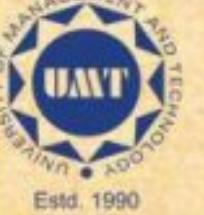


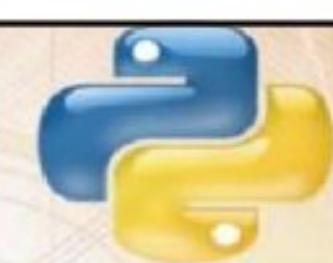


Dr. Ghulam Murtaza is a highly accomplished expert in Mathematical Analysis, with a decade of teaching experience, presently working at the University of Management and Technology (UMT). His diverse interests span machine learning, fuzzy mathematics, soft set theory, cryptography, fixed point theory, and mathematical inequalities. Dr. Murtaza's research contributions are well-recognized, with numerous articles published in respected mathematics journals. He is also a prominent figure in the academic and research communities at UMT and in Pakistan, known for his active participation in international conferences on computational mathematics. Dr. Murtaza's dedication to both teaching and research makes him a significant influencer in the field of Mathematics.

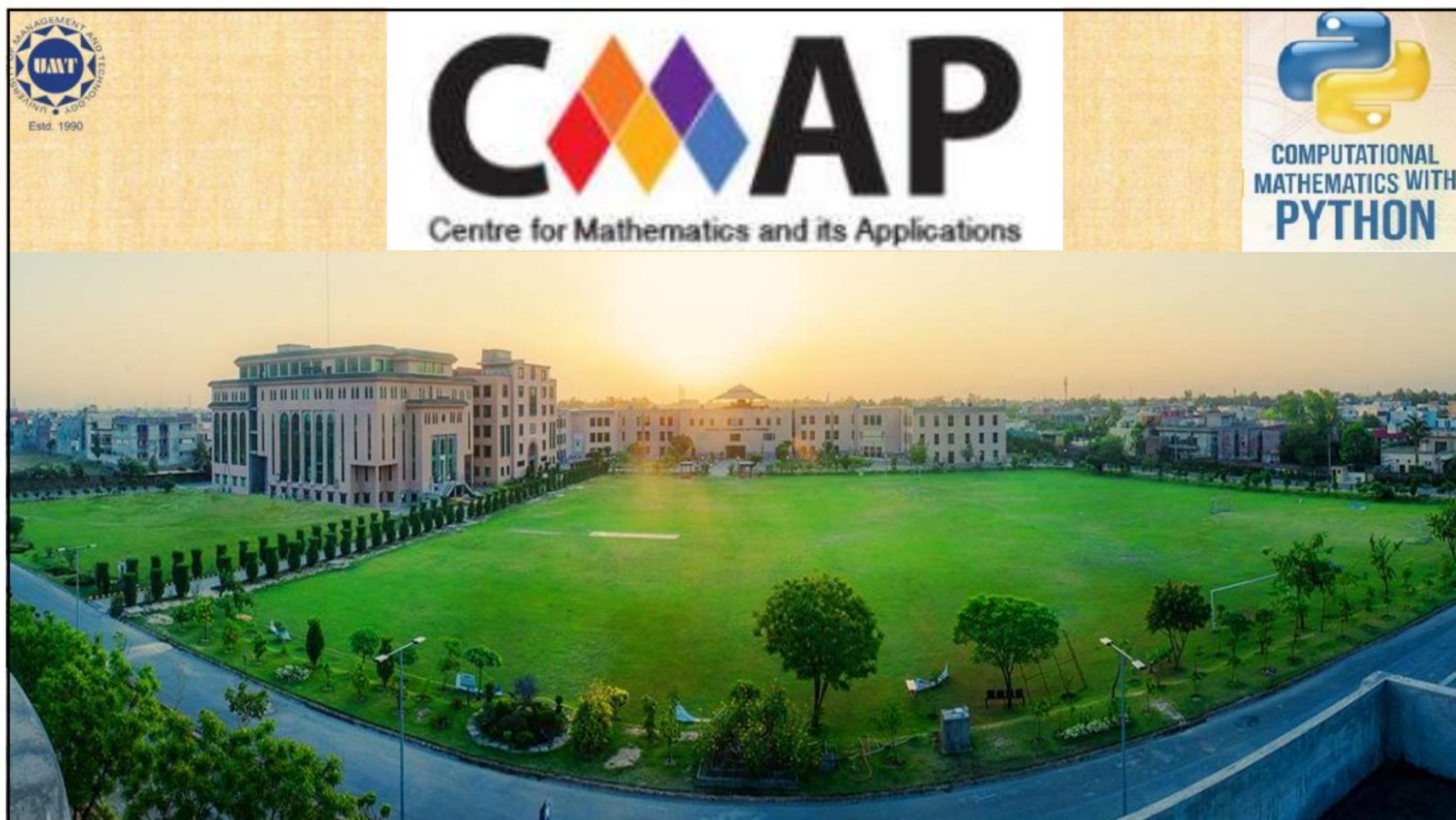
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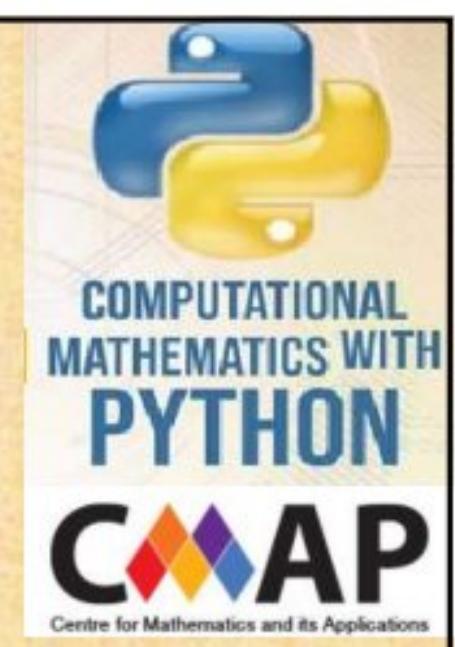
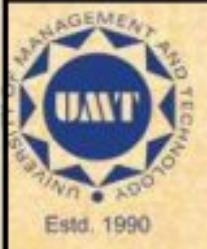


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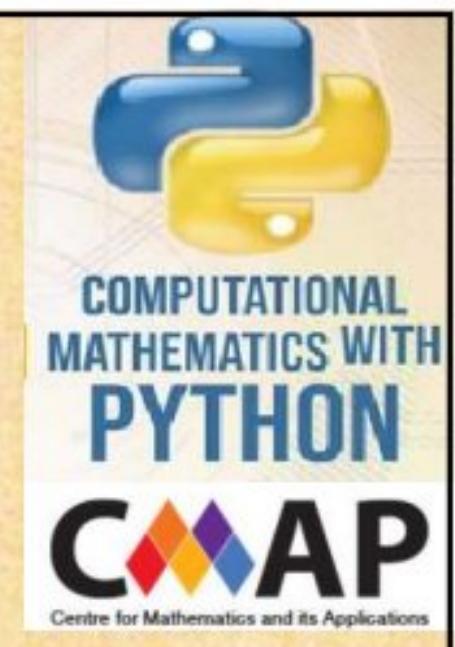
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LECTURE 2

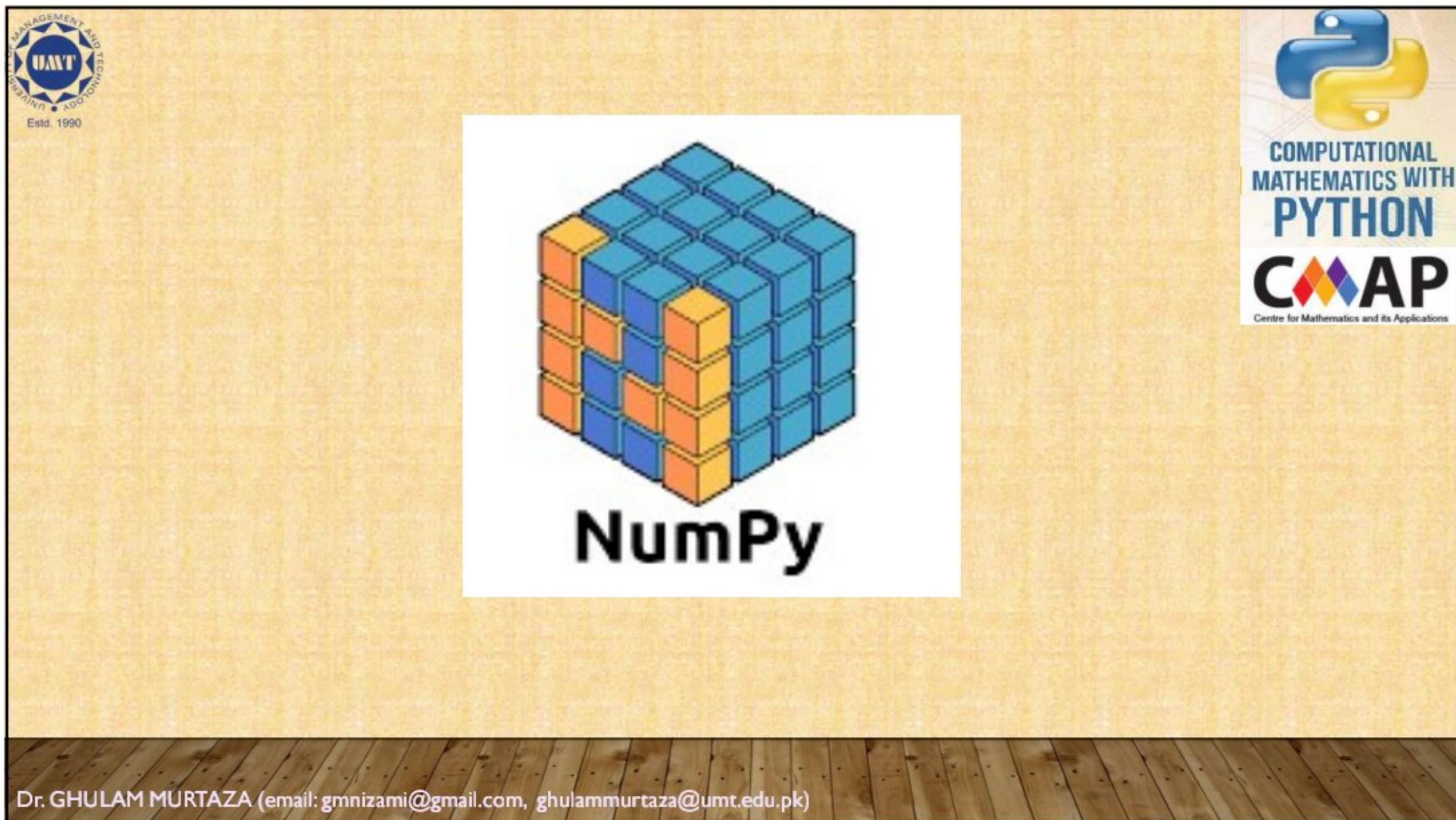
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LEARNING OBJECTIVES

- **Introduction to Numpy**
- **Numpy arrays**
- **Basic Math operations on Numpy arrays**
- **Broadcasting**
- **Matplotlib**

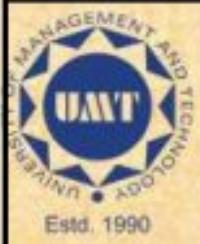
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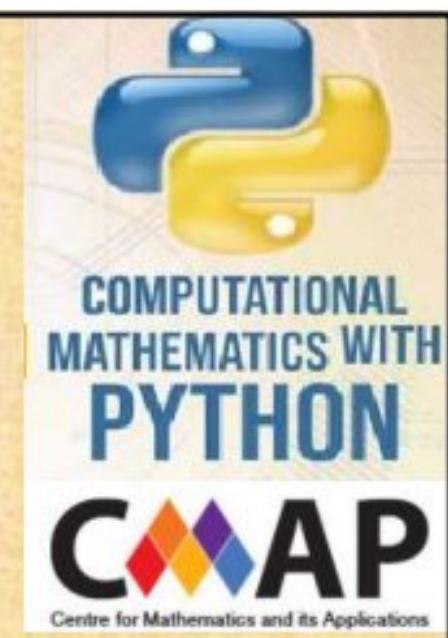
The slide has a yellow background with a wood-grain footer. In the top left corner is the UMT logo with the text "ESTD. 1990". In the center is a large graphic of a Rubik's cube where the letter 'N' is formed by the blue and cyan faces. Above the cube is the text "Uses of NumPy". To the left of the cube are three red boxes containing "Broadcasting", "Matrix operations", and "Searching, sorting & counting". To the right of the cube are four red boxes containing "Arithmetic operations", "Statistical operations", "Bitwise operations", and "Copying & viewing arrays". In the bottom center is a red box containing "Working with other libraries like matplotlib, scipy, pandas". In the bottom left corner is the text "Stacking". In the bottom right corner is the CMAP logo with the text "COMPUTATIONAL MATHEMATICS WITH PYTHON CMAP Centre for Mathematics and its Applications".

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ARRAYS

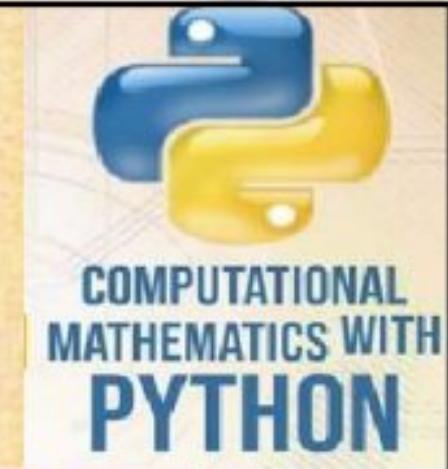
A numpy array is a grid of values, **all of the same type**, and is **indexed by a tuple of nonnegative integers**. The number of dimensions is the **rank** of the array; **the shape of an array is a tuple of integers** giving the **size of the array along each dimension**.



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NUMPY ARRAY ATTRIBUTES



Attribute	Description	Syntax
ndim	returns dimension(total number of axes) of the array	arr.ndim
T	returns transposed array	arr.T
size	returns number of elements in the array	arr.size
dtype	returns datatype of elements in the array	arr.dtype
shape	returns a tuple of sizes of each dimension	arr.shape

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ARRAY CREATION(INITIALIZATION)

- using List(or tuple)
- using numpy functions
 - np.arange
 - np.linspace
 - np.zeros
 - np.ones
 - np.full
 - np.eye
 - np.random.random
 - np.empty(np.empty_like)
- using input function

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Array Operations	Functions	example	COMPUTATIONAL MATHEMATICS WITH PYTHON C MAP <small>Centre for Mathematics and its Applications</small>
np.reshape()	Reshape the array(shallow copy)	myarray.reshape(2,3) myarray.reshape(2,-1) myarray.reshape(-1)	
np.flatten()	Return 1 dim (deep copy) of original array	newarray=myarray.flatten()	
np.ravel()	Returns 1 dim (shallow copy) of origonal array	newarray=myarray.ravel()	
np.trace()	Returns trace of the array	trace1=myarray.trace(0), trace1=myarray.trace() trace1=myarray.trace(1) trace1=myarray.trace(-1)	
np.transpose()	Returns the transpose of the array(shallow copy)	mytranspose=myarray.transpose()	

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ARRAY INDEXING

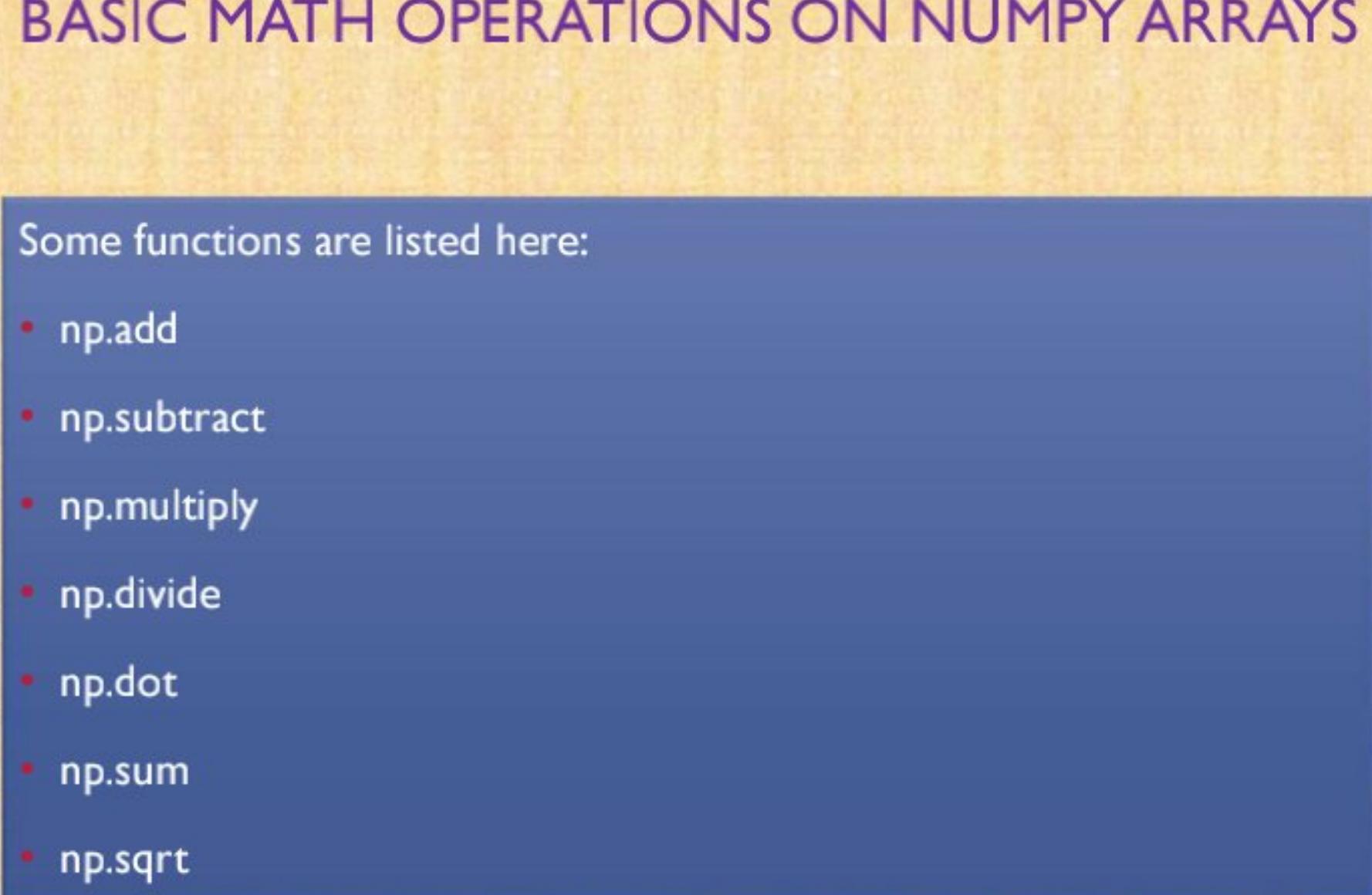
- Slicing(integer indexing)
- Integer array indexing
- Boolean array indexing

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BASIC MATH OPERATIONS ON NUMPY ARRAYS

Some functions are listed here:

- np.add
- np.subtract
- np.multiply
- np.divide
- np.dot
- np.sum
- np.sqrt

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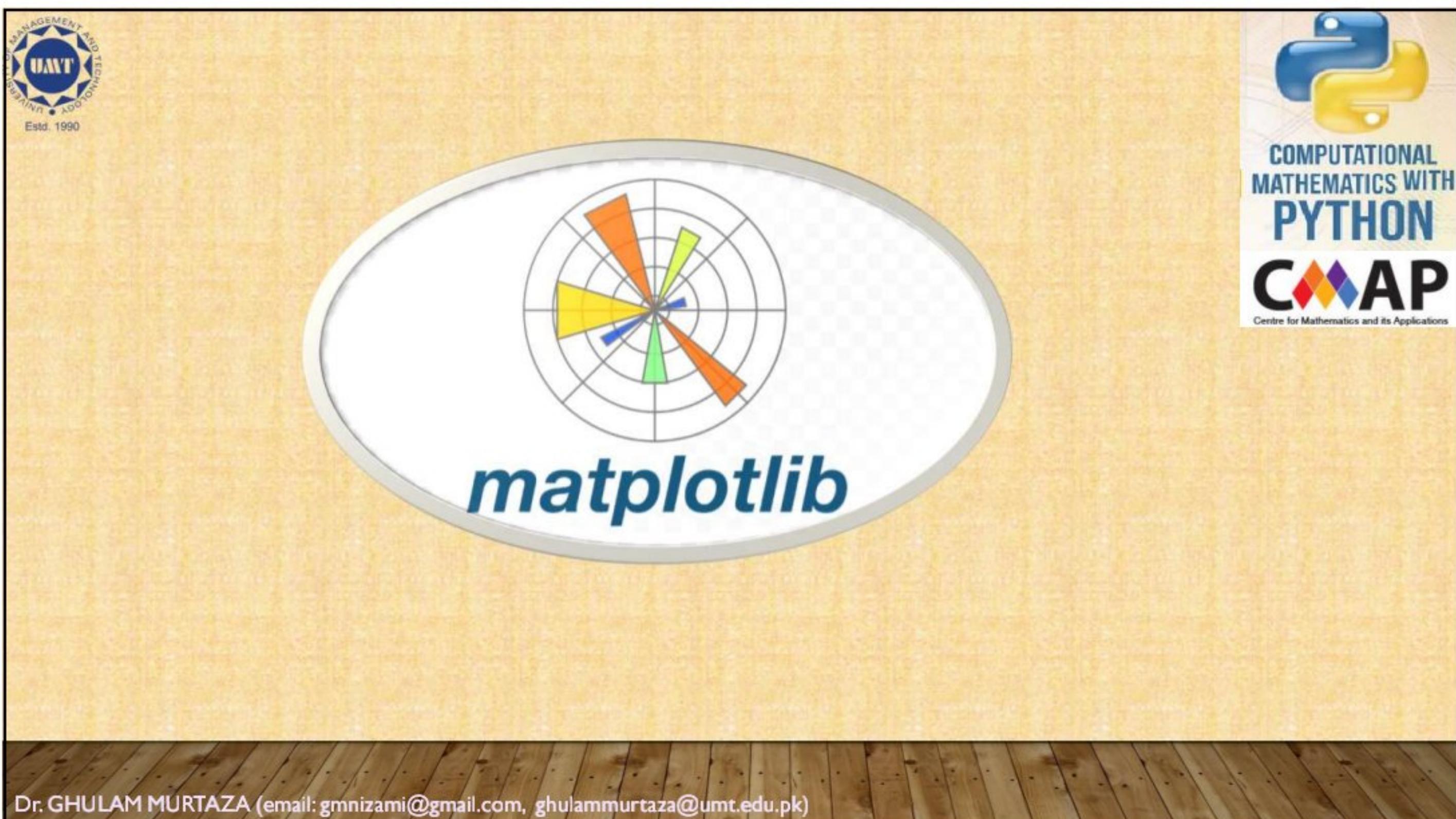
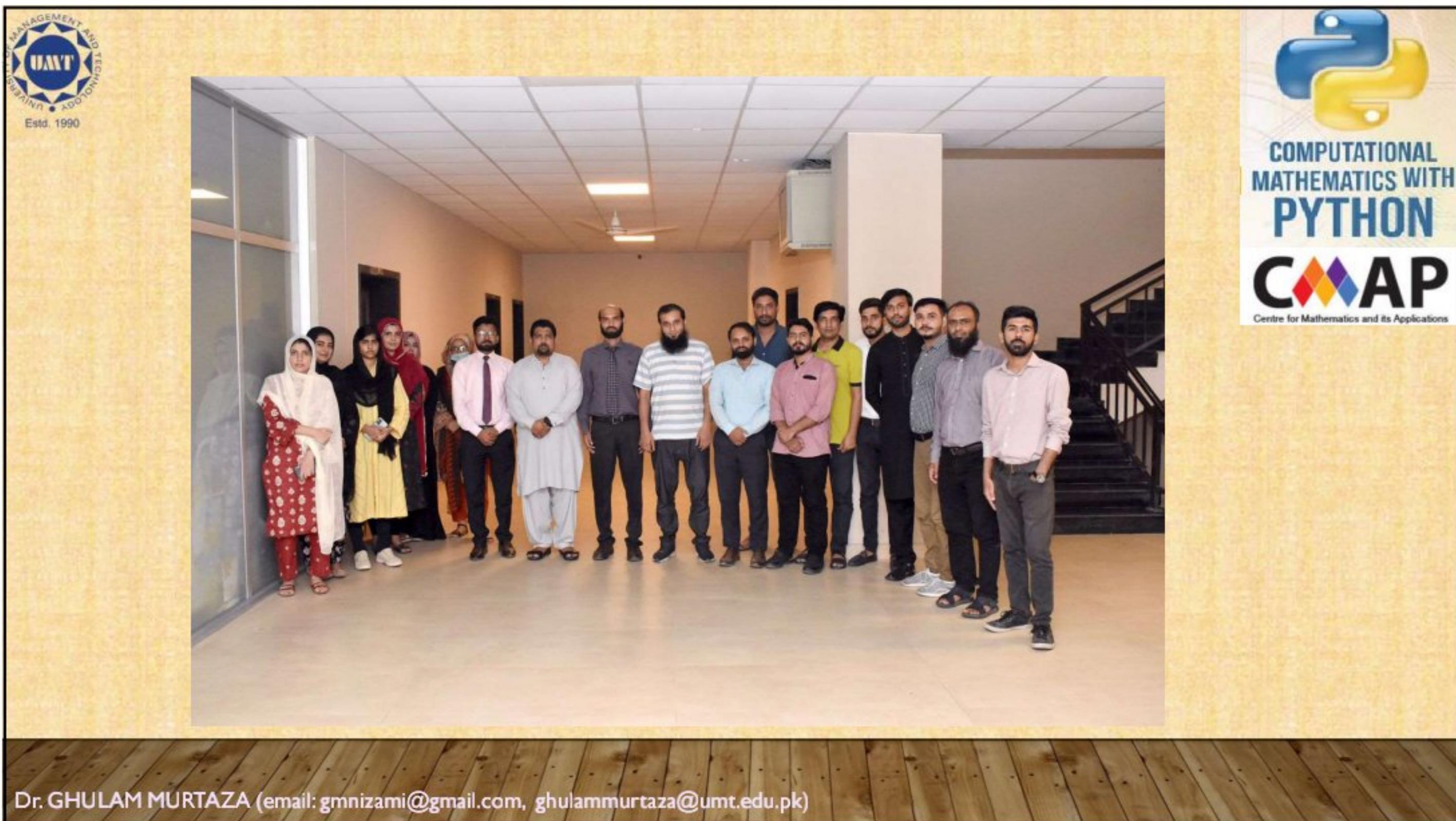
BROADCASTING

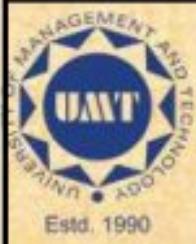
Broadcasting is a powerful mechanism that allows numpy to work with arrays of different shapes when performing arithmetic operations. Frequently we have a smaller array and a larger array, and we want to use the smaller array multiple times to perform some operation on the larger array.

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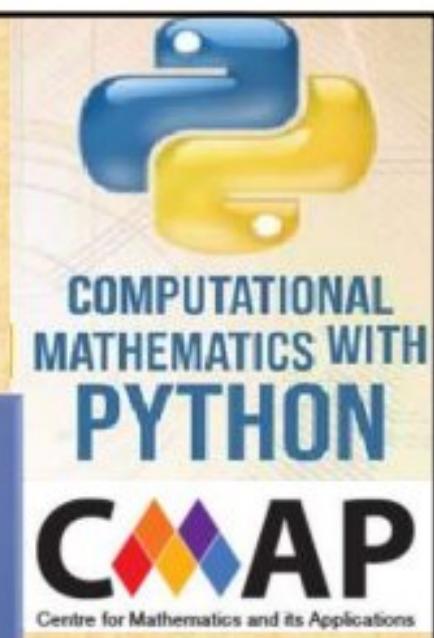
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PYPLOT MODULE



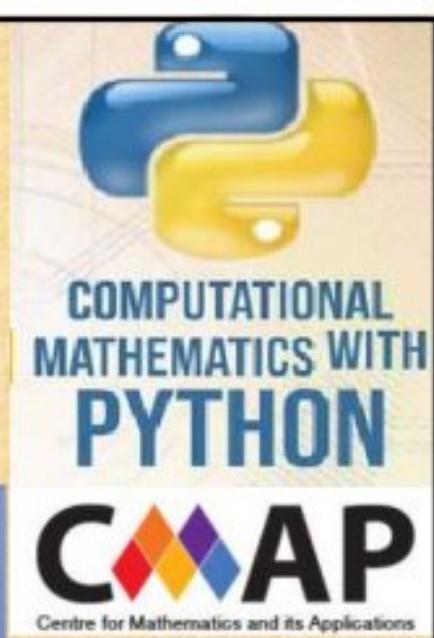
`matplotlib.pyplot` is a collection of functions that make `matplotlib` work like MATLAB. Each ```pyplot``` function makes some change to a figure:
e.g.,

- creates a figure,
- creates a plotting area in a figure,
- plots some lines in a plotting area,
- decorates the plot with labels, etc.

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TYPES OF PLOTS (2D GRAPHS)



Some of 2D graphs are listed here

- Line Plot
- Bar Plot
- Scatter Plot
- Pie Plot
- Histogram Plot

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Line plot

`plt.plot(xpoints, ypoints, marker:line:color,label,lw,.....)`

The slide displays three line plots. The first plot shows the Sine and Cosine functions from 0 to 8 on the x-axis. The second plot shows the functions t , t^2 , and t^3 from 0 to 5 on the x-axis. The third plot shows a scatter plot with a dashed line and an arrow pointing to a 'strange value' at (1.0, 4).

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Some functions of pyplot

	X label,Y label	plt.title()	Add title to the plot
<code>plt.xlabel('x label'), plt.ylabel('ylabel')</code>			
<code>plt.axes(xmin, xmax, ymin, ymax)</code>	Plot axes setting	<code>plt.legend()</code>	Add legend to the plot
<code>plt.show()</code>	To show the plot	<code>plt.grid()</code>	Add grid to the plot
<code>plt.figure()</code>	To create a figure and set figure attributes e.g. <code>plt.figure(figsize=(w,h))</code>	<code>plt.annotate()</code>	
<code>plt.subplot()</code>	To create subplots	<code>plt.savefig("output.jpg")</code>	To save the figure

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Marker

Character	Description	Character	Description	Character	Description
'w'	triangle_up marker	triangle_right marker	'h'	hexagon1 marker	
'<'	triangle_left marker	'l'	tri_down marker	'H'	hexagon2 marker
'.'	point marker	'2'	tri_up marker	'+'	plus marker
'_'	hline marker	'3'	tri_left marker	'x'	x marker
'*'	star marker	'4'	tri_right marker	'D'	diamond marker
'.'	pixel marker	's'	square marker	'd'	thin_diamond marker
'o'	circle marker	'p'	pentagon marker	' '	vline marker
'v'	triangle_down marker				


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Line style		Color	
character	style	character	color
'.'	solid line style	'b'	blue
'--'	dashed line style	'g'	green
'-.'	dash-dot line style	'r'	red
'.'	dotted line style	'c'	cyan
		'm'	magenta
		'y'	yellow
		'k'	black
		'w'	white


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marker	
parameter	function
ms	Marker size
mc	Marker color
mec	Marker edge color
mfc	Marker face color

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bar plot

```
plt.bar(x, height, ....)
```

Categorical Plotting

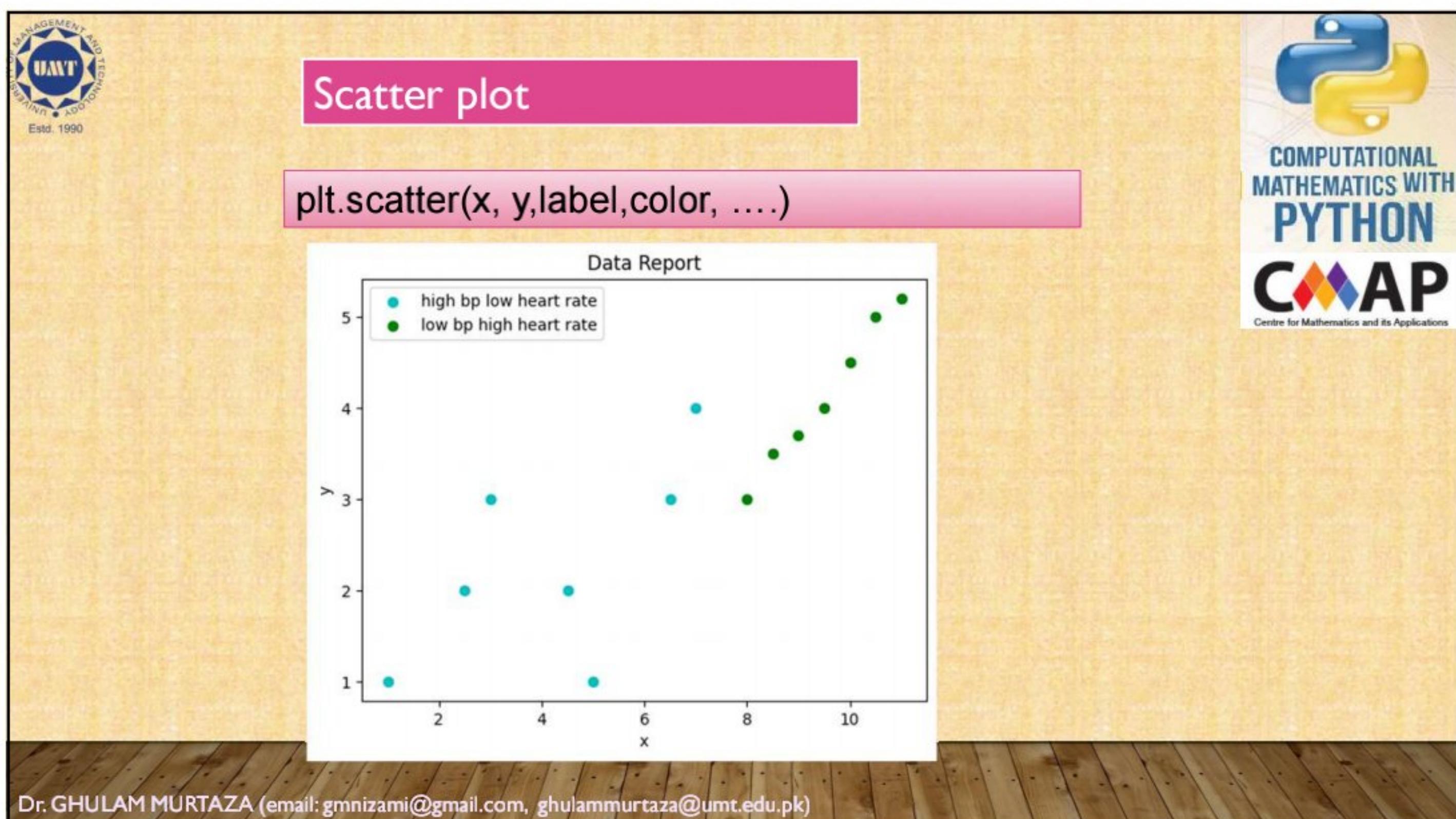
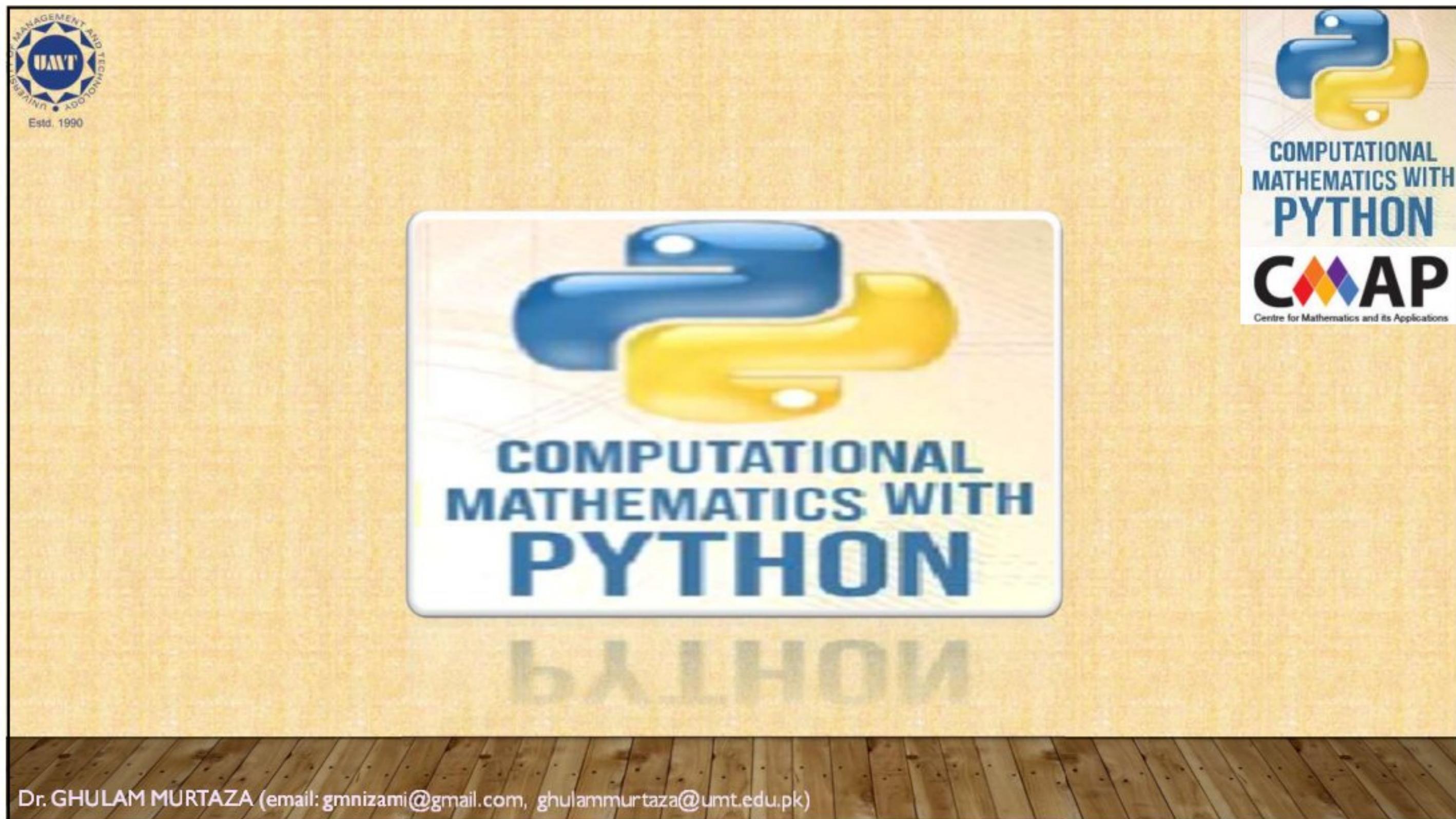
Category	Height
group_a	0
group_b	~10
group_c	100

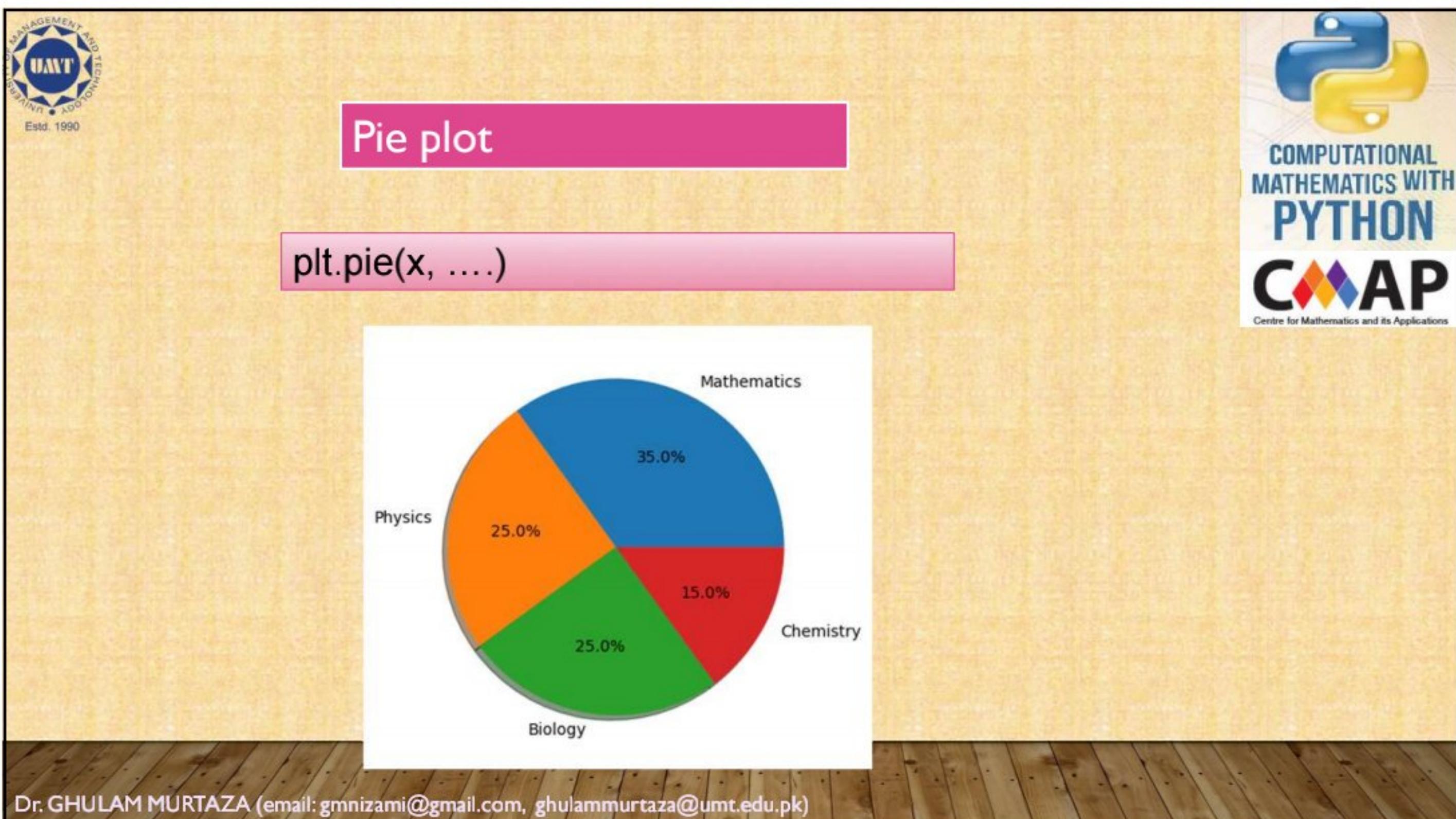
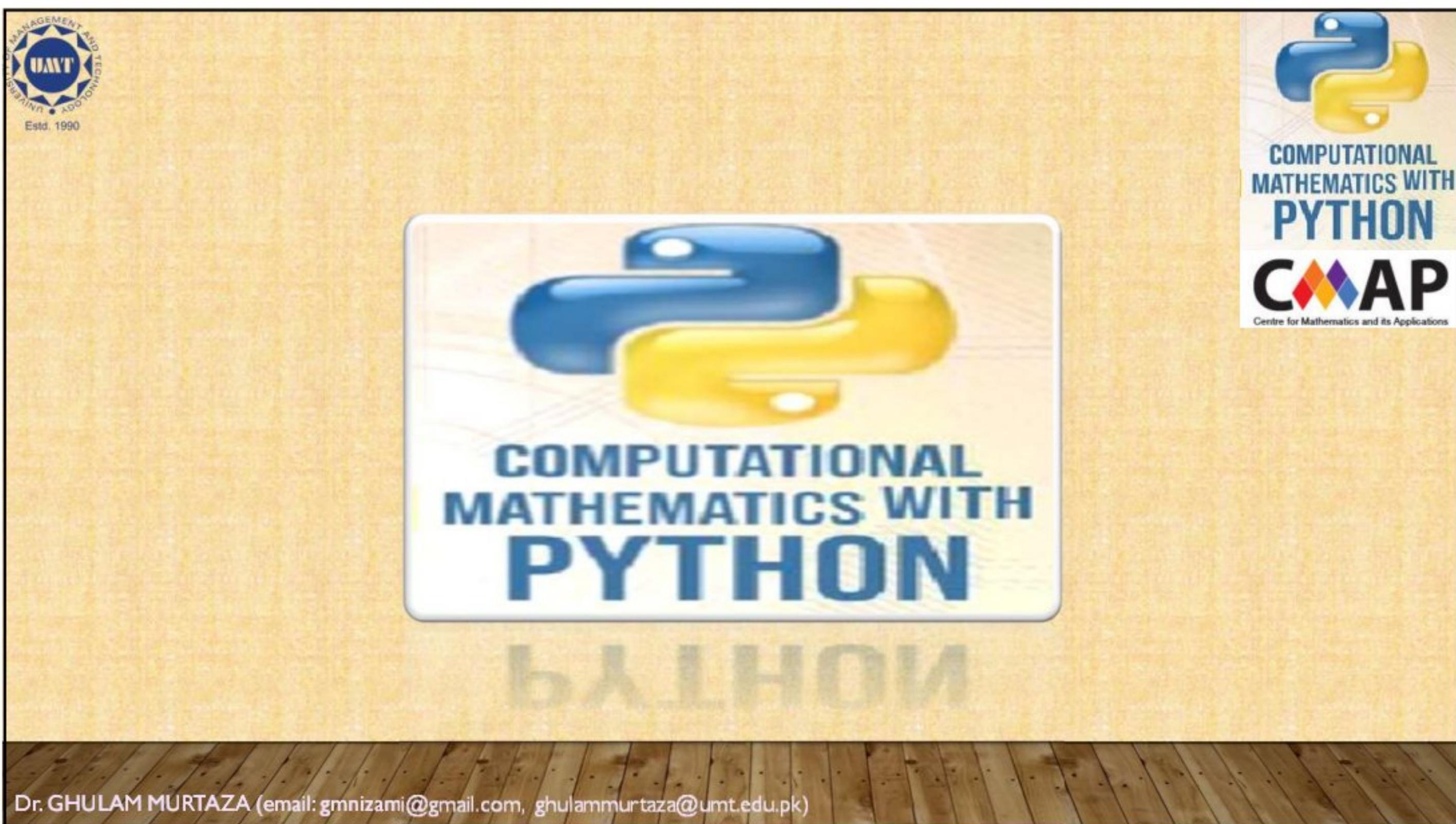
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Histogram plot

```
plt.histogram(x,bin, ....)
```

$\mu = 100, \sigma = 15$

Histogram of IQ

Smarts (Bin Range)	Probability (Frequency)
40 - 50	0.000
50 - 60	0.000
60 - 70	0.000
70 - 80	0.005
80 - 90	0.010
90 - 100	0.025
100 - 110	0.030
110 - 120	0.025
120 - 130	0.010
130 - 140	0.005
140 - 150	0.000
150 - 160	0.000

Probability

Smarts

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