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(*****************************************************************)
(*                                                               *)
(* Generalized Collocation Methods:Solutions to Nonlinear Problems *)
(* Bellomo,N.,Lods,B.,Revelli,R.,Ridolfi,L.                      *)
(* A Birkhäuser book                                             *)
(* ISBN:978-0-8176-4525-0                                        *)
(*                                                               *)
(* Program OneDLaSiInt                                           *)
(*                                                               *)
(*****************************************************************)

OneDLaSiInt[function_, nodes_] :=
 Module[{},
  φ[x_] := function;

  (*** Definition of the equispaced and Chebyshev collocation ***)

  hh = 1/(nodes - 1);
  x_i_ := (i - 1) * hh;
  x1_i_ := -1/2 (Cos[(i - 1) * π/(nodes - 1)] - 1);

  (*** Lagrange polynomial with Chebyshev collocation ***)
     Lagr1[j_, x_] := Product[(If[p ≠ j, (x - x1_p)/(x1_j - x1_p), 1]), {p, 1, nodes}];

     FunctionLagr1[x_] := Sum[((φ[x] /. x → x1_k) * Lagr1[k, x]), {k, 1, nodes}];
  (*** Sinc function ***)
     Sinc[j_, x_] := Which[0 ≤ x ≤ 1 && x ≠ (j - 1) * hh,
    Sin[π * (x - (j - 1) * hh)/hh] / (π * (x - (j - 1) * hh)/hh), x == (j - 1) * hh, 1];
     FunctionSinc[x_] := Sum[(φ[x] /. x -> x_k) * Sinc[k, x], {k, 1, nodes}];

  (*** Derivative Values ***)


  Initder1Lagr1[x_] := (Sum[((φ[x] /. x -> x1_k) * D[Lagr1[k, x], x]), {k, 1, nodes}]);

  Initder2Lagr1[x_] := (Sum[((φ[x] /. x -> x1_k) * D[Lagr1[k, x], {x, 2}]), {k, 1, nodes}]);


  Initder1Sinc[x_] := (Sum[((φ[x] /. x -> x_k) * D[Sinc[k, x], x]), {k, 1, nodes}]);

  Initder2Sinc[x_] := (Sum[((φ[x] /. x -> x_k) * D[Sinc[k, x], {x, 2}]), {k, 1, nodes}]);


  Plot[Evaluate[{φ[x], FunctionLagr1[x], FunctionSinc[x]}], {x, 0, 1}, PlotRange → All,
   PlotStyle → {Dashing[{0.0}], {Dashing[{0.001, 0.005}]}, {Dashing[{0.02, 0.008}]}},
   FrameLabel → {"x", "v(x)"}, AxesOrigin → {0, -1.12}, Frame → True,
   FrameTicks → {{{0, 0, .02}, {0.5, 0.5, .02}, {1, 1, 0.02}},
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      {{-1, -1, .02}, {0, 0, .02}, {1, 1, 0.02}}, None, None}];

   Plot[Evaluate[{(∂x φ[x]), Initder1Lagr1[x], Initder1Sinc[x]}], {x, 0, 1}, PlotRange →
     All, PlotStyle → {Dashing[{0.0}], Dashing[{0.001, 0.005}], Dashing[{0.02, 0.008}]},
    FrameLabel → {"x", "vx (x)"}, Frame → True,
    FrameTicks → {{{0, 0, .02}, {0.5, 0.5, .02}, {1, 1, 0.02}},
      {{-10, -10, .02}, {0, 0, .02}, {10, 10, 0.02}}, None, None}];

   Plot[Evaluate[{(∂x,x φ[x]), Initder2Lagr1[x], Initder2Sinc[x]}],
    {x, 0, 1}, PlotRange → {{-0.01, 1}, {-410, 410}},
    PlotStyle → {Dashing[{0.0}], Dashing[{0.001, 0.005}], Dashing[{0.02, 0.008}]},
    FrameLabel → {"x", "vxx (x)"}, Frame → True,
    FrameTicks → {{{0, 0, .02}, {0.5, 0.5, .02}, {1, 1, 0.02}},
      {{-400, -400, .02}, {0, 0, .02}, {400, 400, 0.02}}, None, None}];

  ];

{function, nodes} = {Exp[-2 (10 x - 5)^2], 21};
OneDLaSiInt[function, nodes]

{function, nodes} = {Tanh[10 x - 5.] + 0.2 Sin[π (10 x - 5.)], 21};
OneDLaSiInt[function, nodes]
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