# Report: Finding Roots Using Hill Climbing

## Problem Overview

For this assignment, I was asked to implement either the Hill Climbing algorithm or Simulated Annealing in order to find the roots of a second-degree equation. The specific function used was:

f(x)=x^2−4

The goal was to find the values of x that make f(x)=0, which means we’re looking for the points where the function crosses the x-axis.

## How I Approached It

### Objective Function

I used ∣f(x)∣ as the measure to minimize. This is because when ∣f(x)| gets very close to 0, it means we’re near a root.

### Hill Climbing Strategy

* I started at a random point between -5 and 5.
* Then, I checked slightly to the left and right of the current point.
* If moving in either direction got me closer to zero (i.e., made ∣f(x)∣smaller), I moved that way.
* This process kept repeating until no further improvement was possible.

### Applying Multiple Starting Points

Hill climbing at times becomes stuck within one area and does not consider other solutions. Therefore, to check that I hadn't missed both roots of this quadratic, I ran the algorithm five times starting from different random points. This helped to have a better chance of discovering both roots: x = −2 and x = -2.

### Results Filtering

Since the results from run to run can be very close to each other (but not equal due to floating-point differences), I rounded each approximated root to 1 decimal place. Then, I removed duplicates so that only distinct roots were shown.

## Plot Analysis

The plot clearly shows the algorithm's performance. Each point on the plot represents a single run from a unique initial point. You can observe how each trace comes closer to a root.

The red dots mark every move that the algorithm took in trying to minimize ∣f(x)∣, and the black dashed line at y=0 shows the target (i.e., when the function hits zero).

## Final Thoughts

The Hill Climbing algorithm worked appropriately for this problem. It found both roots of the equation effectively. Various starting points surely helped to get both solutions, because hill climbing itself will only examine one direction. The plot verified that the algorithm always converged towards the correct values, providing a nice visualization of the optimization process.