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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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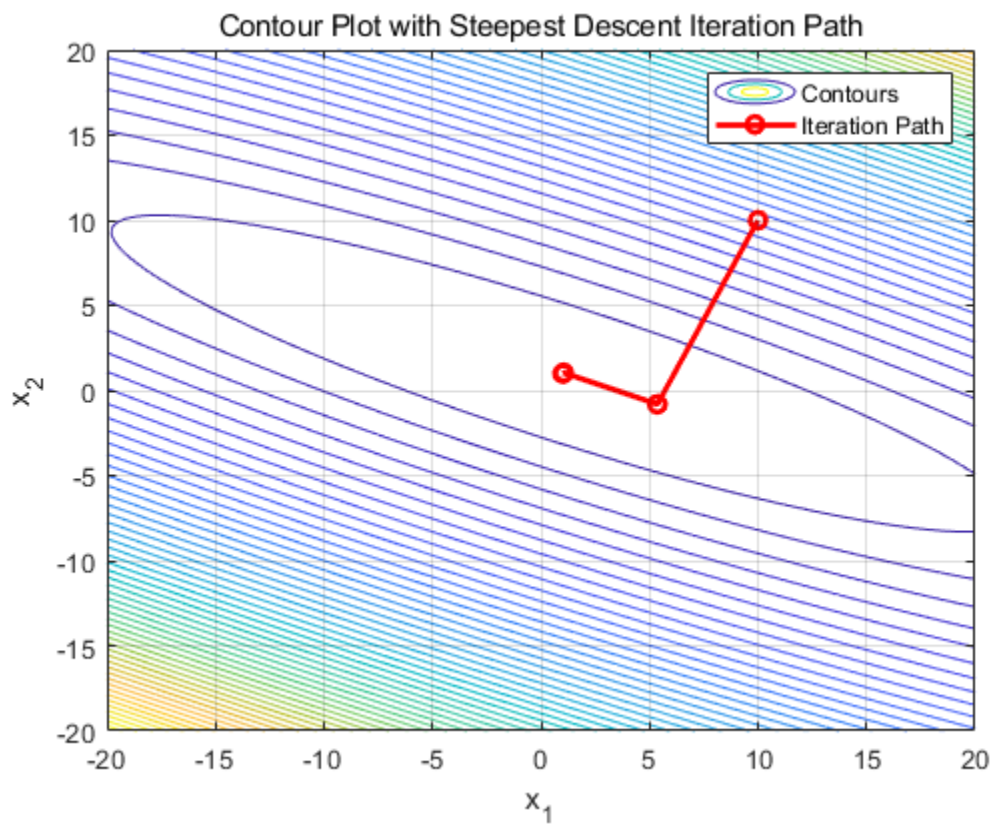
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result_table = array2table(results, 'VariableNames', {'xk1', 'xk2', 'dk1',  
'dk2', 'Norm_dk', 'alpha_k', 'f_xk'});
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% Display the table  
disp(result_table);
```

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% 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);
```

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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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