CAD Laboratory (CE4P001) — Assignment 1

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by

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Question 1: Scalar Field of Hill Height

(a) Plotting the Scalar Field

The scalar function $h(x, y) = 200 - x^2 - 2y^2$ is defined to represent hill elevation.

Grids for x and y are generated using step-based ranges, forming a mesh over which the height values are computed.

Surface and contour visualizations are produced using Plots.jl to illustrate the 3D terrain and its level curves.

(b) Automatic Gradient Evaluation

The CalculusWithJulia.jl package is used to compute gradients automatically.

The height function is rewritten as h(x) where x is an array input.

The gradient is obtained using gradient(h, [x, y]).

Vector components are assigned to u and v across the grid and plotted using quiver() to show gradient directions.

(c) Manual Gradient Evaluation

The gradient is also determined manually by computing partial derivatives: $[-2x, -4y]$.

Results are evaluated on the grid and plotted.

Both manual and automatic gradients match, confirming correctness.

Question 2: Cyclone Velocity Field

(a) Plotting the Vector Field

The wind velocity field vel(v) = $[v_1, -v_2^2]$ is evaluated over a structured grid.

A quiver plot depicts directional and magnitude variations.

(b) Divergence Calculation

Automatic divergence is computed using divergence(vel, [x, y]).

Manually, $\partial v_1/\partial x = 1$ and $\partial v_2/\partial y = -2y$, giving divergence = $1 - 2y$.

Both results are plotted and found identical.

(c) Curl Calculation

Curl is computed automatically and manually using $\partial v_2/\partial x - \partial v_1/\partial y$.

The z-component evaluates to zero everywhere, showing the field is irrotational.

Numerical and plotted results match perfectly.

Question 3: Water Flow Velocity Field

(a) Plotting the Vector Field

The water velocity field $f(x, y) = [e^x y^2, x + 2y]$ is defined and evaluated on a grid.

Component matrices feed into a quiver plot for visualization.

(b) Divergence Calculation

Automatic divergence is computed through divergence().

Manually, $\partial(e^x y^2)/\partial x = e^x y^2$ and $\partial(x + 2y)/\partial y = 2$, giving total divergence $e^x y^2 + 2$.

Both methods align.

(c) Curl Calculation

Automatic and manual curl calculations yield curl = $1 - 2y\, e^x$.

Plots confirm equivalence and correctness.

Question 4: Beam Problem 1

For a beam with length l and uniform load q, reactions at supports are determined using static equilibrium.

A linear space x1 spans 0 to l for the main span.

Shear force is evaluated using $V = V_A - qx$, and bending moment using $M = V_A x - qx^2/2$.

For the overhang part, an additional x2 range spans 0 to 0.25l.

Expressions for shear and moment incorporate both reactions and overhang loading.

Plots of SFD and BMD are generated by combining x1 with l + x2 and their corresponding shear/moment values.

Question 5: Beam Problem 2

The beam with hinge and roller supports is analyzed using equilibrium and hinge conditions.

Reactions V_A, V_B, H_C, and V_C are obtained.

Regions are divided into three segments: from A to load, load to B, and UDL span.

Shear and moment expressions are written for each region using appropriate load distribution and geometry.

Combined ranges x1, x2, and x3 allow plotting of SFD and BMD across the entire beam.