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% Optimization Homework3 Problem2

% Problem2(a)

% Define the function f
f = @(x1, x2) x1.^2 + 5*x2.^2 + 4*x1.*x2 - 6*x1 - 14*x2 + 20;

% Define the gradient of f in terms of x1 and x2
grad_f = @(x1, x2) [2*x1 + 4*x2 - 6; 10*x2 + 4*x1 - 14];

% Initial value
x = [10; 10];
% Tolerance
epsilon = 1e-6;
% Counter of iterations
iterations = 0;

% Store the values during iterations
results = [];
% Store the path of iterations
iterate_history = x';

while norm(grad_f(x(1), x(2))) > epsilon

    % Compute the gradient at current point x=(x1, x2)
    d_k = -grad_f(x(1), x(2));

    % According to Problem1
    % Minimize f(x_k + alpha * d_k) with respect to alpha
    % Symbol variable declaration
    syms alpha_sym;
    % Establish the function f_alpha = f(x_k + alpha * d_k)
    f_alpha = f(x(1) + alpha_sym * d_k(1), x(2) + alpha_sym * d_k(2));
    % Calculate the derivative of f_alpha with respect to alpha
    df_alpha = diff(f_alpha, alpha_sym);
    % Find optimal alpha when df_alpha=0
    alpha_k = double(solve(df_alpha == 0, alpha_sym));

    % Update x
    x = x + alpha_k * d_k;

    % Store results
    results = [results; x(1), x(2), d_k(1), d_k(2), norm(d_k), alpha_k,
    f(x(1), x(2))];

    % Store the path for plotting
    iterate_history = [iterate_history; x'];
    % Iteration counter
    iterations = iterations + 1;

end

% Create a table with the results

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result_table = array2table(results, 'VariableNames', {'xk1', 'xk2', 'dk1',
'dk2', 'Norm_dk', 'alpha_k', 'f_xk'});

% Display the table
disp(result_table);

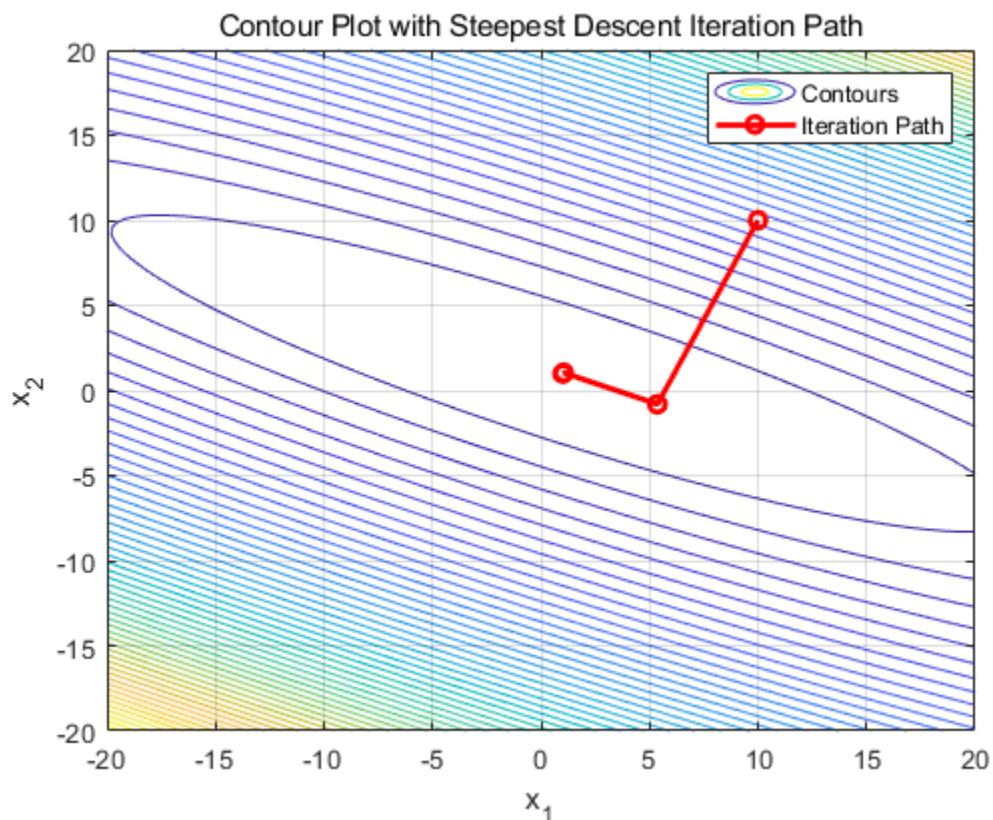
% Plot the contour of the function and the iteration path
[x1_vals, x2_vals] = meshgrid(-20:0.1:20, -20:0.1:20);
f_vals = f(x1_vals, x2_vals);

figure;
contour(x1_vals, x2_vals, f_vals, 50);
hold on;
plot(iterate_history(:, 1), iterate_history(:, 2), '-ro', 'LineWidth', 2,
'MarkerSize', 6);
xlabel('x_1');
ylabel('x_2');
title('Contour Plot with Steepest Descent Iteration Path');
grid on;
legend('Contours', 'Iteration Path');



| xk1      | xk2      | dk1         | dk2         | Norm_dk    |
|----------|----------|-------------|-------------|------------|
| alpha_k  | f_xk     |             |             |            |
| 5.3669   | -0.81065 | -54         | -126        | 137.08     |
| 0.085799 | 13.834   |             |             |            |
| 1.0426   | 1.0426   | -1.4911     | 0.63905     | 1.6223     |
| 2.9      | 10.018   |             |             |            |
| 1.0207   | 0.99143  | -0.25562    | -0.59645    | 0.64892    |
| 0.085799 | 10       |             |             |            |
| 1.0002   | 1.0002   | -0.0070586  | 0.0030251   | 0.0076795  |
| 2.9      | 10       |             |             |            |
| 1.0001   | 0.99996  | -0.00121    | -0.0028234  | 0.0030718  |
| 0.085799 | 10       |             |             |            |
| 1        | 1        | -3.3413e-05 | 1.432e-05   | 3.6353e-05 |
| 2.9      | 10       |             |             |            |
| 1        | 1        | -5.728e-06  | -1.3365e-05 | 1.4541e-05 |
| 0.085799 | 10       |             |             |            |


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