## The "Funnel" of Harrell's Solution.

Below are several different initial guesses for a my Colebrook Solution, I called it a funnel. I already know the solution to this. $1 / \mathrm{sqrt}(\mathrm{F})$ is about 4 . So I am showing the "path" for initial guesses of $-4,-2,0,2,4,6,8,10$ and 12 . The red background shows where the results become the same to 15 decimals places. I will plot the steps 1,2 and 3 , after that the differences are just too small to graph.

|  |  |  | Min | Max | Decimals | lue |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reynolds Number, Re |  |  | 2,500 | 500,000 | 0 | 12000 |  |  |  |
| Relative Rouchness Rr |  |  | 0.0001 | 0.05 | 8 | 0.03 |  |  |  |
| 1 | -4.00 | -2.00 | 0.00 | 2.00 | 4.00 | 6.00 | 8.00 | 10.00 | 12.00 |
| 2 | 4.2768 | 4.2282 | 4.1822 | 4.1385 | 4.0969 | 4.0572 | 4.0192 | 3.9828 | 3.9479 |
| 3 | 4.0913 | 4.0922 | 4.0932 | 4.0941 | 4.0949 | 4.0957 | 4.0965 | 4.0972 | 4.0979 |
| 4 | 4.0950 | 4.0950 | 4.0950 | 4.0950 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 5 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 6 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 7 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 8 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 9 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 10 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 11 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 12 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 13 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 14 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 15 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 16 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 17 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 18 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 19 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |
| 20 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 | 4.0949 |

Plot the Funnel for results for steps 1,2 and 3. At the far left at the initial guess, from $\mathbf{- 4}$ to 12. By step 2, the each of results are all close to a value of four. You see the lines from step 1 to step 2 cross over each a tiny bit to the left of step 2. At step 3, those paths are converging again... too small to see. Next is a zoomed screen capture at step 2 to show how the paths are converging, This shows that even if you guess is not close, my procedure quickly takes you to the solution.

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