School of Engineering
Brown University

EN1750: Advanced Mechanics of Solids

Homework 1: Introduction to finite element analysis

Due Friday Sept 21, 2018

1. Please answer the following general questions about finite element analysis

a. What is the difference between a static and a dynamic FEA computation (please limit your answer to a sentence!)

A static analysis solves **F**=**0;** a dynamic one solve **F**=m**a**.

[1 POINT]

b. What is the difference between the displacement fields in 8 noded and 20 noded hexahedral elements?

The displacements in 8 noded elements vary linearly between the nodes on the element; those on the 20 noded element vary quadratically.

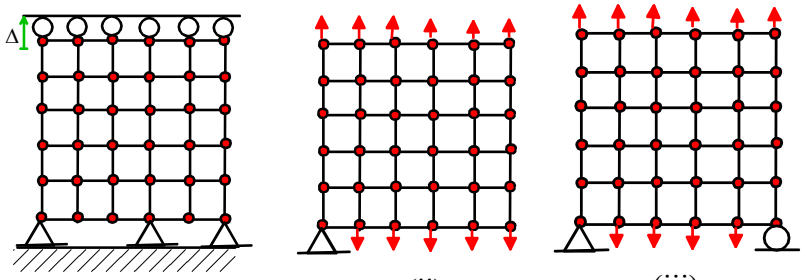
[1 POINT]

c. What is the key difference between the nodes on a beam element and the nodes on a 3D solid element?

Nodes on beam elements have rotational DOF, those on solid elements do not

[1 POINT]

d. Which of the boundary conditions shown below properly constrain the solid for a plane strain static analysis?



(i) (ii) (iii)

(i) and (iii) are fine; (ii) has an unconstrained rotational motion.

[1 POINT]

e. List three ways that loads can be applied to a finite element mesh

(i) Forces on nodes; (ii) pressure on element faces; (iii) body forces in the interior of elements. There are many other options…

[1 POINT]

f. In a quasi-static analysis of a ceramic cutting tool machining steel, which surface would you choose as the master surface, and which would you choose as the slave surface?

The stiffer solid is usually master surface – in this case the cutting tool.

[1 POINT]

g. You conduct an FEA computation to calculate the natural frequency of vibration of a beam that is pinned at both ends. You enter as parameters the Young's modulus of the beam *E*, its area moment of inertia *I,* its mass per unit length *m* and its length *L*. Work through the dimensional analysis to identify a dimensionless functional relationship between the natural frequency and other parameters. You can assume that only the product *EI* appears in the governing equations, (i.e. *E* and *I* are not separate parameters).

We have that $\omega_n = f(EI, m, L)$; the dimensions of the variables (in order) are 1/s, kg $m^{3/}s^2$, kg/m and m. It follows that

$$\omega_n \sqrt{\frac{mL^4}{EI}} = g(.)$$

(the (.) means the function has no argument, since there is no way to combine EI, m and L into a dimensionless group). Thus

$$\omega_n = C \frac{1}{L^2} \sqrt{\frac{EI}{m}}$$

where *C* is a constant. A single FEA simulation would tell us the behavior of all beams!

[2 POINTS]