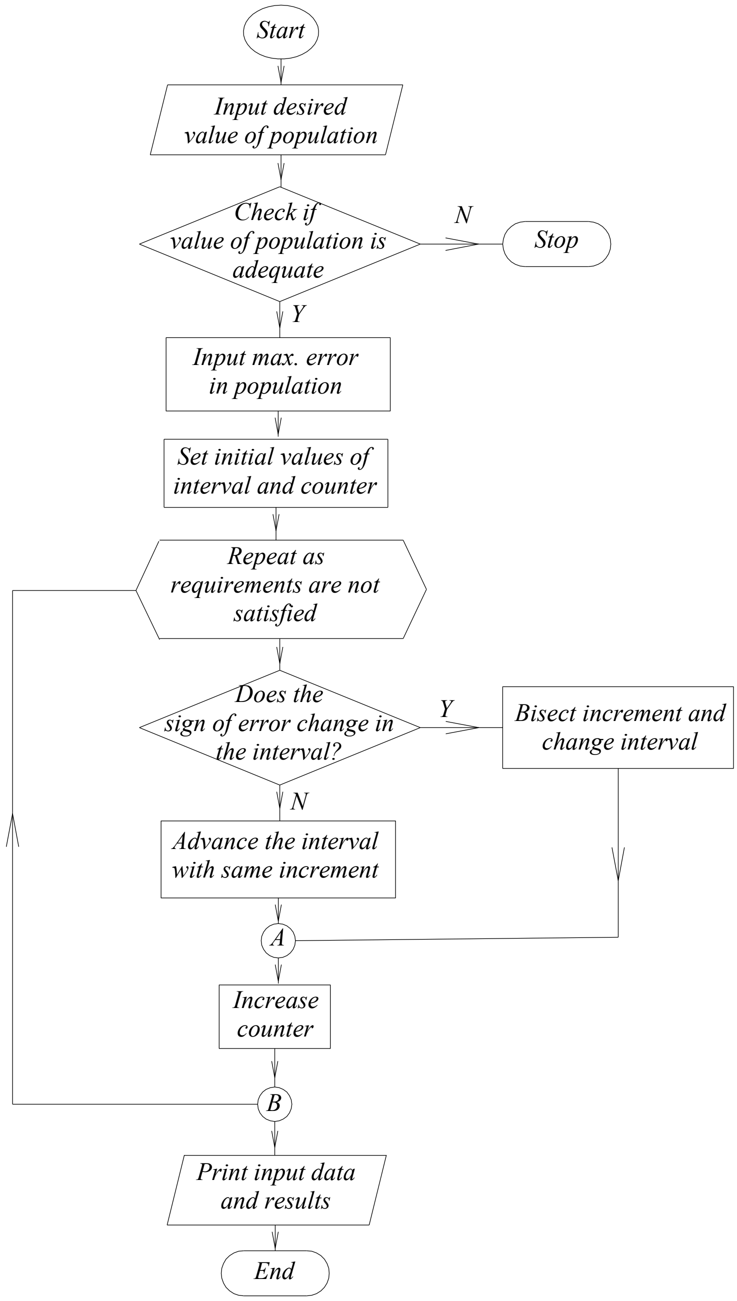
College of Maritime Engineering, and, Biological, Oceanic & NNRR. Sciences

Finite Elements

Final exam: Programming, Bars & Beams **Nov. 27th, 2017**

Student: ....

1.- The following is a mathematical model to predict the population of an small city as function of time t in years: $P(t) = \dfrac{260{,}000}{1 + 0.721 e^{-0.048t}}$. Next you have the flow chart to implement Bisection algorithm to find roots of functions:



You need to calculate the time for a city to reach a population of 205,000 citizens, with precision of 1 day, using the provided Visual Fortran project `Bisection`, which uses the Bisection algorithm, *but which includes some errors*. So, first describe the errors that you solve in the project:

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Answer: ……………………years (40)

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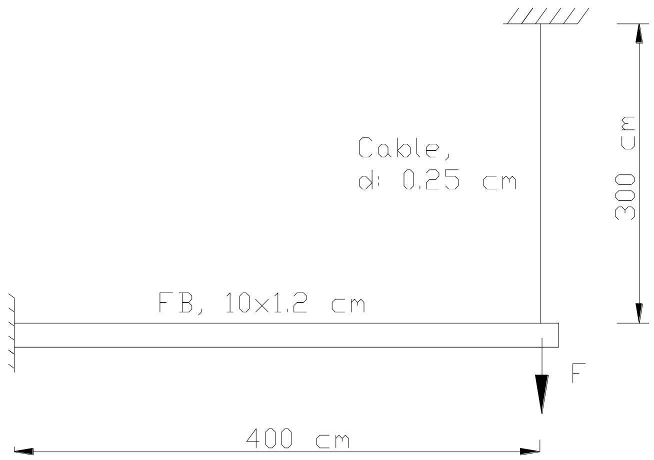
2.- Starting with the polynomials to interpolate the deflection of a beam element, defined with two joints, deduce the stiffness matrix applying Direct method. Polynomials N_i's are presented in the following page:

$$\tilde{v}(\hat{x})^{(e)} = \lfloor N_1(\hat{x}) \quad N_2(\hat{x}) \quad N_3(\hat{x}) \quad N_4(\hat{x}) \rfloor \begin{Bmatrix} \hat{d}_{1y} \\ \hat{\phi}_{1z} \\ \hat{d}_{2y} \\ \hat{\phi}_{2z} \end{Bmatrix}$$

(15)

3.- Consider a 4-m long steel beam which is clamped on its left end in a vertical wall, fabricated from a flat bar 10x1.2 cm, and, to increase its stiffness a steel cable 3 m long and 0.25 cm in diameter has been installed vertically on its right end, as shown in the figure. Considering the normal stress developed by the bending of the beam, applying the Finite Element method, what is maximum force F that may be applied to the system, taking a safety factor of 2.5? As a simplification, neglect the compression of the beam.



(45)

Useful formulations:

For a bar element, polynomials for interpolation are:

$$N_1(\hat{x}) = \left(1 - \frac{\hat{x}}{l}\right), \text{ and, } N_2(\hat{x}) = \frac{\hat{x}}{l}$$

For a beam element, polynomials for interpolation are:

$$N_1(\hat{x}) = \frac{1}{l^3}(2\hat{x}^3 - 3\hat{x}^2 l + l^3), \; N_2(\hat{x}) = \frac{1}{l^3}(\hat{x}^3 l - 2\hat{x}^2 l^2 + \hat{x} l^3), \quad N_3(\hat{x}) = \frac{1}{l^3}(-2\hat{x}^3 + 3\hat{x}^2 l), \quad \text{and,}$$

$$N_4(\hat{x}) = \frac{1}{l^3}(\hat{x}^3 l - \hat{x}^2 l^2)$$

Stiffness matrix for a bar-beam, in the plane:

$$[k]^{(e)} = \frac{E}{l}\begin{bmatrix} AC^2 + 12\frac{I}{l^2}S^2 & \left(A - 12\frac{I}{l^2}\right)CS & -6\frac{I}{l}S & -\left(AC^2 + 12\frac{I}{l^2}S^2\right) & -\left(A - 12\frac{I}{l^2}\right)CS & -6\frac{I}{l}S \\ & AS^2 + 12\frac{I}{l^2}C^2 & 6\frac{I}{l}C & -\left(A - 12\frac{I}{l^2}\right)CS & -\left(AS^2 + 12\frac{I}{l^2}C^2\right) & 6\frac{I}{l}C \\ & & 4I & 6\frac{I}{l}S & -6\frac{I}{l}C & 2I \\ & & & AC^2 + 12\frac{I}{l^2}S^2 & \left(A - 12\frac{I}{l^2}\right)CS & 6\frac{I}{l}S \\ & & & & AS^2 + 12\frac{I}{l^2}C^2 & -6\frac{I}{l}C \\ & & & & & 4I \end{bmatrix}$$

I certify that during this exam I have complied with the Code of Ethics of our university.

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