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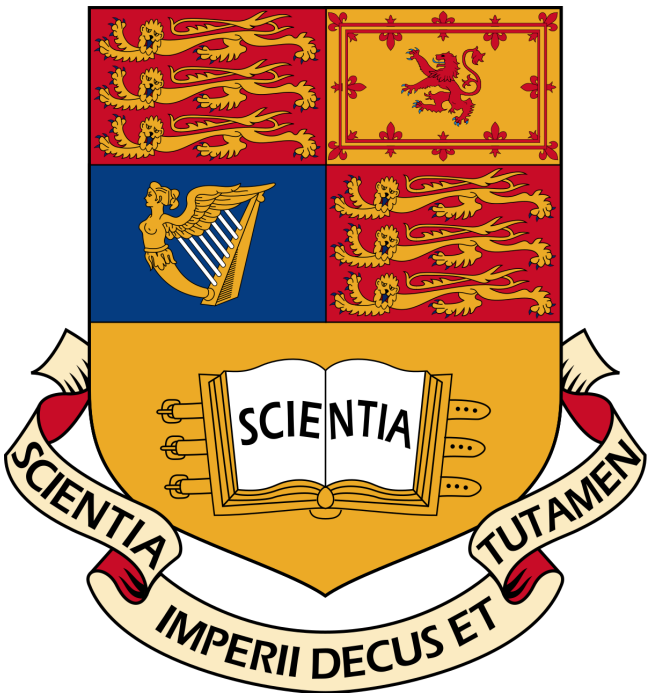
# High Performance Computing Coursework

Coursework Report

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|---|---|---|---|
| **Academic Responsibles:** | Dr. Chris Cantwell & Dr. Omar Bacarreza | **Student:** | Ion Berasaluce |
| **Department:** | Department of Aeronautics | **CID:** | 00950097 |
| **Course:** | A401 & A410 MEng in Aeronautics | **Due Date:** | 26/03/2017 |
| **Module:** | AE3-422 High Performance Computing | **Academic Year:** | 2016/2017 |

# Introduction

The aim of the coursework was to create a C++ code which would solve the displacements of a beam with symmetrical boundary conditions. Explicit and Implicit numerical schemes where considered, as well as the effect of parallelisation when solving large scale problems.

# Results

The figures below show the outcomes of the code for all tasks required.

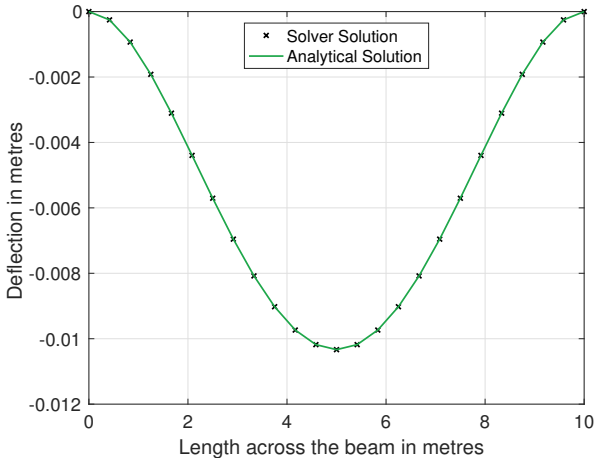


Figure 1: Full beam deflection with applied static load.

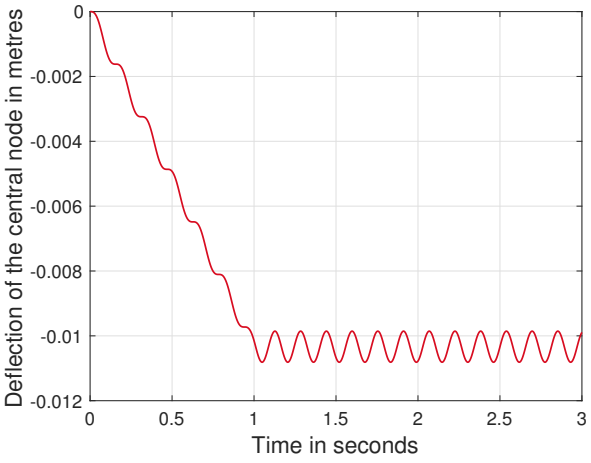


Figure 2: Central node deflection due to an applied dynamic load.

As can be seen from Figure 1 the analytical solution matches the solution obtained from the solver perfectly as expected. On the other hand, form Figure 2 it can be seen how the solution oscillates throughout, due to the nature of the explicit solver used.

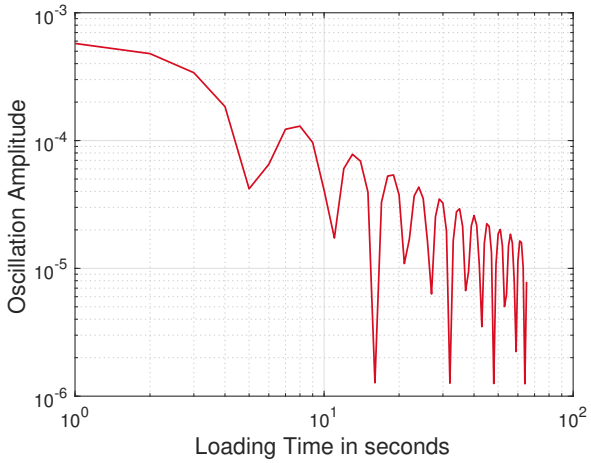


Figure 3: Log Log plot of the amplitude vs loading time for the explicit solver in serial used.

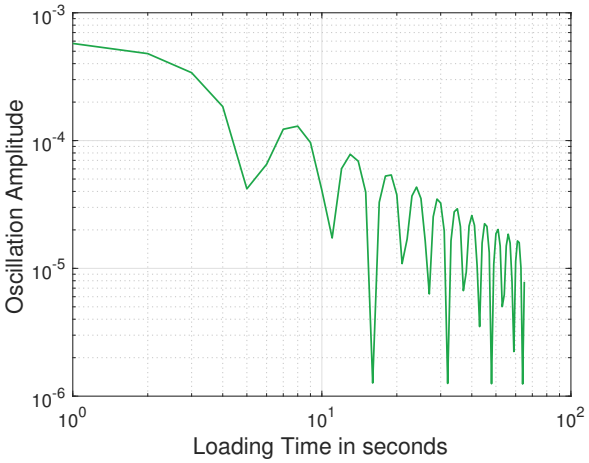


Figure 4: Log Log plot of the amplitude vs loading time for the implicit solver in serial used.

The log log plots show the exact same response, as expected. There a recurring pattern throughout where the amplitudes of the oscillations are minimal at loading times which are multiples of 16. Further analysis of these plots was deemed beyond the scope of this course.

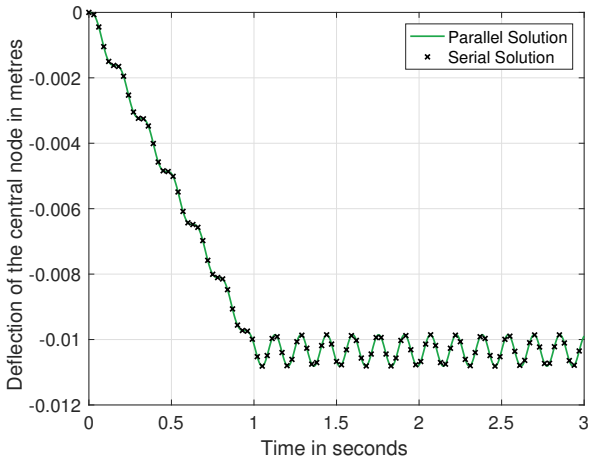


Figure 5: Central node deflection due to an applied dynamic load comparison between serial and parallel execution using an explicit solver

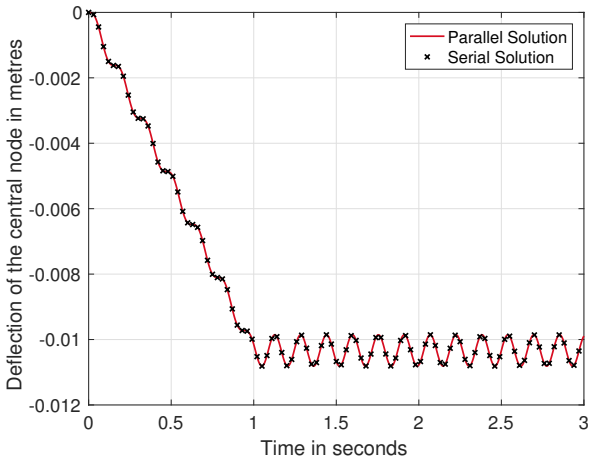


Figure 6: Central node deflection due to an applied dynamic load comparison between serial and parallel execution using an implicit solver

From Figure 5 & Figure 6 it can be seen that the same solution was reached using the serial and parallel implementation of the solvers.

Table 1: Performance of the Serial and Parallel implementations of the explicit integration schemes.

| No Processors | No elements | Timesteps | Time Taken (minutes) | % CPU |
|---|---|---|---|---|
| 1 | 960 | 20000000 | 20:21 | 93% |
| 2 | 960 | 20000000 | 11:09 | 92% & 99% |

Table 2: Performance of the Serial and Parallel implementations of the implicit integration schemes.

| No Processors | No elements | Timesteps | Time Taken (seconds) | % CPU |
|---|---|---|---|---|
| 1 | 960 | 200000 | 46.53 | 98% |
| 2 | 960 | 200000 | 56.54 | 96% & 98% |
| 4 | 960 | 200000 | 39.74 | 96% & 97% |
| | | | | 95% & 97% |

## Implementation

The aim of the task was to implement both the explicit and implicit integration schemes as efficiently as possible. Firstly, a symmetric, trigonometrical banded matrix was used for the stiffness matrix to avoid storing unnecessary data. On the other hand an extra row of zeros (top row) was included to simplify the implementation of SCALAPACK. Furthermore, the Mass matrix was simplified into a vector rather than the original diagonal matrix. To further optimise the routines used, values that where changed every iteration by the LAPACK or SCALAPACK solvers (`dpbsv` and `pdpbsv`) were pre-calculated and then copied every iteration thus saving computation time. When executing the parallel solver special care must be taken into account with the number of elements used. The problem was assumed to be symmetric and therefore will only run if $2^n$ elements are inputted, however an `if` statement was used to validate this condition. To further optimise the program, an in-depth analysis into the timesteps required can be performed, specially for the explicit integration schemes (implicit scheme is unconditionally stable). This was deemed to be beyond the scope of this course.