Laboratory # 3

Goals

The goals of this lab are:

1. To familiarize you with the free-particle code.
2. To give you the opportunity to think about how to handle data leaving one process and entering another process.

During Lab: Team Development

1. As a team, discuss the plan for parallelization and the scaffolding provided in `mpiInfo.h`.
2. Together, complete the the design in `mpiInfo.h` by filling in the "`TO-DO in Lab`" code.
3. Also complete other "`TO-DO in Lab`" code, i.e., that in `fp.cpp`.
4. Demonstrate that the parallel code works on the case contained in `./run` in the `./codes/fp_mpi/src` directory. A sample command for running `fp` is:

   ```
   ./fp -nPEx 2 -nPEy 2 -nCellx 5  -nCelly 5 -flux 100. -vx_bdy 1. -npHat 10. -tEnd 1 -dt .01
   ```

   The inputs have the following meaning:

   - `nPEx`: Number of PEs in the $x-$ direction
   - `nPEy`: Number of PEs in the $y-$ direction
   - `nCellx`: Number of cells in the $x-$ direction on each PE
   - `nCelly`: Number of cells in the $y-$ direction on each PE
   - `flux`: The flux density in $\frac{C/m^2}{sec}$. Increasing this value causes particle injection to occur more often.
   - `npHat`: The density of particles entering the mesh. Increasing this value causes more particles to be injected, when injection occurs.
   - `vx_bdy`: The $x-$ velocity of the particles when injected.
   - `tEnd`: The final time of the simulation
   - `dt`: The time steps used to march up to `tEnd`.
5. If your particles disappear in a non-physical way, they protrude past the mesh, are not transferred correctly from one mesh to another, or behave in any other non-physical way, you will have to debug the code. Expect that. Here are some tips for debugging:

   - **Asymmetric Reduced Spatial Decomposition:** Run a 2x1 case, i.e., 2 PE in the $x-$ direction and 1 PE in the $y-$ direction. Looking at the resulting plots might help you find bugs.

- **Coarse Particle Testing:** Use far fewer particles and at a lower speed. Modify `./run` to use a much smaller flux, which will cause fewer injections, a smaller value for `npHat`, which causes fewer particles to be injected each time, and a smaller value for the injection velocity, which will allow you to track them more easily.
- **Decreased Domain Size:** Decrease the mesh size and injection velocity to track particles without excessive output.
- **Printing Values:** In combination with the above techniques, print the $x - y$ positions and velocities of each particle, by process. Sort the output into different files per process and compare them, looking for appropriate transfer of particle information between processes.

If you are unsuccessful getting the parallel version to work, for full credit you must exercise the above techniques, or similar techniques. Use the names listed in bold, above, in your report, with truncated output that demonstrates you have systematically worked through the debugging process. Even if you were ultimately not successful in finding your bug(s), you will receive full credit if you carry out and report on the debugging process professionally.

After Lab: Group Lab Report

Teams are to submit a joint report, individually. In other words, each person should submit a report, but that report should be the same for each member of the team. Be sure to put all team members' names on the report.

1. In the main body of the report:
   (a) A description of the implemented design, with illustrations. Your description should demonstrate that you clearly understand the design. Be sure to introduce the purpose and requirements of the lab so that your report is a stand-alone document.
   (b) Self-evaluation: What worked out well, what did not work out well
2. Also include two appendices:
   (a) The team's source code for the routine `ParticleExchange` in the mpiInfo class.
   (b) The team's results, in the form of the final time step's plot in the `./run` file's example problem. If the code did not work, discuss your debugging strategy and results.

Grading Rubric

Component	Expectations	Weight
Illustrated Intro & Design	1-2 pages	30%
Self-evaluation	Results, if obtained, in Appendix B, discussion of outcome	10%
Appendix A	Code listing with in-line comments	30%
Appendix B	Results or discussion of debugging procedure	30%