UNIVERSITY OF NOTRE DAME
Department of Civil Engineering
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CE 60130 Finite Elements in Engineering **February 10^{th}, 2012**
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Homework Set #3

Problem 1

Consider the fourth order equation:

$$\frac{d^2}{dx^2}\left(EI\frac{d^2v}{dx^2}\right)+kv=P \qquad\qquad 0<x<1$$

Assume that EI, k amd P are constant (for simplicity).

a) Establish the essential and natural boundary conditions. Determine if the operator is self adjoint.

b) Generate the sequence of weak forms and identify the space requirements. Stop at the symmetrical weak form. Assume the essential boundary conditions are specified at $x=0$ and the natural boundary conditions at $x=1$. Use the weak Galerkin method. Comment on the functional continuity requirements for the various forms.

c) Develop the boundary and approximating functions for this case assuming that you are using a polynomial sequence.

d) Consider and solve the case for which:

- $k=7$; $EI=1$; and $P=12$ are constant.
- The essential boundary conditions are enforced at $x=0$. Assume they are homogeneous.
- The natural boundary conditions are specified at $x=1$. Assume they are also homogeneous.

Generate a number of solutions using the symmetrical weak form of the Galerkin scheme. Use a 1, 3, 6 and 10 term polynomial expansion.

e) Examine the error associated with the natural boundary conditions at $x=1$ for each of the three expansions.

Problem 2

Prove that the operator for the Laplace equation is self adjoint. Also find the essential and natural boundary conditions.