## Functions

**Function**: func_1

Solve $y = f(x)$

**Input**
- xdata: ndarray (n x 1)

**Output**
- ndarray (n x 1)

**Function**: func_2

Solve $y_i = f(x)$

**Input**
- xdata: ndarray (n x 1)

**Output**
- ndarray (2 x n x 1)

**Function**: func_3

Solve $y_i = f(x)$

**Input**
- xdata: ndarray (n x 1)

**Output**
- ndarray (3 x n x 1)

**Function**: func_4

Solve $y_i = f(x_i, x_j)$

**Input**
- xdata: ndarray (2 x 1 x n x m)

**Output**
- ndarray (n x m x 2 x 1)

**Function**: func_5

Solve $y_i = f(x_i, x_j)$

**Input**
- xdata: ndarray (2 x 1 x n x m)

**Output**
- ndarray (n x m x 3 x 1)

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**Start**

xdata
function

**Function**: plotter

Compute injected function and make line or contour plot(s) for resulting ydata

**Input**
- xdata: ndarray of shape...
  - (n) – 1D
  - (n x 1) – 2D column vector
  - (2 x n x m) – 2D grid

**Output**
- Figures

xdata
ydata

Figure(s)

xdata

ydata

Invoke function

**Generic 2D element class**

**self.shape_n*i***
Compute the value of the shape function for node $i$ as a function of position within the element in terms of the natural coordinate system $\boldsymbol{\eta}$

$\boldsymbol{\eta} = (\boldsymbol{\eta_1}, \boldsymbol{\eta_2})$

**self.N**
Compute the shape function matrix **N** for a 2D element with $k$ nodes in terms of the natural coordinate system $\boldsymbol{\eta}$

$$\mathbf{N}(\boldsymbol{\eta}) = \begin{bmatrix} N_1(\boldsymbol{\eta}) & 0 & \cdots & N_k(\boldsymbol{\eta}) & 0 \\ 0 & N_1(\boldsymbol{\eta}) & \cdots & 0 & N_k(\boldsymbol{\eta}) \end{bmatrix}$$

$N_i(\boldsymbol{\eta})$

$[N_1, N_2, .., N_k]$

**self.get_shape_funcs**
Return a list of $k$ shape functions for the element ordered by local node number

**plot_shape_functions**
Plot the value of each shape function for the element $N_i$ in either the natural ($\boldsymbol{\eta}$) or local ($\boldsymbol{x}$) coordinate systems for a p x p grid of coordinates

$\boldsymbol{\phi}(\boldsymbol{\eta})$: $\boldsymbol{\eta}$ or $x$ positions within the element

$N_i(\boldsymbol{\eta})$ or $N_i(x)$ within the element

Figure(s)

$\boldsymbol{\eta} = (\boldsymbol{\eta_1}, \boldsymbol{\eta_2})$

$\mathbf{N}(\boldsymbol{\eta})$

$p$: $grid\ size$
$coord.\ sys$

**self.interpolate**
Interpolate the value of quantity $\boldsymbol{\phi}$ as a function of position within the element given a vector of nodal values $\widehat{\boldsymbol{\phi}}$ for a grid of p coordinates in the natural coordinate system $\boldsymbol{\eta}$ using shape functions

$$\boldsymbol{\phi}(\boldsymbol{\eta}) = \mathbf{N}(\boldsymbol{\eta})\widehat{\boldsymbol{\phi}}$$

**Generic 2D element class**

**self.shape_n*i***

Compute the value of the shape function for node *i* as a function of position within the element in terms of the natural coordinate system $\boldsymbol{\eta}$

$\boldsymbol{\eta} = (\boldsymbol{\eta_1}, \boldsymbol{\eta_2})$

$N_i(\boldsymbol{\eta})$

**self.N**

Compute the shape function matrix $\mathbf{N}$ for a 2D element with $k$ nodes in terms of the natural coordinate system $\boldsymbol{\eta}$

$$\mathbf{N}(\boldsymbol{\eta}) = \begin{bmatrix} N_1(\boldsymbol{\eta}) & 0 & \cdots & N_k(\boldsymbol{\eta}) & 0 \\ 0 & N_1(\boldsymbol{\eta}) & \cdots & 0 & N_k(\boldsymbol{\eta}) \end{bmatrix}$$

$[N_1, N_2, .., N_k]$

**self.get_shape_funcs**

Return a list of $k$ shape functions for the element ordered by local node number

$\mathbf{N}(\boldsymbol{\eta})$

**self.interpolate**

Interpolate the value of quantity $\boldsymbol{\phi}$ as a function of position within the element given a vector of nodal values $\widehat{\boldsymbol{\phi}}$ for a grid of p coordinates in the natural coordinate system $\boldsymbol{\eta}$ using shape functions

$$\boldsymbol{\phi}(\boldsymbol{\eta}) = \mathbf{N}(\boldsymbol{\eta})\widehat{\boldsymbol{\phi}}$$

$\boldsymbol{\eta} = (\boldsymbol{\eta_1}, \boldsymbol{\eta_2})$

$\boldsymbol{\phi}(\eta)$: displacements within the element
$\boldsymbol{\phi}(\eta)$: $\eta$ or $x$ positions within the element

**plot_element_field**

Plot the value of interpolated quantity $\boldsymbol{\phi}$ within the element in either the natural ($\boldsymbol{\eta}$) or local ($\boldsymbol{x}$) coordinate systems for a p x p grid of coordinates given a given a vector of nodal values $\widehat{\boldsymbol{\phi}}$

$\boldsymbol{\phi}(\boldsymbol{\eta})$ or $\boldsymbol{\phi}(\boldsymbol{x})$: displacements within the element

Figure(s)

$p$: *grid size*
*coord. sys*
$q$: *nodal values*