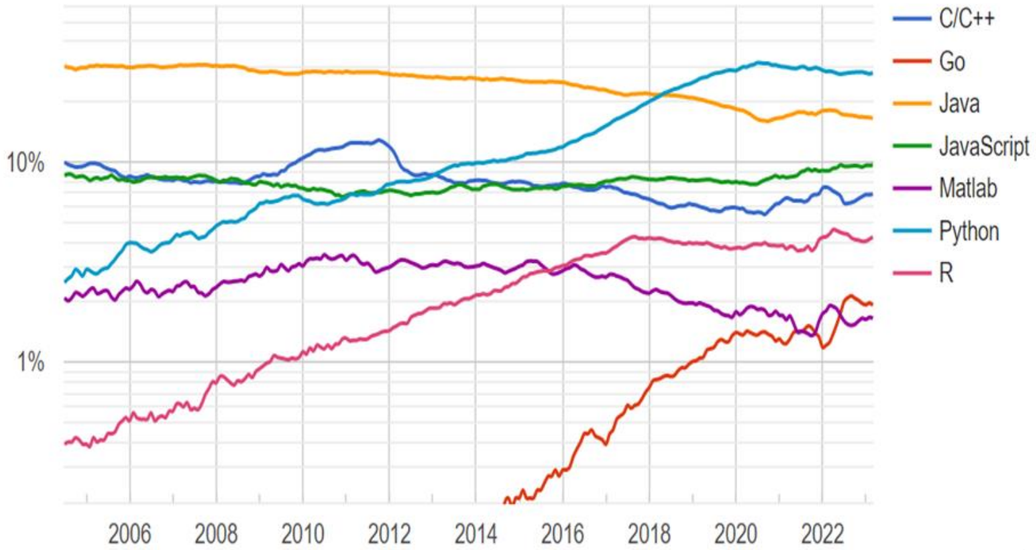
The Change

From PET415 & PET512 to PET328

- From 400L & 500L to 300L - early exposure
- From FORTRAN/MATLAB/Excel to Python
- More varied applications in PET328 than in PET415
- Introduced blended learning opportunities (Cousera & DataCamp)
- Use of GitHub for collaboration



Why Python?!

- Popularity - tops PYPL chart
- Open-source license
- Extensive functionalities - modules/libraries
- Ease of learning
- Vast users' community support

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The Motivation/Relevance

Oilfield Emerging Trends

- Oilfield Digitalization
  - Smart fields; intelligent wells; digital twin; cloud computing; Internet of Things (IoT)
- Post-COVID
  - Remote work; labour automation
- Data Proliferation
  - Petroleum Data Analytics (PDA); Machine Learning (ML); Artificial Intelligence
- SPE Competency Matrix
  - Analytics programming language
- Advocacy for PE graduates with both domain and digital knowledge
- Integration with industry softwares
  - Petrel, Techlog etc have Python extensions

Human competence in computer programming is crucial in driving these innovations

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The Vision & the Mission

The Vision

Petroleum engineering graduates possessing a balanced blend of PE domain knowledge and digital skills

The Mission

To provide opportunities to acquire competence in computer programming, as a pre-cursor to develop digital skills relevant to emerging oil/gas opportunities

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APPETIZER | LEARNERS' EXPERIENCE DESIGN | LESSON PLAN | TOOLBOX | DELIVERABLES

2021-2024: Success Stories
- Learners-side

200+
Online Courses completed by PET328 students

190
Free DataCamp licenses to over 400 data science courses - worth over 20,000 USD

70.5%
Pass rate

20+
PET328 students joined the PDA Special Interest Group

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2021-2024: Success Stories
- Instructor's side

Teaching experience published in SPE NAICE 2023


OnePetro

SPE Nigeria Annual International Conference and Exhibition

ARTICLE NAVIGATION

Introducing Python Coding to Petroleum Engineering Undergraduates: Excerpts from a Teaching Experience

O. O. Mosobalaje; O. D. Orodu

Paper presented at the SPE Nigeria Annual International Conference and Exhibition, Lagos, Nigeria, July 2023.

Paper Number: SPE-217148-MS

https://doi.org/10.2118/217148-MS

Published: July 30 2023

Publication got a bronze medal

Launched a Community of Practice for Educators

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2021-2024: Success Stories
- Instructor's side

Collaborations via PET328

With Professional Bodies:
- Society of Petroleum Engineers (SPE) DSEATS Africa Region
- Triple Helix Nigeria (THN)

With Industry:
- CypherCrescent Limited

With Government Agency:
- Nigerian Content Development & Management Board (NCDMB)

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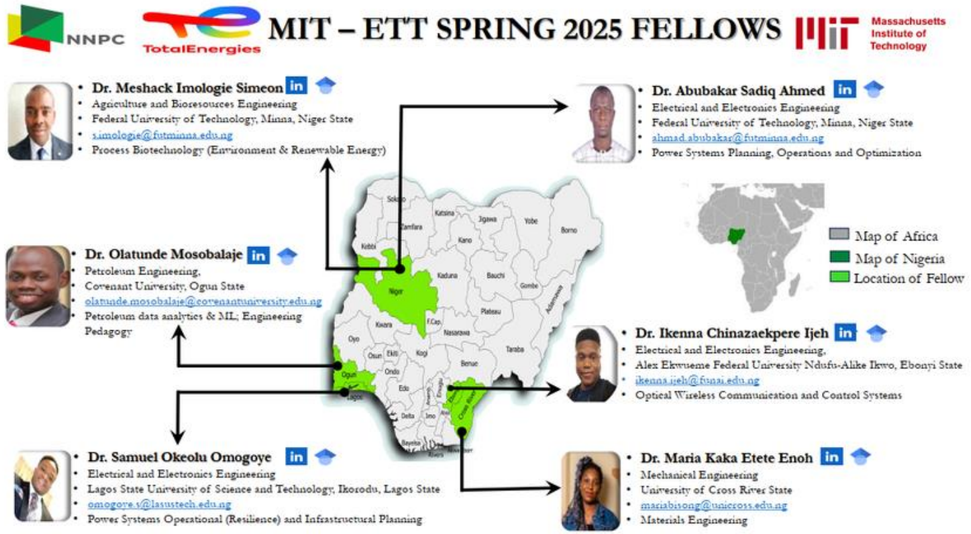
2021-2024: Success Stories
- Instructor's side

PET328 - selling point for selection into the MIT-ETT Fellowship: https://ett.mit.edu/current-fellows/



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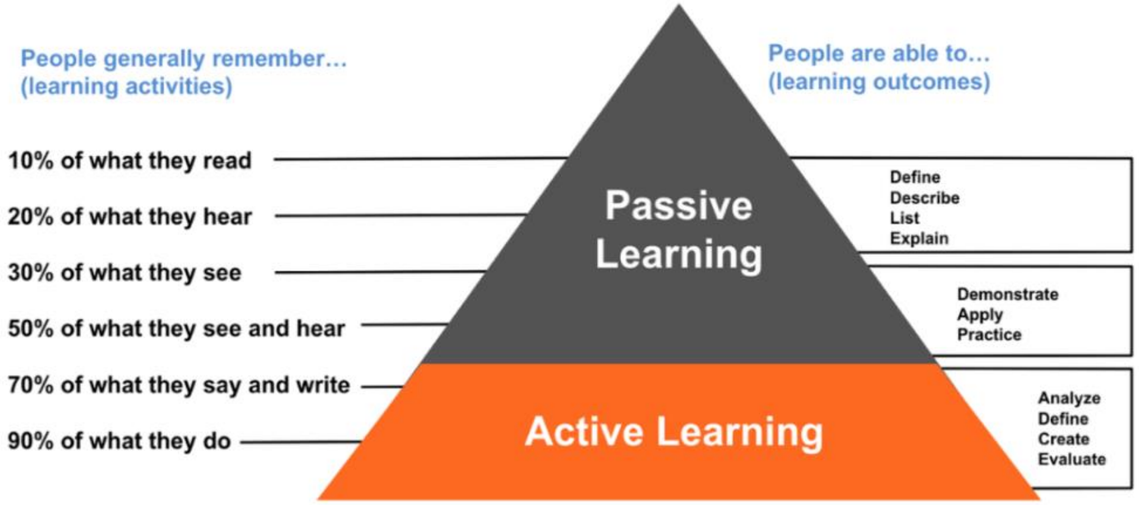
2025 - the Active Learning Edition

Springing from my ongoing participation in the MIT-ETT fellowship, the 2024/2025 edition of PET328 is designed around the Active Learning Pedagogy:

- **Class time will be for participatory (higher-order) learning activities such as:**
  - **discussions**
  - **problem solving**
  - **exploring concepts**
  - **analyzing**
  - **evaluating etc**



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2025 - the Active Learning Edition

How would it happen?!

- Flipped classroom:
  - Pre-class assignments:
    - videos - self-sufficient
    - readings
    - DataCamp contents - mapped to PET328
    - Kaggle contents - mapped to PET328
    - Off-class discussion forum - Telegram group (voluntary)
- Class starts with quiz:
  - Not to be graded
  - To assess learners understanding of pre-class assignments
- Real-time Feedback using:
  - Google form
  - Slido.com
- Compulsory to bring PC or device to class

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Learning Outcomes - Acquire skills

Students acquire skills to:

- **Analyze** features in Python codes such as input/output, execution flow, control structures
- **Create** & assign values to variables; convert values/variables between types; use math and string operators
- **Develop** Python scripts to implement conditional execution (*if…else*) and repetitive (*for* and *while*) loops.
- **Create** & call functions for common PE computations; set or skip values for arguments of functions
- **Create** and (re-)assign multi-valued data: *lists*, *tuples* and *dictionaries;* access element(s) and loop through the values/indices

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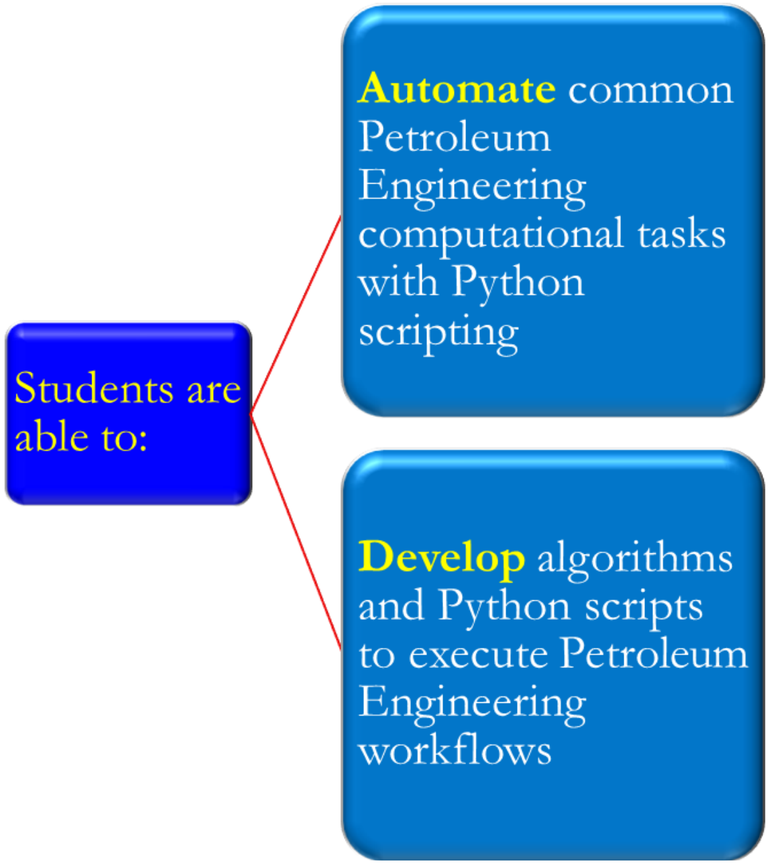
Learning Outcomes - Professional Competencies



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Assessments

Learning Outcome	Assessment
LO1: Students should be able to analyze the workings of fundamental patterns in Python programs such as input/output statements, execution flow, control structures etc	Acceptable evidence of mastery of this LO will be: • Ability to construct Python statements to request input parameters from program users ◦ Example: porosity for use in a volumetric program • Ability to construct Python statements to report the output of a computation/simulation. ◦ Example: cumulative oil produced, material balance simulator program. • Ability to formulate a while loop ◦ Example: updating oil formation volume factor at series of decreasing pressure values until bubble point pressure is attained

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Assessments

Learning Outcome	Assessment

LO2: Students should be able to create and assign values to variables; convert values/variables from one type to another; write executable Python statements involving mathematical and string operators	**Acceptable evidence of mastery of this LO will be:**
	• **Ability to create variables to hold computation parameters and outputs of a kinds (numeric, string, categorical or Boolean etc).**
	  ◦ **Example: a variable to hold lithology types ('shale', 'sandstone', 'limestone')**
	• **Ability to construct Python statements to convert values from one type to another**
	  ◦ **Example: conversion of user-input from string to numeric before computation.**
	• **Ability to implement petroleum engineering equations/formulae in Python programs without missing the order of operations (BODMAS).**
	  ◦ **Example: cost-per-foot formula in drilling engineering**

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Assessments

Learning Outcome	Assessment
LO3: Students should be able to develop Python scripts to implement conditional execution (if…else) and repetitive (for and while) loops.	Acceptable evidence of mastery of this LO will be: • Ability to identify binary courses in workflows, formulate Boolean expressions and construct Python if or if…else statements ◦ Example: advancing or terminating simulation cycles depending on average reservoir pressure. • Ability to formulate a for loop ◦ Example: looping through gridblocks and computing flow parameters in a discretized reservoir model • Ability to formulate a while loop ◦ Example: updating oil formation volume factor at series of decreasing pressure values until bubble point pressure is attained

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Assessments

Learning Outcome	Assessment

LO4: Students should be able to create and call custom functions for common PE computational tasks; set or skip values for positional or keyworded arguments of functions	**Acceptable evidence of mastery of this LO will be:**
	• **Ability to construct the header of a function, listing relevant arguments.**
	  ◦ **Example: a function to compute solution gas-oil ratio, Rs**
	• **Ability to specify default values for function arguments.**
	  ◦ **Example: setting standard temperature and pressure (STP) values in natural gas density computations**
	• **Ability to pass a function's output value via a return statement.**
	  ◦ **Example: returning flowrate, q, from a function written to implement Vogel's inflow performance relationship**
	• **Ability students to alternate between positional and keyworded argument passing when calling in-built or custom functions.**

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Assessments

Learning Outcome	Assessment

LO5: Students should be able to create and (re-)assign multiple values to data structures: lists, tuples and dictionaries; access element(s) of data structures; loop through the indices or values in data structures.	Acceptable evidence of mastery of this LO will be:
	• Ability to deploy Python's in-built data structures (lists, tuples and dictionaries) in storing data multi-valued data encountered in PE workflow.
	  ◦ Example: storing gridblock permeability values to be used in a reservoir flow simulator.
	• Ability to extract values stored in multi-valued data structures for use in repetitive workflows.
	  ◦ Example: extracting gridblock pressure for use in material balance computations
	• Ability to use a for… loop to iterate through a multi-valued data structure.
	• Ability to match the 1-D indices of the data structures with the 2-D gridblock indices in a discretized reservoir.
	• Ability to modify data structures using various in-built methods and functions.
	  ◦ Example: appending latest computed flowrate to a pre-defined list, tuple or dictionary while looping through simulation time-cycles

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Assessments

Learning Outcome	Assessment
LO6: Students should be able to automate common petroleum engineering computational tasks with Python code scripting.	Acceptable evidence of mastery of this LO will be: • Ability to script code chunks with a view to automate PE computational task. ◦ Example: a Python script to request reservoir properties and compute reservoir volumetrics such as BV, PV, HCPV and STOIIP.

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Assessments

Learning Outcome	Assessment
LO7: Students should be able to develop algorithms and Python scripts to execute integrated petroleum engineering computational workflows.	Acceptable evidence of mastery of this LO will be: • Ability to interpret a given PE problem statement, formulate algorithms and write a wholistic Python script to solve the problem. ◦ Example: a script that completely implements the oil material balance equation for a discretized reservoir. The inputs being gridblock rock and fluid properties as well as gridblock pressure values per time. The output being various reservoir performance parameters such as well flowrates, cumulative oil produced, average reservoir pressure, etc.

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APPETIZER | **LEARNERS' EXPERIENCE DESIGN** | LESSON PLAN | TOOLBOX | DELIVERABLES

Learning Activities

In-Class (2hrs/week)

- 'Vital-sign' quizzes
- Lecture (review of pre-class assignments
- Demos (in Jupyter Notebook)
- Class discussions
- Brainstorming
- Formative Assessments:
  - MCQs; Multiple T/F; FITB
  - Coding exercises (short, long)
  - Peer Instruction (think-pair-share)
- Digital whip-around
- Retrieval practice - recall concepts from previous classes
- Polls, exit surveys

Off-Class

- Pre-class Assignments:
  - videos,
  - readings
  - blended learning
- Office hours (1hrs/week)
- Recitations
- Programming assignments
- Problem Sets
- Discussion forums (on Telegram)

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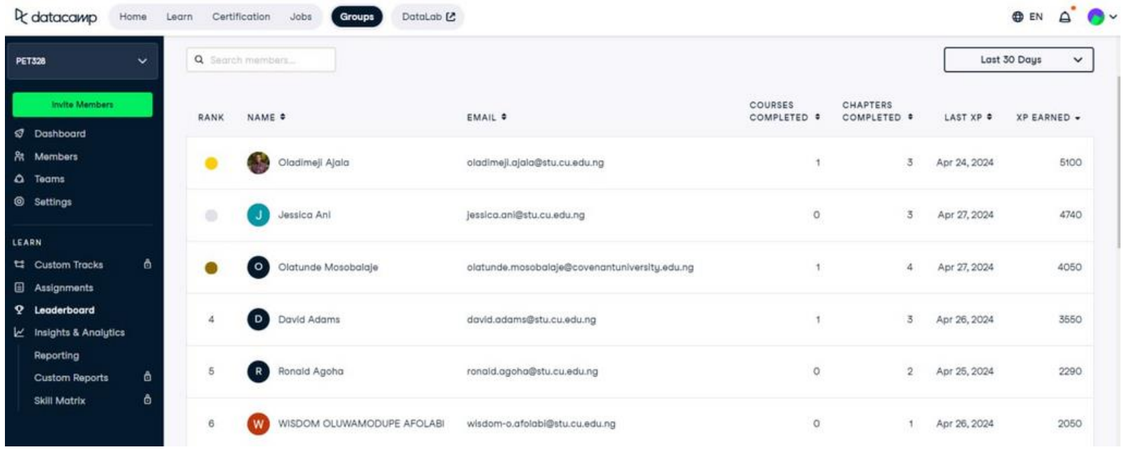
APPETIZER | **LEARNERS' EXPERIENCE DESIGN** | LESSON PLAN | TOOLBOX | DELIVERABLES

Blended Learning Opportunities

DataCamp

Already secured 120 free licenses (worth over 20,000 USD) - access to 500+ data science courses



Kaggle

Free courses (with certificate)

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Course Contents

- **Introduction to Computer programming**

Input/Output Statements | Execution Control Structures | Collaboration using GitHub.

- **Getting Started with Python**

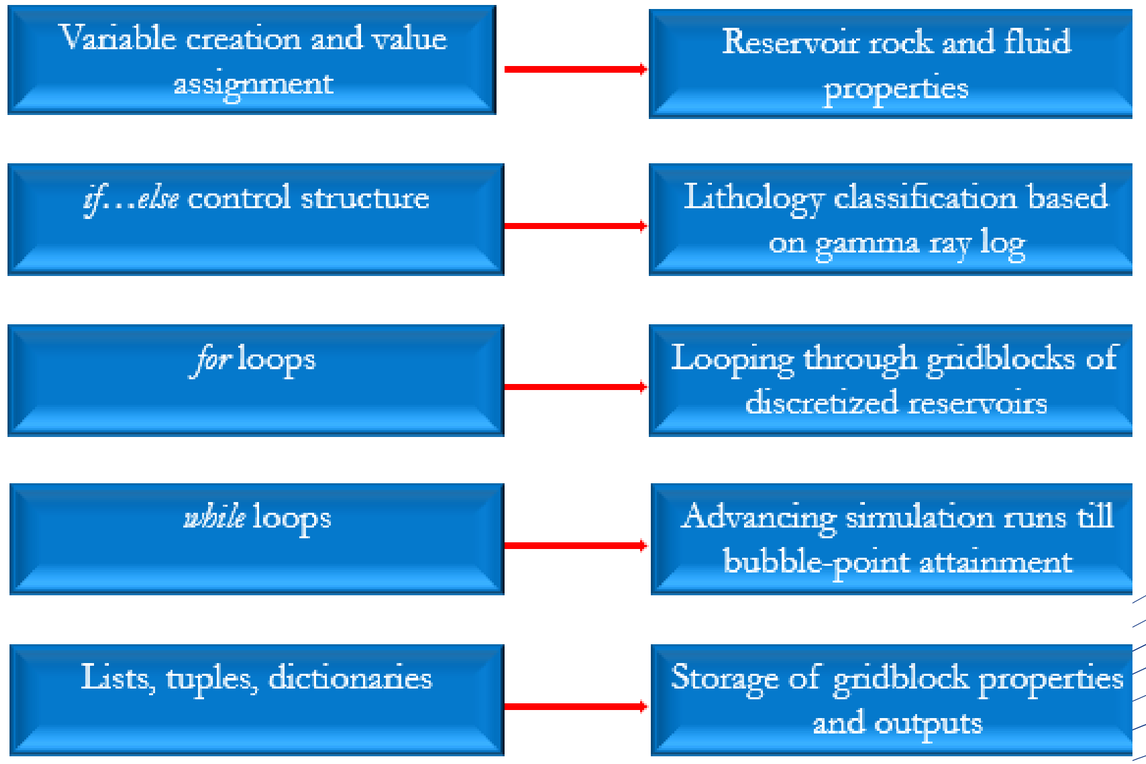
Basic Python Objects | Boolean Expressions | Logical Operators | Conditional Structures (if…, if…else) | Repetitive Loops (for, while) Reservoir Discretization | User-defined Functions.

- **Python Data Structures**

Lists: Creation and Accessing Element(s) | List Methods/Functions/Operations | Tuples | Dictionaries: Creation and Accessing Elements | Looping through Dictionaries.

- **Application Projects**

Hydrocarbon Reservoir Volumetrics | Material Balance Analysis | Fluid PVT Property Correlations | Reservoir Performance Prediction | Decline Curve Analysis | Reservoir Simulation.



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Course Calendar

Week	Topic	Outline	Activities/Materials

1	First-day Package	• Appetizer
		• Learners' Experience Design
		• Lesson plan
		• Toolbox
		• Deliverables
			• Assignments: Installations:
			  ◦ Python 3
			  ◦ Jupyter Notebook/Google Colab
			  ◦ GitHub account & app
			• Office Hour

Week	Topic	Outline	Activity/Materials

2	Introduction to Patterns in Computer Programming	• Input-output Statements
		• Introduction to Conditional Structures
		• Introduction to Repetitive Structures
		• Introduction to User-defined Functions
			• Pre-class materials
			  ◦ Video (link)
			  ◦ Reading (link)
			• Vital-sign Quiz
			• Office Hour
			• Problem Set 0 (link)

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Course Calendar

Week	Topic	Outline	Activities/Materials

3	Basic Python Objects	• Values & Variables
		• Data Types
		• Statements
		• Order of Arithmetic Operations
			• Pre-class materials
			  ◦ Video (link)
			  ◦ Reading (link)
			• Vital-sign quiz
			• Office Hours
			• Problem Set 1 (link)

Week	Topic	Outline	Activity/Materials

4	Conditional Structure I	• Boolean Values
		• Logical Expressions
		• Conditional Execution
		• Alternative Execution
		• Chained Conditional Structure
			• Pre-class materials
			  ◦ Video (link)
			  ◦ Reading (link)
			• Office Hour
			• Programming Assignment (link)

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Grading

Grading Plan

- DataCamp Course Completion - 10%
- Problem Sets - 10%
- Programming Assignments - 5%
- Graded Quizs - 5%
- Final Exam - 70%
  - Applied questions
  - Set in quasi real-field contexts
    - Samples to be provided

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Python 3

Download:
https://www.python.org/downloads/

Juoyter Notebook

- **Comes with Anaconda.**
- **See installation guide here: Download: https://www.python.org/downloads/**

GitHub

- **A GitHub account: Sign up here: https://github.com/signup**
- **GitHub Desktop app: https://desktop.github.com/download/**

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Deliverables

- DataCamp Certifications!
- Good Grades!!
- Professional enhancements!!!
- Internship opportunities!!!!
- Learning resources!!!!!
- Admission to PDA_SIG!!!!!!
- Candies!!!!!!!
- Lots of fun!!!!!!!!

```
>>>#TTOWG!
>>>print(‘…to the only wise God’)
```