

Name: _____

CDS 251 Final

Due May 3, 2021 by 3:00 PM on Blackboard

Exam is 115 out of 100 possible points. (15 points built in Extra Credit)

Remember the GMU Honor code

- Complete this exam in a single sitting.
 - Open notes but **no collaboration, no internet.**
 - Do binary by hand, you may use a calculator for decimal calculations but no 'computer science' calculators (or google) to do binary operations or conversions for you.
 - Exam is designed for a 2 hr period. You may take as long as you like as long as you do the exam in a **single sitting.**
 - After you complete the exam, you will not return to it.
 - Do not discuss the exam with anyone until after the due date.
 - Fill in the information below after completing the exam.
 - Without this signature page, your exam will not be graded.
-

Date exam taken: _____

Time spent on exam: _____

I attest that I have adhered to the above guidelines:

Your signature

1) (5 pts) Add these two **unsigned** bytes. Either convert to decimal or explain the error in the addition.

$$\begin{array}{r} 1\ 0\ 1\ 0\ 1\ 1\ 1\ 0 \\ +\ 0\ 0\ 1\ 1\ 1\ 1\ 0\ 1 \\ \hline \end{array}$$

2) (5 pts) Add these two **signed** bytes. Either convert to decimal or explain the error in the addition.

$$\begin{array}{r} 1\ 1\ 1\ 0\ 1\ 1\ 1\ 0 \\ +\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 0 \\ \hline \end{array}$$

3) (10 pts) The following is a four byte Single Precision Real Number as stored in computer memory. What is the number in decimal?

1 10000000 010000000000000000000000

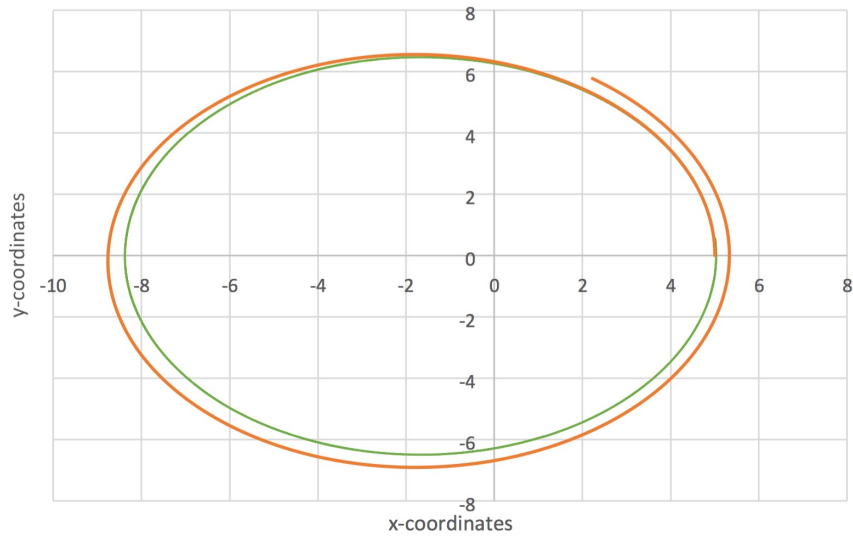
4) (5 pts) Write down a Fortran line that updates the variable 'Average' for computing the average of numbers you are reading in. Just one line, correct Fortran syntax.

5) (5 pts) Write a Fortran variable declaration that declares a two dimensional real array to store the state of 400,000 planets, where each planet can have x, y, and z coordinates and Vx, Vy, Vz velocities all in this array. The dimensions are ordered such that it minimizes computer cache misses. (Fixed size array here, do not use allocatable memory.)

6) (5 pts) How many bytes away from each other are the x-coordinates of two planets that are next to each other in the array? Assume the array is of type **real**.

7) (5 pts) In Big $O()$ notation, what are the computational complexities of Bubble Sort and Quick Sort?

8) (10 pts) QuickSort takes 2.1 seconds to sort 60,000 numbers. Bubble Sort takes 1.1 minutes. How long would it take to do 12 million numbers with each algorithm? Answer in appropriate units (one that a normal human does not have to stop and think how long this is).



9) (5 pts) The planet simulation with Forward Euler numerical solution produced the above two orbits. What kind of error dominates numerical simulations of differential equations? Circle One:

Rounding Error : Precision Error : Truncation Error

10) (5 pts) In the above orbits, one simulation was done with time step $h = 0.01$ and one was done with time step $h = 0.1$. Which one is which (Orange/Green)?

11) (5 pts) Rewrite this equation such that it is set up to be programmed as a fixed point method. Clearly indicate the equation $g(x)$.

$$2x^2 - 4x + 2 = 0$$

12) (5 pts) There is a root 'close' to 2. Pick one of your two equations from problem 11 and determine if you would converge on a root if your initial guess is 2. Use the convergence criterion.

16) (20 pts) Amino acids are organic compounds that contain amine and carboxyl functional groups, along with a side chain specific to each amino acid. The Table below shows the types of amino acids with their three and one letter codes.

Amino acid	Three letter code	One letter code
alanine	ala	A
arginine	arg	R
asparagine	asn	N
aspartic acid	asp	D
asparagine or aspartic acid	asx	B
cysteine	cys	C
glutamic acid	glu	E
glutamine	gln	Q
glutamine or glutamic acid	glx	Z
glycine	gly	G
histidine	his	H
isoleucine	ile	I
leucine	leu	L
lysine	lys	K
methionine	met	M
phenylalanine	phe	F
proline	pro	P
serine	ser	S
threonine	thr	T
tryptophan	trp	W
tyrosine	tyr	Y
valine	val	V

Find on Blackboard, a data file named ‘**ASequenceData.txt**’ of amino acids one letter codes. The first line has an integer which represents the total number of amino acids that follow, one per line.

Your task is to write a FORTRAN program that reads the file and counts the different number of amino acids present. Write your output to a file and present your results in a **table** and also make a **well labeled histogram plot** representing the amino acid types (The three letter code) on the horizontal axis and the amino acids counts on the vertical axis. Finally, write a short report and upload your code and report on blackboard.

13) (10 pts) Write the do loop for Newton's Method for root finding for the following equation. Do not write separate Fortran functions, just put the math in the do loop.

$$f(x) = x^2 + \cos(x) = 0$$

$$f'(x) = 2x - \sin(x) = 0$$

14) (10 pts) What is the **forward difference** approximation to the 1st derivative of the following function at $x = 3$ using a step size of $h = 0.5$ and a second answer using a step size $h = 0.1$? (No programming here, use the formula by hand just to get an answer.) **Circle** the one you think is most accurate to the actual derivative at 3. (Do the actual calculation using a calculator. Show your equations.)

$$y = x^2 + 2x - 13$$

15) (5 pts) Write a Fortran do loop that adds the **even** numbers from 2 to n. Just code the do loop. Assume n is already set.