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## Homework Introduction

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```
% Geneva Porter, 2019.09.26
% Homework 1, Math 693A
% Professor Uduak George, SDSU

% This assignment programs the steepest descent and Newton algorithms using
% the backtracking line search to minimize the Rosenbrock function:
%
%           f(x) = 100(x2-x1^2)^2 + (1-x1)^2
%
% The initial step length is alpha_0 = 1, and each step length used by each
% method is reported at each iteration. First, the initial point (1.2,1.2)
% is used, then the more difficult point (-1.2, 1) is used for each method.
% The suggested values of alpha, rho, and c are used, as shown below. Since
% we know that the minimum of the function is (0,0) from straightforward
% analysis, the iteration stops when the absolute value of f or the norm of
% the gradient is less than our tolerance, 10^(-8). Only the initial
% values, the first 10 iterations, and the last iteration are shown in the
% output. The function backtrack_line_search contains the algorithm that
% produces these results.
```

## Establishing Parameters

---

```
clear
clc

alpha      = 1.0;
rho        = 0.5;
c          = 1e-4;

tolerance  = 10e-8;

param = [alpha, rho, c, tolerance];

p1        = [ 1.2; 1.2];
p2        = [-1.2; 1.0];
```

## Setting Up Functions

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```
x      = sym('x', [2,1]);
f(x) = 100*(x(2) - x(1)^2)^2 + (1 - x(1))^2;

NE = "Newton";
SD = "steepest descent";
```

**Iterating Methods and Printing Results:**

```

SD_point1 = backtrack_line_search(SD, f, p1, param);
figure(1)
plot_search(SD_point1, SD, f, [1 1.25 1 1.3]);

SD_point2 = backtrack_line_search(SD, f, p2, param);
figure(2)
plot_search(SD_point2, SD, f, [-1.5 1 0 1.5]);

newton_point1 = backtrack_line_search(NE, f, p1, param);
figure(3)
plot_search(newton_point1, NE, f, [1 1.3 1 1.5]);

newton_point2 = backtrack_line_search(NE, f, p2, param);
figure(4)
plot_search(newton_point2, NE, f, [-2 2 0 1.5]);

```

8013 iterations using steepest descent method,  
starting at point (1.2, 1.2):

Columns 1 through 3

'x_1'	'x_2'	'f(x_0)'
[1.2000000000000000]	[1.2000000000000000]	[ 5.8000000000000000]
[1.084556380218966]	[1.247935067037108]	[ 0.520844867766157]
[1.112908489938083]	[1.234792754665416]	[ 0.014171542193907]
[1.111092579236144]	[1.235511896924088]	[ 0.012438618590703]
[1.111453064010314]	[1.235182550136198]	[ 0.012423898527980]
[1.110967259744601]	[1.235231670340972]	[ 0.012410443854420]
[1.111327595548179]	[1.234902160572132]	[ 0.012395990435597]
[1.110841835172505]	[1.234951712933593]	[ 0.012382370390347]
[1.111202102896445]	[1.234622128731623]	[ 0.012368097637211]
[1.110716376613773]	[1.234672014174615]	[ 0.012354380581293]
...	...	...
[1.000272818224001]	[1.000529720003345]	[1.000005898847002e-07]
[1.000258958836932]	[1.000536103422000]	[9.988836636352177e-08]

Columns 4 through 6

'p_k1'	'p_k2'	'alpha'
[-0.923548958248274]	[ 0.383480536296861]	[ 0.1250000000000000]
[ 0.907267511011768]	[-0.420553995894121]	[ 0.0312500000000000]
[-0.929746279393009]	[ 0.368200836439648]	[ 0.0019531250000000]
[ 0.738272817500003]	[-0.674502221597978]	[4.882812500000000e-04]
[-0.994927136179316]	[ 0.100598179377284]	[4.882812500000000e-04]
[ 0.737967725727935]	[-0.674836006585258]	[4.882812500000000e-04]
[-0.994837249380811]	[ 0.101483236272901]	[4.882812500000000e-04]
[ 0.737828298629528]	[-0.674988445635521]	[4.882812500000000e-04]
[-0.994767426913563]	[ 0.102165387249150]	[4.882812500000000e-04]
[ 0.737795836220382]	[-0.675023928506144]	[4.882812500000000e-04]
...	...	...
[-0.908288790967811]	[ 0.418343724946642]	[1.525878906250000e-05]
[ NaN]	[ NaN]	[ NaN]

8776 iterations using steepest descent method,  
starting at point (-1.2, 1):

Columns 1 through 3

'x_1'	'x_2'	'f(x_0)'
[-1.2000000000000000]	[1]	[24.199999999999996]
[-0.968538089076200]	[1.094474249356653]	[6.321495316645386]
[-1.077967207963939]	[1.034056802046682]	[5.955234291215224]
[-1.020578428602165]	[1.058811155267189]	[4.112427323765299]
[-1.025701258230099]	[1.052912700142907]	[4.103537774540148]
[-1.017896971745113]	[1.052554553929377]	[4.098936564058503]
[-1.022808404700743]	[1.046478948398044]	[4.091765532760610]
[-1.014997101864393]	[1.046342184920335]	[4.086208653105395]
[-1.019802933358129]	[1.040182709301111]	[4.079607300509300]
[-1.011990772464195]	[1.040109919073143]	[4.073657597876354]
...	...	...
[0.999833847006819]	[0.999632889526216]	[1.489342960470657e-07]
[0.99982026622051]	[0.999639846809682]	[3.235574565310428e-08]

Columns 4 through 6

'p_k1'	'p_k2'	'alpha'
[0.925847643695199]	[0.377896997426612]	[0.2500000000000000]
[-0.875432951101911]	[-0.483339578479767]	[0.1250000000000000]
[0.918220469788388]	[0.396069651528101]	[0.0625000000000000]
[-0.655722192375568]	[-0.755002255908007]	[0.0078125000000000]
[0.998948670078197]	[-0.045842715331890]	[0.0078125000000000]
[-0.628663418320567]	[-0.777677508010551]	[0.0078125000000000]
[0.999846763052762]	[-0.017505725146776]	[0.0078125000000000]
[-0.615146431198182]	[-0.788412879260696]	[0.0078125000000000]
[0.999956594423558]	[-0.009317149179921]	[0.0078125000000000]
[-0.607735484412824]	[-0.794139522367141]	[0.0078125000000000]
...	...	...
[-0.890004096100181]	[0.455952529244987]	[1.525878906250000e-05]
[NaN]	[NaN]	[NaN]

14 iterations using Newton method,  
starting at point (1.2, 1.2):

Columns 1 through 3

'x_1'	'x_2'	'f(x_0)'
[1.2000000000000000]	[1.2000000000000000]	[5.8000000000000000]
[1.195918367346939]	[1.430204081632653]	[0.038384034418534]
[1.098284494370630]	[1.196688127560039]	[0.018762343235565]
[1.081386326814726]	[1.164340488247641]	[0.009179946242836]
[1.061152849388324]	[1.123108026369094]	[0.004602469610835]
[1.041891729408251]	[1.083698713368497]	[0.002093352782430]
[1.026579669138199]	[1.052711526677770]	[8.397174465864355e-04]
[1.015782458019240]	[1.031120277046601]	[2.972114149467173e-04]
[1.008852698461973]	[1.017388883139979]	[9.396361167102329e-05]
[1.004750340388426]	[1.009308975141881]	[2.715695575364381e-05]
...	...	...
[1.000321342023033]	[1.000628085439280]	[1.248751865081991e-07]
[1.000161142059241]	[1.000314933487477]	[3.140818272013415e-08]

Columns 4 through 6

'p_k1'	'p_k2'	'alpha'
[-0.004081632653061]	[0.230204081632653]	[1]
[-0.195267745952617]	[-0.467031908145227]	[0.5000000000000000]
[-0.033796335111809]	[-0.064695278624796]	[0.5000000000000000]
[-0.040466954852803]	[-0.082464923757096]	[0.5000000000000000]
[-0.038522239960146]	[-0.078818626001193]	[0.5000000000000000]
[-0.030624120540105]	[-0.061974373381454]	[0.5000000000000000]

[ -0.021594422237916]	[ -0.043182499262338]	[0.500000000000000]
[ -0.013859519114534]	[ -0.027462787813243]	[0.500000000000000]
[ -0.008204716147095]	[ -0.016159815996197]	[0.500000000000000]
[ -0.004555133452465]	[ -0.008939272404981]	[0.500000000000000]
'...'	'...'	'...'
[-3.203999275827620e-04]	[-6.263039036068313e-04]	[0.500000000000000]
[ NaN]	[ NaN]	[ NaN]

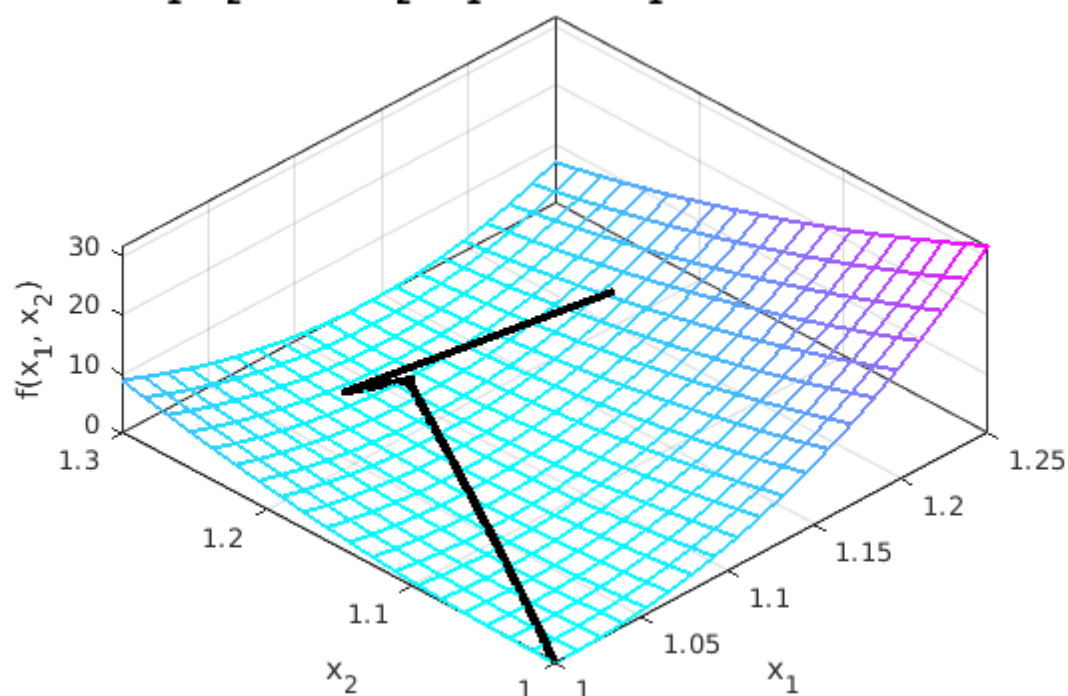
115 iterations using Newton method,  
 starting at point (-1.2, 1):  
 Columns 1 through 3

'x_1'	'x_2'	'f(x_0)'
[-1.200000000000000]	[ 1]	[ 24.199999999999996]
[-1.175280898876405]	[1.380674157303371]	[ 4.731884325266608]
[-0.932981427619794]	[0.811210655796923]	[ 4.087398662072152]
[-0.914176259038676]	[0.783526370798856]	[ 3.936469794389347]
[-0.893257895403843]	[0.751804210696937]	[ 3.796996775067121]
[-0.870104082602084]	[0.716202740634736]	[ 3.664393425249008]
[-0.844627699033879]	[0.676978326670232]	[ 3.535275676761747]
[-0.816791907892380]	[0.634508769138097]	[ 3.407271439428506]
[-0.786624868822658]	[0.589308413801200]	[ 3.278878105929675]
[-0.754230561250740]	[0.542027861718612]	[ 3.149341295787916]
'...'	'...'	'...'
[ 0.999667603660405]	[0.999328126705433]	[1.156585223862693e-07]
[ 0.999709093531272]	[0.999411977752842]	[8.858793693185425e-08]

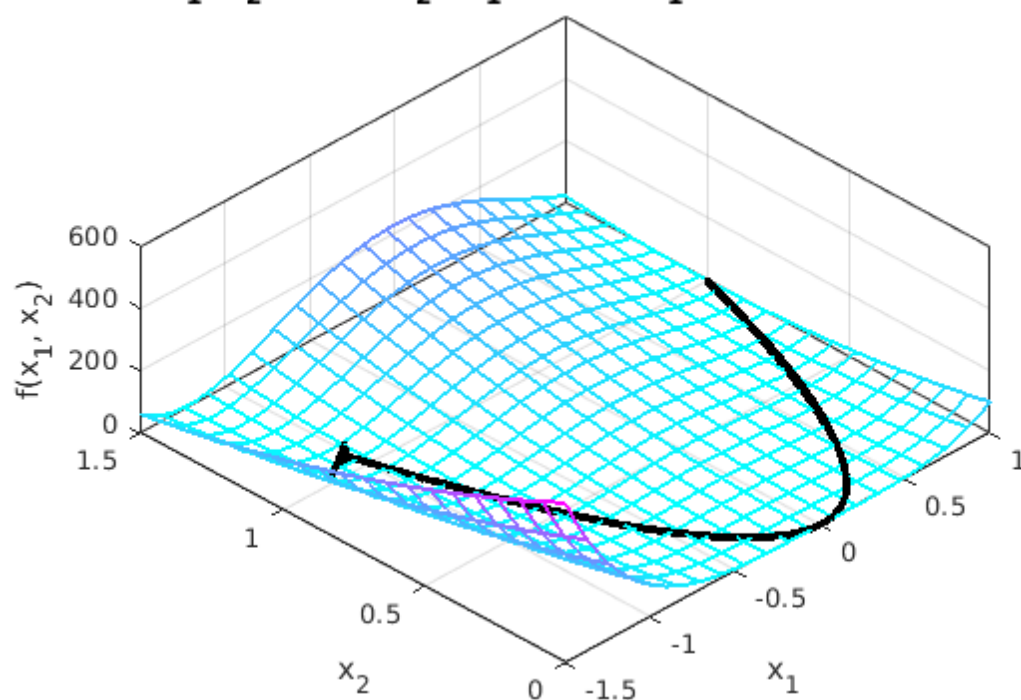
Columns 4 through 6

'p_k1'	'p_k2'	'alpha'
[ 0.024719101123595]	[ 0.380674157303371]	[ 1]
[ 1.938395770052881]	[ -4.555708012051582]	[0.125000000000000]
[ 0.150441348648949]	[ -0.221474279984540]	[0.125000000000000]
[ 0.167346909078666]	[ -0.253777280815348]	[0.125000000000000]
[ 0.185230502414071]	[ -0.284811760497614]	[0.125000000000000]
[ 0.203811068545639]	[ -0.313795311716029]	[0.125000000000000]
[ 0.222686329131994]	[ -0.339756460257082]	[0.125000000000000]
[ 0.241336312557772]	[ -0.361602842695171]	[0.125000000000000]
[ 0.259154460575344]	[ -0.378244416660710]	[0.125000000000000]
[ 0.275511574070746]	[ -0.388762620478912]	[0.125000000000000]
'...'	'...'	'...'
[3.319189669336502e-04]	[6.708083792723814e-04]	[0.125000000000000]
[ NaN]	[ NaN]	[ NaN]

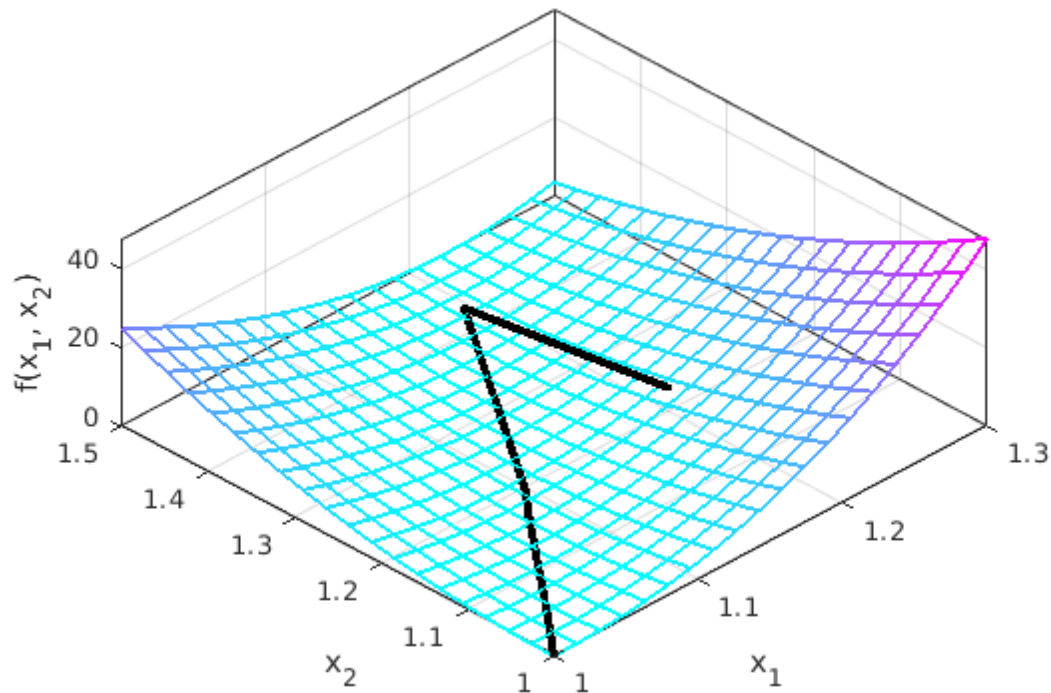
**Backtracking line search using steepest descent method  
for  $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$  starting at  $(1.2, 1.2)$**



**Backtracking line search using steepest descent method  
for  $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$  starting at  $(-1.2, 1)$**



**Backtracking line search using Newton method**  
**for  $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$  starting at  $(1.2, 1.2)$**



**Backtracking line search using Newton method**  
**for  $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$  starting at  $(-1.2, 1)$**

