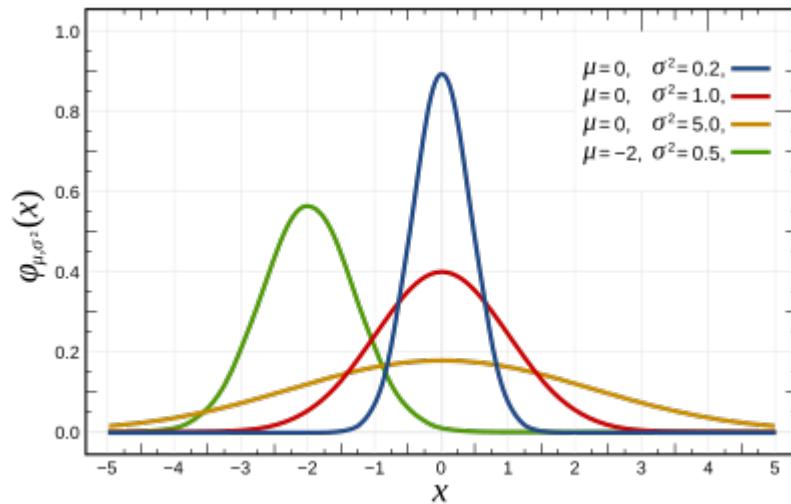
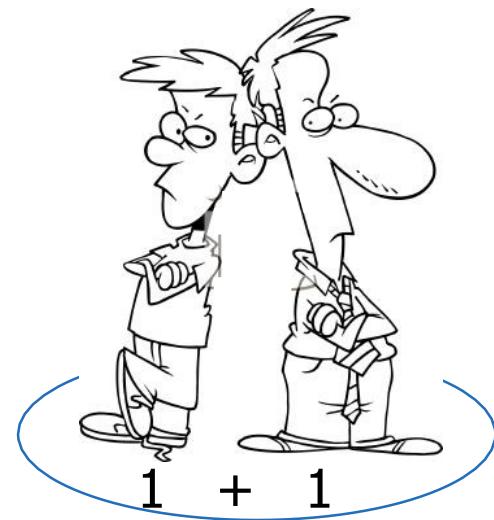


HW2: Implementation of ES(1+1) with 1/5 Rule



The red curve is the *standard normal distribution*

HW2 program will be used for training (optimizing weight values) for simple Neural Networks for HW3

LTU CS
CJ Chung

HW2

- **ES11_15_yourName.ipynb** file is provided on Canvas
- Complete all the missing part of the program to solve 5 optimization functions using ES(1+1) with 1/5 rule introduced in class.
- 5 objective functions with search domain as $-5 \leq x_i \leq 5$ are:

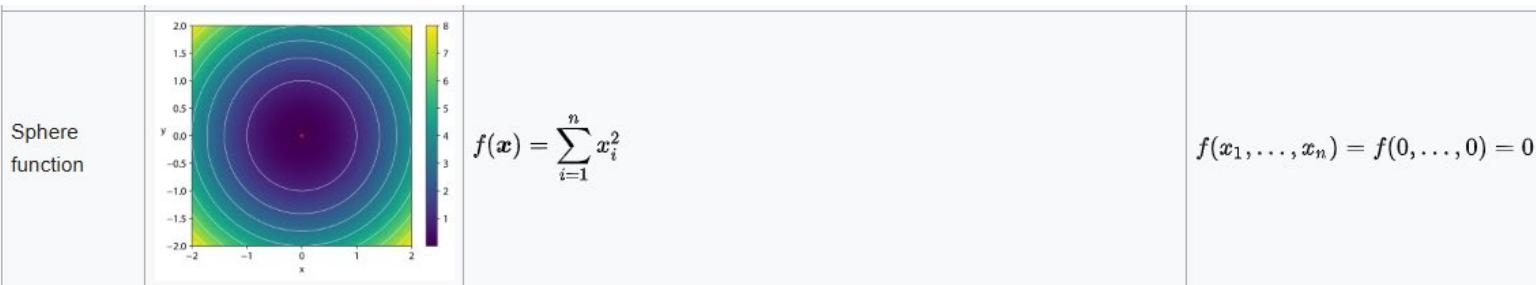
(1) findroot: objective function to find the root of the following function using this ES(1+1) with 1/5 rule:

$$f(x) = x^3 - 2x^2 - x + 2 = (x+1)(x-1)(x-2)$$

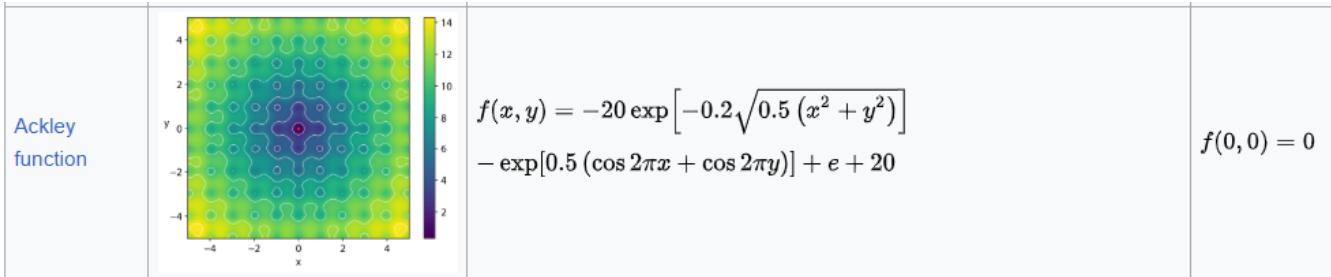
$$\text{minimize } f(x) = |x^3 - 2x^2 - x + 2|$$

Note that there are 3 roots

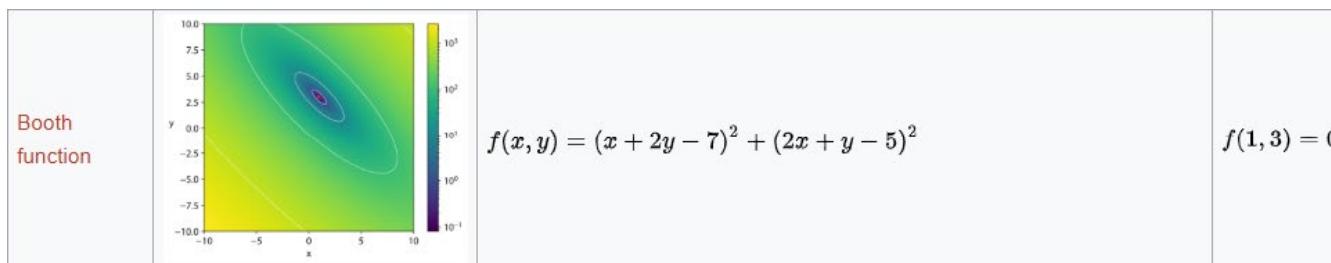
(2)

Use n as 20

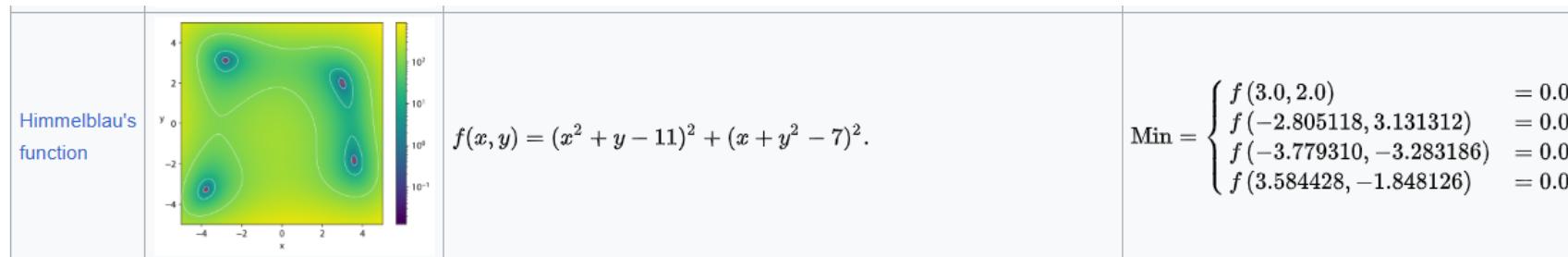
(3)



(4)



(5)



A sample expected output (1 /4)

----- findroot2 -----

T=0, Min_Eval= 0.00001 at [1.00000632], gen=1016

T=1, Min_Eval= 0.00003 at [2.00000944], gen=1498

T=2, Min_Eval= 0.00002 at [2.00000502], gen=1366

System Success = 100.0%

Avgverage # of generations used = 1,293

----- sphere_n -----

T=0, Min_Eval= 0.00004 at [4.86711734e-04 4.02301854e-03 -2.44914436e-03 1.44283467e-03

-7.84474253e-05 -1.62282379e-03 -3.99814421e-04 -1.27332571e-04

4.22905242e-04 7.79189208e-04 -1.39760326e-03 -1.26270169e-03

-2.14024193e-03 -9.32837862e-04 -7.48129941e-04 2.89771569e-04

-7.16231505e-04 -7.05439464e-04 -2.29114161e-03 5.70322612e-06], gen=1382

T=1, Min_Eval= 0.00004 at [-0.00046407 0.00344629 0.00032897 0.00050425 -0.00214914 0.00042268

0.00026882 -0.0004115 0.00316019 -0.00111952 0.0007591 -0.00012328

0.00232848 0.0003027 -0.00028458 -0.00144004 -0.00146663 -0.00172993

0.00027397 -0.00146657], gen=1353

T=2, Min_Eval= 0.00005 at [1.03855344e-03 2.15064709e-03 -7.35689411e-04 3.63427408e-04

-1.97675374e-03 4.87973265e-04 -8.10039103e-04 -2.38617155e-03

-6.31022201e-04 9.02150652e-04 -4.82734497e-05 8.15149267e-04

3.74913874e-03 -4.35468223e-04 2.35799922e-03 -1.10238584e-03

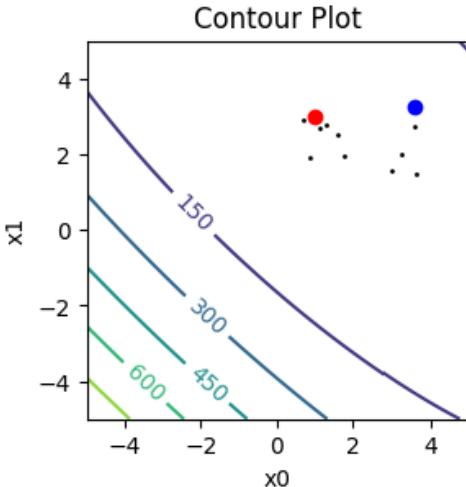
3.22868093e-04 1.62646540e-03 -1.79330028e-03 9.65114288e-04], gen=1434

System Success = 100.0%

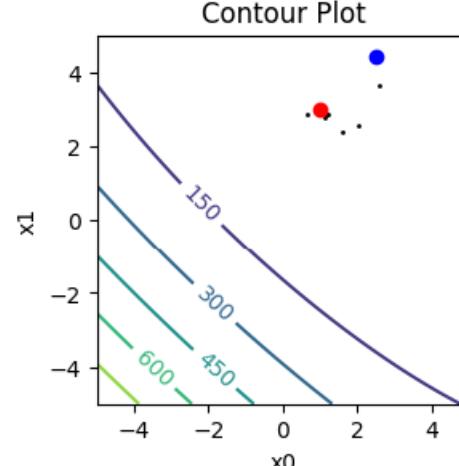
Avgverage # of generations used = 1,390

A sample expected output (2 /4)

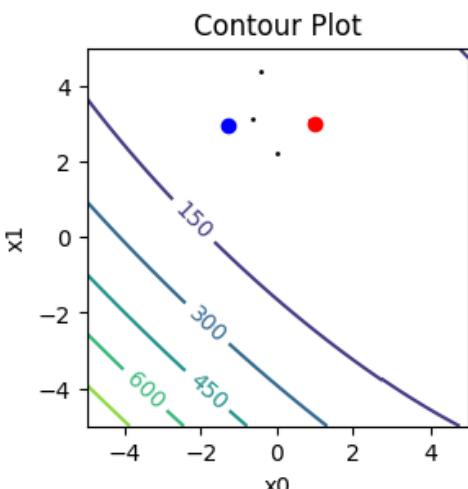
----- booth -----
T=0, Min_Eval= 0.00003 at [1.00145089 2.99667858], gen=558



T=2, Min_Eval= 0.00002 at [0.99839888 3.00305433], gen=343



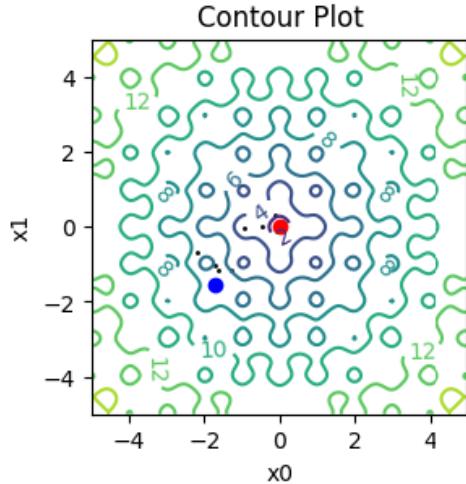
T=1, Min_Eval= 0.00003 at [0.99741715 3.00384483], gen=780



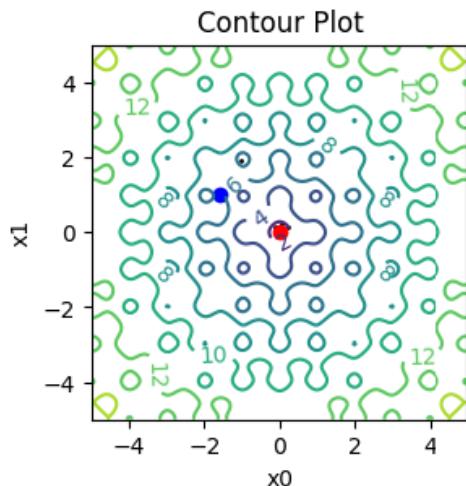
System Success = 100.0%
Avergeage # of generations used = 560

A sample expected output (3 /4)

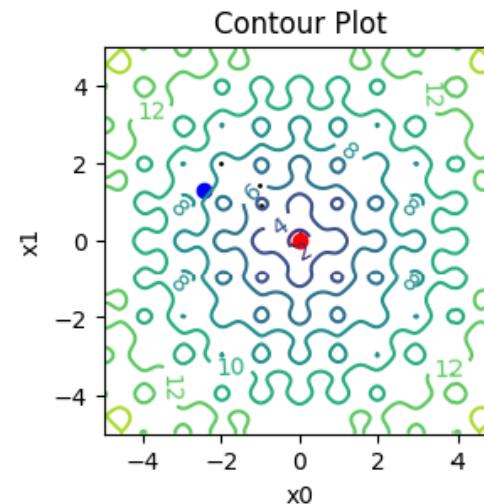
----- ackley -----
T=0, Min_Eval= 0.00002 at [-4.57895759e-06 4.02745263e-06], gen=1819



T=1, Min_Eval= 0.00002 at [-6.41934275e-07 -5.31341081e-06], gen=1727



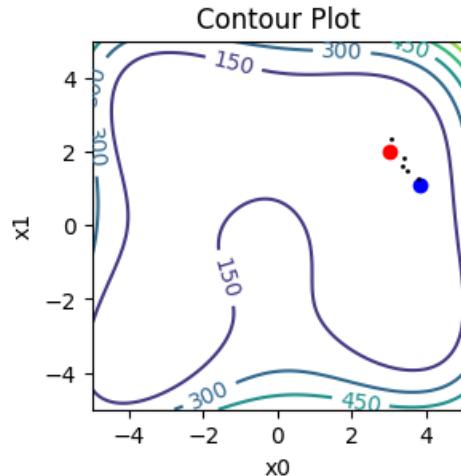
T=2, Min_Eval= 0.00005 at [-4.06699044e-06 1.67554237e-05], gen=1890



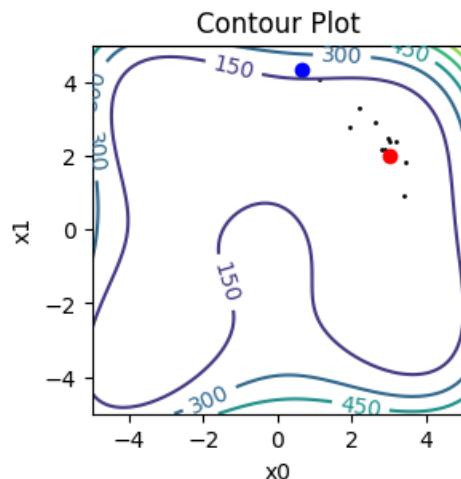
System Success = 100.0%
Averge # of generations used = 1,812

A sample expected output (4 /4)

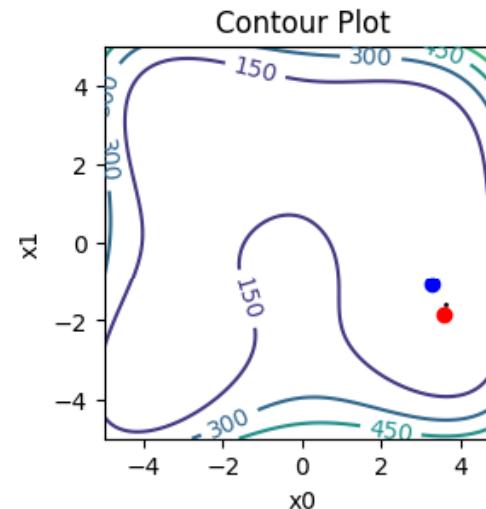
----- himmelblau -----
T=0, Min_Eval= 0.00001 at [2.99952212 2.00041348], gen=924



T=1, Min_Eval= 0.00000 at [2.99991188 2.00040288], gen=766



T=2, Min_Eval= 0.00002 at [3.58502393 -1.84807062], gen=752



System Success = 100.0%
Avergeage # of generations used = 814

HW2 Instructions

- Submitted file must have your name: **ES11_15_yourName.ipynb**
- Required markdown text cell in the beginning of the code.
Please make sure to specify the % of generative AI tool use
- Do not change other parts of the code. Complete only missing parts
- Your submitted .ipynb file must run correctly for the 5 functions and must include run results including contour plots
- Please read the rule in the syllabus for pre-checking before the deadline

HW2 is important

HW2 program will be used for training (optimizing weight values) for simple Neural Networks for HW3

Quiz #1

- Wed Sep 10th, 2025
- You must come to the class to take the exam
- No make up exam is allowed