

## Project-3

To initialize the system, I gave the points random velocities in different directions and most of the particles flew away from the origin. Some particles with low velocities were near the origin and formed swarms. Yes, the behavior was as anticipated.

### **Serial:**

The execution times for Serial codes for 20 iterations and 100,000 bodies was:

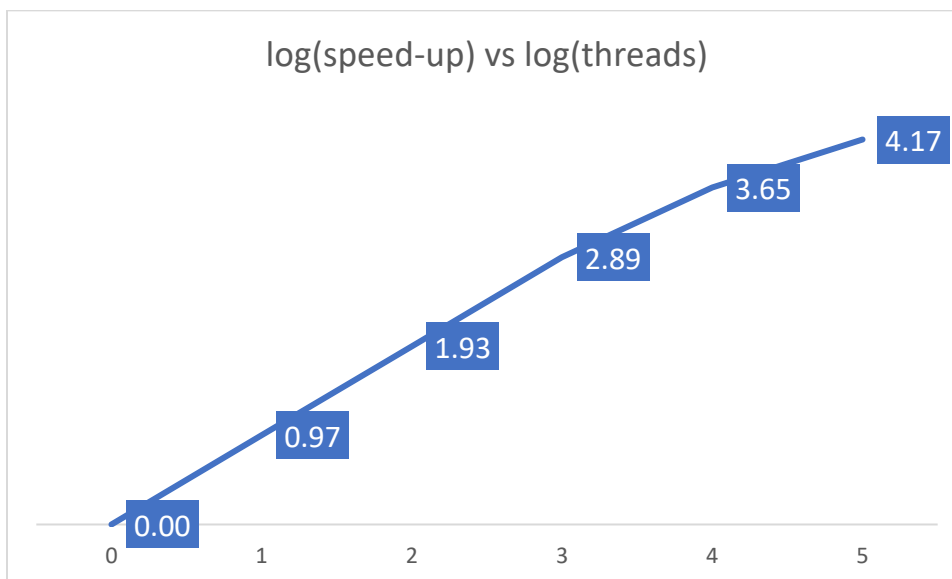
Avg Time: 51.8s Total Time: 984.2s

Grind Rate:  $1/\text{Avg Time} = 0.019$

### **Parallel:**

Using openmp, we get the following times:

Threads	Total Time	Avg Time	Speed Up	Grind Rate
1	982.620	51.717	1.0	0.02
2	502.622	26.454	2.0	0.04
4	257.735	13.565	3.8	0.07
8	132.222	6.959	7.4	0.14
16	78.281	4.120	12.6	0.24
32	54.504	2.869	18.0	0.35



The observations look in line with what was anticipated. On increasing the threads, we get speed-up up to a certain level. The total time taken for 1 thread is very similar to the total time taken for serial execution.

**CUDA:**

For GPU, we get the following performance:

Threads/Block	Total Time	Avg Time	Grind Rate
1	35.860	1.887	0.53
2	18.020	0.948	1.05
4	9.120	0.480	2.08
8	4.620	0.243	4.11
16	2.460	0.129	7.72
32	1.290	0.068	14.73
64	0.970	0.051	19.59
128	0.950	0.050	20.00
256	1.000	0.053	19.00

We get the best performance for 128 threads/block. The proof of correctness can be seen in the GIF generated. The performance is way better than parallel code where the best total time was around 54s, which is around less than 1s here.