Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade\_\_\_\_\_\_\_\_\_\_\_\_\_

Computational Physics Exam 1

# Instructions

You are to work all of the following problems by writing and running Python programs. Your solutions to the exam **must** be in the form of **one Jupyter notebook with your name** that includes the following:

* A header markup cell with **your name** and **Comp Phys Exam 1**
* Python code in code cells—one problem or section per cell
* **answers** to all questions in markup cells

**Place your Jupyter notebook in the Brightspace Dropbox**

**by 5 p.m., Sunday September 24, 2023.**

The point value for each problem is shown. You will be graded on **the completeness** of your solutions, your **programming**, **refinements** to your output (such as formatting print statements, labeling axes, including legends, etc.), and your **answers** to questions. Notes, textbook, and other *non-human* resources are permitted. You probably will need to look up features of difference commands in SciPy or NumPy online. You *may not* discuss the exam or your solutions with anyone but your instructor.If you have questions, please contact me in my office or via e-mail over the weekend.

Best wishes and happy computing!

1. (20 pts) Python StufF Multiple Choice:

1.1 Suppose x = 1, y = -1, and z = 1. What will be displayed by the following statement?

if x > 0:

if y > 0:

print("x > 0 and y > 0")

elif z > 0:

print("x < 0 and z > 0")

A. x > 0 and y > 0

B. x < 0 and z > 0

C. x < 0 and z < 0

D. nothing displayed

1.2 Assume x = 4 and y = 5, which of the following is true?

A. x < 5 and y < 5

B. x < 5 or y < 5

C. x > 5 and y > 5

D. x > 5 or y > 5

1.3 What is the output of this code?

def increment\_items(L, increment):

i = 0

while i < len(L):

L[i] = L[i] + increment

i = i + 1

values = [1, 2, 3]

print(increment\_items(values, 2))

print(values)

A. None

[3, 4, 5].

B. None

[1, 2, 3].

C. [3, 4, 5].

[1, 2, 3].

D. [3, 4, 5].

None

1.4 What is the output for y?

y = 0

for i in range(0, 10, 2):

y += i

print(y)

A. 9

B. 10

C. 11

D. 20

1.5 Given the following four patterns,

Pattern A        Pattern B        Pattern C        Pattern D  
1                1 2 3 4 5 6                1       1 2 3 4 5 6  
1 2              1 2 3 4 5                2 1        1 2 3 4 5  
1 2 3            1 2 3 4                3 2 1          1 2 3 4  
1 2 3 4          1 2 3                4 3 2 1            1 2 3  
1 2 3 4 5        1 2                5 4 3 2 1              1 2  
1 2 3 4 5 6      1                6 5 4 3 2 1                1

Which of the pattern is produced by the following code?  
  
for i in range(1, 6 + 1):  
    for j in range(6, 0, -1):  
       print(j if j <= i else " ", end = " ")  
    print()

A. A

B. B

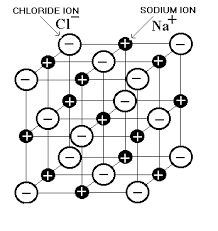
C. C

D. D

1. (20 pts) In 1910, Srinivasa Ramanujan, an Indian mathematician, found the rapidly converging infinite series for *π*

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**Using this series, determine π when the following number of terms, *n*, are used in the calculation: *n* = 1, 2**. (You might need to use **np.float64**() for calculations if your version of Python doesn’t automatically calculate floating point to 64-bit precision.) For each value of *n* print the NumPy value of π and then the value you calculated. Use Pythonic formatting with {:50.45} for a number. **What is amazing about this method of calculating π?**

1. (20 pts) In condensed matter physics the Madelung constant gives the total electric potential felt by an atom in a solid. It depends on the charges on the other atoms nearby and their locations. Consider for instance solid sodium chloride—table salt. The sodium chloride crystal has atoms arranged on a cubic lattice, but with alternating sodium and chlorine atoms, the sodium ones having a single positive charge +*e* and the chlorine ones a single negative charge −*e*, where *e* is the charge on the electron. If we label each position on the lattice by three integer coordinates (*i*, *j*, *k*), then the sodium atoms fall at positions where *i* + *j* + *k* is even, and the chlorine atoms at positions where *i* + *j* + *k* is odd.

Consider a sodium atom at the origin, *i* = *j* = *k* = 0, and let us calculate the Madelung constant. If the spacing of atoms on the lattice is *a*, then the distance from the origin to the atom at position (*i*, *j*, *k*) is  and the potential at the origin created by such an atom is



where the sign of the expression depend on whether *i* + *j* + *k* is even (+) or odd (-). The total potential felt by the sodium atom is therefore the sum of this quantity over all atoms. If we assume a cubic box around the sodium at the origin, with *L* atoms in all directions, we have

,

where *M* is the Madelung constant (approximately for finite-sized lattice) and is given by



where the sign is + if the value of *i + j + k* is even and – if the value is odd.

This last expression is used by condensed matter researchers to characterize difference ionic molecules.

**Write a program to calculate and print the Madelung M constant for sodium chloride for the value *L*  = 100, using the above equation. What value did you obtain?**

1. (20 pts) Download the file stars.txt from Resources on Brightspace, which contains stars’ temperatures (in Kelvin) and luminosity (in magnitude).
   1. **Determine the mean and standard deviation for the magnitudes and for temperatures**.
   2. **Plot a histogram of (a) number of stars versus temperature and (b) number of stars versus magnitude. Do the values peak around your answers in (a)?**
   3. **Construct a graph of magnitude versus temperature with the most negative magnitudes higher on the vertical axis and temperatures going from hottest to coolest along the horizontal axis. (You will need to look up how to reverse axes in Matplotlib; it is *very* easy.)**
   4. **What information can you infer from your graph in (c)?**
2. (20 pts) Antarctic mass measurements from 04/2002 to 06/2020 taken from GRACE under the auspices of the NASA MEaSUREs program reveal trends in ice shelf mass. The file containing this data, Antarctica\_mass\_200204\_202006.txt, can be found under Resource Files on Brightspace. To understand better the changes in ice shelf mass,

* 1. **Find the Pearson correlation coefficient for the data.**
  2. **Determine the linear regression for the data.**
  3. **Plot the data and the model curve (linear regression).**
  4. **What do you note about yearly and decadal changes in mass?**