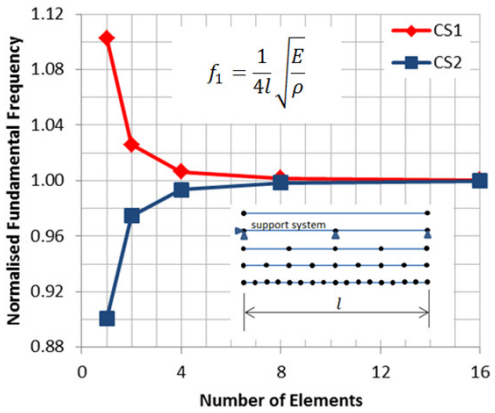
NAFEMS The NAFEMS Benchmark Challenge

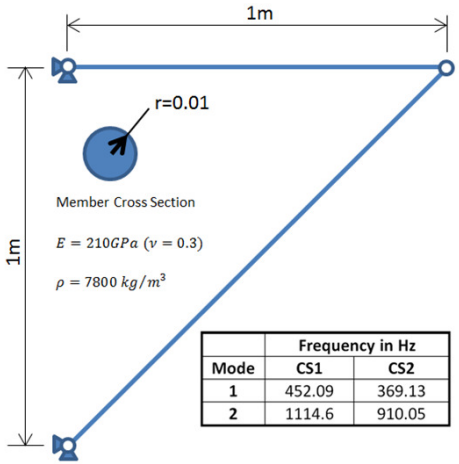
Dynamic Characteristics of a Truss Structure

In the final year of his engineering degree course a student was introduced to finite element analysis and conducted an assessment of a simple, planar, pin-jointed truss structure. This included a modal analysis to establish the natural frequencies of the structure. Being a cautious student he thought he'd better conduct some verification tests on the axial element used to model the truss structure. He found an analytical solution for a bar, fixed at one end and with uniform cross section and material properties. He conducted a convergence study on this test structure in two commercial finite element systems (CS1 and CS2) starting with a single element and then performing uniform mesh refinement until he reach a mesh with 16 elements. In his model he supported all nodes in the vertical direction and for the node at the left-hand end he also supported is against horizontal displacement. His results for the fundamental frequency are shown in figure 1. The frequencies have been normalised (divided) by the theoretical value which was obtained from the equation inset into the figure and he used the same elastic and inertial properties as for his truss structure.

The results worried him since, although he saw that the finite element programmes provided results that converge with mesh refinement to the theoretical solution, he also saw that a single element could be in excess of 10% in error and he realised that using different software would provide different approximations with CS1 giving an upper-bound and CS2 a lower-bound to the theoretical value. As his truss structure analysis had used single elements for each of the members he was concerned that the natural frequencies for the structure might be rather inaccurate.



(a) Test structure



	Frequency in Hz	
Mode	CS1	CS2
1	452.09	369.13
2	1114.6	910.05

(b) Truss structure

Figure 1: Student's structures and results

The Challenge

The challenge is to work with this student to understand why different finite element systems provide different approximations for coarse meshes and to provide some guidance on how he might obtain accurate frequencies for his truss structure.