Quiz 3 - Computational Physics II

NAME: Juan Daniel Vásquez ______________________ **SCORE:** 8/20

Date: Tuesday 6 May 2025 **Duration:** 45 minutes

Credits: 20 points (4 questions) **Type of evaluation:** LAB

Provide clear and concise answers to the following items.

1. **(5 points) High-performance computing**
   (a) List and briefly explain 3 key architectural differences between CPUs and GPUs.
   -0.5 (b) Provide 1 example of an application more suited for CPUs and 1 more suited for GPUs.

a) ① CPUs are optimized to give fast response to complex calculations, GPUs are good at simpler tasks but a lot of tasks.

② CPUs have normally 8 - 16 cores per CPU, and GPUs have a lot more "smaller" cores per GPU.

③ CPUs have L1, L2, L3 cache, and GPUs normally not more than L1, L2.

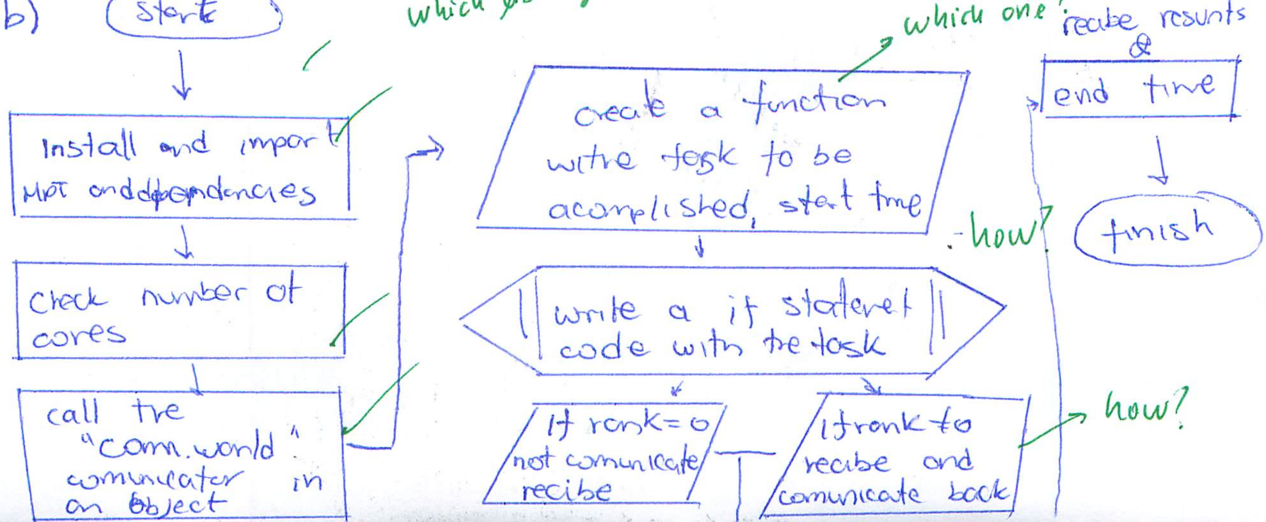
b) CPU: Summing the elements of a large vector can be devided on parts and parallelized how?

GPU: Multiplying a small vector time another but with different components every time can be parallelized on GPU ? → This can be done in CPUs.

2. **(5 points) MPI parallelisation**
   (a) Describe 1 difference between point-to-point and collective MPI communication.
   -2.5 (b) Sketch a workflow that clearly shows the main steps needed to parallelise python code using collective MPI communication.

a) Point - to - point communication localizes jobs into every core and then returns the information to the rank=0 core to collect the total task. collective comunication uses a collective workforce ? of the cores to complete a job and a constant communication

b) which library & functions are used?



-4 3. **(5 points) Partial Differential Equations (PDEs)**

(a) Explain the concept of a stencil in the context of numerically solving PDEs.

(b) Mathematically explain why the heat equation is used to study diffusion processes.

a) I don't really remeber well but referes to how we can use grids or maps to encounter a numerical solutions to the PDEs which we know have a very condensed space dependencies, this stencil can be a useful tool in discretising methods to a step sized job?  → These are stencils

b) $\frac{\partial f}{\partial t} = c \frac{\partial^2 f}{\partial x^2}$: Evolution in time is linearly compared to a slope in second order. this garantees to an easy convergence into BCs, therefore in diffusion problems when we know the BCs, and sometime ther are constants borders (0 (zeros)) its easier to solve numerically this kind?

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4. **(5 points) Discretisation and numerical stability**

Consider the one-dimensional heat equation with a positive thermal diffusivity ($c > 0$).

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(a) Write down the discrete equation that results from applying an implicit numerical scheme (first order in time, second order in space) on a uniform grid to the heat equation.

(b) Derive the stability condition for the above implicit scheme based on the amplification factor obtained from the von Neumann analysis.

$$\frac{\partial f}{\partial t} = c\frac{\partial^2 f}{\partial x^2} \qquad \frac{f(t-1) - f(t) + f(t+1)}{\Delta t} = \left(\sum_{j}^{N-1} \frac{c^{(n)}(-\Delta x)}{j!}\right)\left(\sum_{i}^{n-1} \frac{f(n+1) + f(x) - f(x-1)}{\Delta x^2} + \dots\right)$$

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Just had a mental lagoon. Dont remember I'm sorry.