

Midterm Exam (part 1) - Computational Physics I

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SCORE: 8.5
/10

Date: Wednesday 17 April 2024 Duration: 45 minutes

Credits: 10 points (5 questions) Type of evaluation: LAB

Part 1 is closed-book, in-class, and contains short-answer questions. Please provide short and concise answers to the following items:

1. (2 points) Python functions

Explain what a python function is, and list 4 types of python functions.

A python function is a programming tool that allows us to do something with arrays, numbers, etc. python

- Basic operations (+, -, *, /)

- Open, read and write files (.open, .read, .write)

- Matrix operations (@, .T, etc)

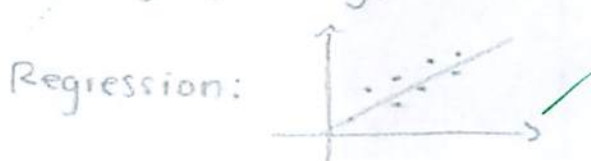
- def and return allow to make our own functions.

What about inputs
& outputs?
Arguments?
Incomplete → 4 types?

2. (2 points) Interpolation versus regression

Explain the difference between carrying out interpolation versus regression in data analysis. When do you use interpolation and when regression?

The main difference is that a regression gets a curve that does not aim to pass through each point, but that better fits them all; while an interpolation does pass through each point. Graphically,



3. (2 points) Gauss methods for systems of linear equations

Briefly explain how the LU decomposition and the Gauss elimination methods for solving systems of linear equations work.

Gauss elimination:

Reduces the system $Ax=b$ to

$Bx=c$ where B is a triangular matrix and c is a vector transformed with the same steps as B . B and c are gotten using linear combinations of the rows. $Bx=c$ can be solved easily since a solution is given and can be used to obtain another, and so on.

LU decomposition

In this case A is decomposed as $A=LU$ where L is a lower Δ matrix and U is an upper Δ matrix. The solution can be obtained with

$$Ax=b \Rightarrow LUX=b$$

$$\Rightarrow x=L^{-1}U^{-1}b$$

4. (2 points) Systems of nonlinear equations

Indicate 2 methods that we can use to solve systems of linear equations in python, and briefly explain how each method works.

f.solve:

We generate a functional of the type $f(x)=0$ with a function and then we use `f.solve()` to get the points where the functional is satisfied.

simpy.solve:

- We assign symbols for the variables to be found, (x, y, z) .
- Get fit the function the list of equations and indicate the symbols.
- We get the solution.

5. (2 points) Image processing

Imagine you obtain the following photograph of iron crystals from a scanning electron microscope (credits: NASA/JSC), and you are asked to isolate the more prominent crystals from the background and from the rest of the image. Design and sketch a suitable algorithm workflow to achieve this goal in python.



I don't remember the specific symbols and figures for the workflow, but the process would be: OK, but it was required.

- 1) Get the image into a 2D array using an appropriate method and packages based on the type of image.
- 2) Use Gaussian smoothing to get an image with less irregularities in the background.
- 3) Now use thresholding (intensity) to isolate the brightest features of the image. The pixels that we're not interested in can be replaced with 0 or nans.
- 4) Hopefully, by now we have isolated the more prominent crystals.

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