

ME2 Computing- Session 1: Revision of arrays and introduction to Numpy, graphics

Learning outcomes:

- Regain confidence with concepts of arrays and their implementation
- Be able to implement and manipulate arrays with Numpy formalisms
- Get familiar with advanced graphics tools and techniques
- Be able to choose appropriate array representation for vector field analysis

Before you start

In your H drive create a folder `H:\ME2MCP\Session1` and work within it.

Task A: Generate an array with a non-uniform range

1. Generate an array x of numbers in the range $[-5 : 5]$ with the following steps:

$$\Delta x = 0.5 \text{ in } -5 \leq x \leq -2$$

$$\Delta x = 0.05 \text{ in } -2 < x < 3$$

$$\Delta x = 0.5 \text{ in } 3 \leq x \leq 5$$

2. Compute the function: $y = \sin(x)$.
3. Plot, with scattered points, y vs x .

Task B: Multi-dimensional arrays

1. Represent with appropriate variables the two functions:

$$f(x, y) = \sin x \cdot \cos y$$

$$g(x, y) = \cos x \cdot \sin y$$

in the range $x = [-2\pi : 2\pi]$ and $y = [-\pi : \pi]$ with steps $\Delta x = \Delta y = 0.1$.

2. Compute the two functions:

$$s(x, y) = f(x, y) + g(x, y)$$

$$p(x, y) = f(x, y) \cdot g(x, y)$$

Task C: Surface plots

1. Plot, both with a surface plot and a contour plot separately, the functions $s(x, y)$ and $p(x, y)$ of Task B.

2. Consider the function:

$$r(x, y, t) = f(x, y) \cdot e^{-0.5t}$$

in the same range of x and y as in Task B and $t = [0 : 10]$ with $\Delta t = 0.05$.

3. Plot, with a surface plot, $r(x, y, t = 0)$ and $r(x, y, t = 5)$.

Task D: Vector plots

From Maths tutorial sheet:

Sketch the following vector fields (xy-plane only) and calculate their divergence and curl. Are they conservative?

(a) $\mathbf{f}(x, y, z) = x\mathbf{i} + y\mathbf{j}$

(b) $\mathbf{f}(x, y, z) = y\mathbf{i} - x\mathbf{j}$

(c) $\mathbf{f}(x, y, z) = \frac{y}{x^2+y^2}\mathbf{i} - \frac{x}{x^2+y^2}\mathbf{j}$

1. Represent with appropriate variables the vector fields $\mathbf{f}(x, y, z)$ in the range $x = y = [-5 : 5]$ with intervals $dx = dy = 0.1$.
2. Plot as quivers and streamlines the three $\mathbf{f}(x, y, z)$, and observe whether the fields are conservatives, irrotational, etc.

Task E: Bonus (a bit challenging) Slicing with conditions

1. Compute, with vectorised operations, the value:

$$ym = |y| = |\sin(x)|$$

in the range $x = [-5 : 5]$ with $dx = 0.1$.

2. Compose the array $ymsat$ such that:

$$\begin{cases} ymsat = 0 & \text{for } -5 \leq x \leq 0 \\ ymsat = ym & \text{for } x > 0 \text{ and } ym \leq 0.5 \\ ymsat = 0.5 & \text{for } x > 0 \text{ and } ym > 0.5 \end{cases}$$