Project

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Exercice 1: Nonlinear Equations

Objective: Solve numerically $f(x) = 0$ in $[a, b]$ with f a nonlinear function.

1. By using the Dichotomie method.
2. By using the secant method (false position).
3. By using the Newton method.

Application: $f(x) = x^3 - x + 1; x \in [-2, 0]$

Remarque: For the question 2) and 3), we will represent in the same figure the curve of te function f, and of the secant for 2) and tangent for 3). (First and last).

Exercice 2: Finite Difference Method

Objective: Solve an evolution equation by finite difference with a explicit scheme and a implicit scheme.

$$(P)\begin{cases} \dfrac{\partial u}{\partial t}(x,t) - \dfrac{\partial^2 u}{\partial x^2}(x,t) = 0 & , x \in [0,1], t \in [0,1] \\ u(0,t) = 0 \\ u(1,t) = 0 \\ u(x,0) = \sin \pi x \end{cases}$$

1. Explicit scheme. Show that the scheme is uncondionally stable. Give the condition for stability.
   Choose N (number of subdivision of the space) and M (number of subdividing of the time) for the scheme is stable.

2. Implicit scheme. Taking the values giving an unstable explicit scheme, show that the implicit scheme is uncondionally stable.

Exercice 3: Finite Element Method

1. Solve in the domain $[0,1]$, l'équation

$$\begin{cases} u''(x) &= 1 \\ u(0) &= 0 \\ u'(1) &= 0 \end{cases}$$

   Use three elements whose nodes are

$$x = 0; \quad x = 0.5; \quad x = 0.75; \quad \text{and } x = 1$$

2. Give the variational formulation.

3. Give the variational problem on each element.

4. Give the elementary matrix and the elementary second matrix for each element.

5. Assemble to get the global matrix and the second global member.

6. Solve the system global.