Programming task

Select **one** of the below programming exercises to complete **before** your interview.

1. The recommended language is Python, but you may use any open language, i.e. C, C++, Julia, etc, but not MATLAB.
2. Do not use any specialised finite element libraries, but you may use general purpose numerical libraries, e.g. NumPy, SciPy, MPI, mpi4py.
3. Focus on clarity and simplicity over generality and performance.
4. Use git when developing your solver and put your work on Bitbucket, GitHub or GitLab. Send a link to your repository to Chris Richardson (`cnr12@cam.ac.uk`) when you are ready to share your work. Ensure that the repository can be accessed.
5. Contact Chris Richardson (`cnr12@cam.ac.uk`) for any clarifications on the exercise.

Exercise 1 (MPI)

Create an MPI program that generates a set of M random integers (indices) in the range $[0, N)$, on each process (rank). The random number generator is seeded differently on each rank. For each index on a rank, the program must be able to compute which other ranks also have that index. Bear in mind that M and the number of ranks may be large.

Exercise 2 (finite element method)

Create a finite element solver to solve the Poisson equation

$$\begin{aligned} -\nabla^2 u &= f \quad \text{in } \Omega, \\ u &= 0 \quad \text{on } \partial\Omega, \end{aligned}$$

on the square domain $\Omega := (0, 1) \times (0, 1)$ using a structured mesh of four-noded quadrilateral Lagrange elements (see fig. 1 for an example mesh). Allow the number of elements to be varied in each direction. Compute a solution for $f = 4(-y^2 + y)\sin(\pi x)$ and plot the result.

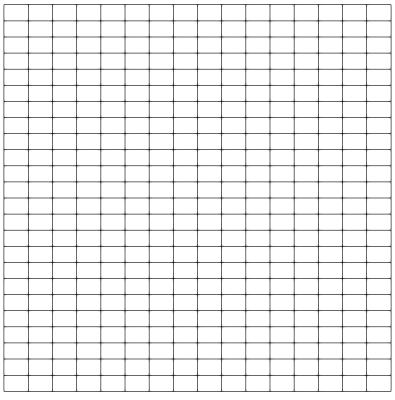

Figure 1: Sample mesh with quadrilateral cells.