Quest Journals
Journal of Research in Applied Mathematics
Volume 2 ~ Issue 9 (2016) pp: 10-18
ISSN(Online) : 2394-0743 ISSN (Print):2394-0735
www.questjournals.org

Research Paper

Block-wise Density Distribution of Primes less than a Trillion in Arithmetical Progressions 10*n* + *k*

Neeraj Anant Pande[1]

Received 05 June, 2016; **A**ccepted 20 June, 2016 © The author(s) 2016. **P**ublished with open access at **www.questjournals.org**

ABSTRACT : *All prime numbers, except 2 and 5, fit in one of the forms of arithmetical progressions 10n + 1, 10n + 3, 10n + 7 and 10n + 9. Each of them contains infinitely many primes. Here a comparison of abundance of primes in them in ranges 1 – 10^n for n = 1, 2, . . . , 12 is done. In all blocks of these sizes covered till 1 trillion, first and last primes of these forms are determined. 10 power blocks containing minimum number of primes of these forms, first & last blocks of such minimum occurrences of primes, and number of such blocks till 1 trillion are determined. All this analysis is also done for maximum number primes within blocks.*

Keywords:- *Arithmetical progressions, block-wise distribution, prime, prime density*

I. INTRODUCTION

Fundamental Theorem of Arithmetic highlights the role of prime numbers as multiplicative building units of all integers. Primes are divisors of other numbers but themselves have no non-trivial divisors. They have been proven to be infinite long ago [1].

II. PRIMES NUMBERS AND ARITHMETICAL PROGRESSIONS

It is said that the simplest example of integer sequences are arithmetical progressions as the successive terms in them are constructed just by adding a fixed number. The other way round, an arithmetical progression can be seen to be the list of those numbers that when divided by a fixed number give a fixed remainder. If $an + b$ is an arithmetical progression, it contains all those numbers which when divided by a give remainder b. Since there are a different possible remainders b in the division by a, viz., $b = 0, 1, . . . , a – 1$, for any positive integer a, there are a number of different arithmetical progressions : $an + 0$, $an + 1$, . . . , $an + (a – 1)$.

We consider prime numbers and arithmetical progressions together. Dirichlet, in his famous result [2], has proved that an arithmetical progression $an + b$ contains infinite number of primes if, and only if, a and b are relatively prime, i.e., have greatest common divisor 1. For all single digit a's from 2 to 9, the detailed analysis of primes in all such possible arithmetical progressions $an + b$ is recently done [3]-[12]. For the first time now a two digit $a = 10$ is considered here.

The symbol $\pi_{a,b}(x)$ introduced in previous works which means the number of primes of form $an + b$ that are less than or equal to x is used here also.

III. PRIMES DISTRIBUTIONS IN ARITHMETICAL PROGRESSIONS 10*n* + *k*

By property stated earlier, if the dividing number is chosen to be 10, then there will be 10 possible remainders in the process of division, viz., 0, 1, 2, . . . , 9. They give rise to overall 10 arithmetical progressions $10n + k$ for these 10 values of k. Of these, by Dirichlet's property only 4 will contain infinite number of primes, viz., $10n + 1$, $10n + 3$, $10n + 7$, $10n + 9$.

Apart from these four, there are two more progressions from these categories which contain primes. They are $10n + 2$ and $10n + 5$. But it is so that they contain only one prime each. $10n + 2$ contains 2 only and $10n + 5$ contains 5 only. Hence in our main analysis of prime density here, we have omitted them.

IV. PRIMES NUMBER RACE

Granville and Martin coined the term prime number race [13] for dominance of primes in the arithmetical progressions of same family $an + b$. Due to the reasons stated earlier, ignoring $10n + 2$ and $10n + 5$, the number of primes till 1,000,000,000,000, i.e., 10^{12} in $10n + 1$, $10n + 3$, $10n + 7$ and $10n + 9$ are determined. This required large prime data that could be generated by choosing most efficient algorithm resulting out of comparisons in [14]-[20]. Java programming language made handy by excellent explanation in [21] was used for implementations of these.

Table 1 : Number of Primes of form $10n + k$ in First Blocks of 10 Powers

Sr. No.	Range 1-x (1 to x)	Number of Primes of Form			
		$10n + 1$ ($\pi_{10,1}(x)$)	$10n + 3$ ($\pi_{10,3}(x)$)	$10n + 7$ ($\pi_{10,7}(x)$)	$10n + 9$ ($\pi_{10,9}(x)$)
1.	1-10	0	1	1	0
2.	1-100	5	7	6	5
3.	1-1,000	40	42	46	38
4.	1-10,000	306	310	308	303
5.	1-100,000	2,387	2,402	2,411	2,390
6.	1-1,000,000	19,617	19,665	19,621	19,593
7.	1-10,000,000	166,104	166,230	166,211	166,032
8.	1-100,000,000	1,440,298	1,440,474	1,440,495	1,440,186
9.	1-1,000,000,000	12,711,386	12,712,499	12,712,314	12,711,333
10.	1-10,000,000,000	113,761,519	113,765,625	113,764,039	113,761,326
11.	1-100,000,000,000	1,029,517,130	1,029,509,448	1,029,518,337	1,029,509,896
12.	1-1,000,000,000,000	9,401,960,980	9,401,979,904	9,401,997,000	9,401,974,132

Since all primes, except 2 and 5, are of only of one of these forms, their quantity is expected to be averagely distributed. The deviation from respective averages is plotted separately.

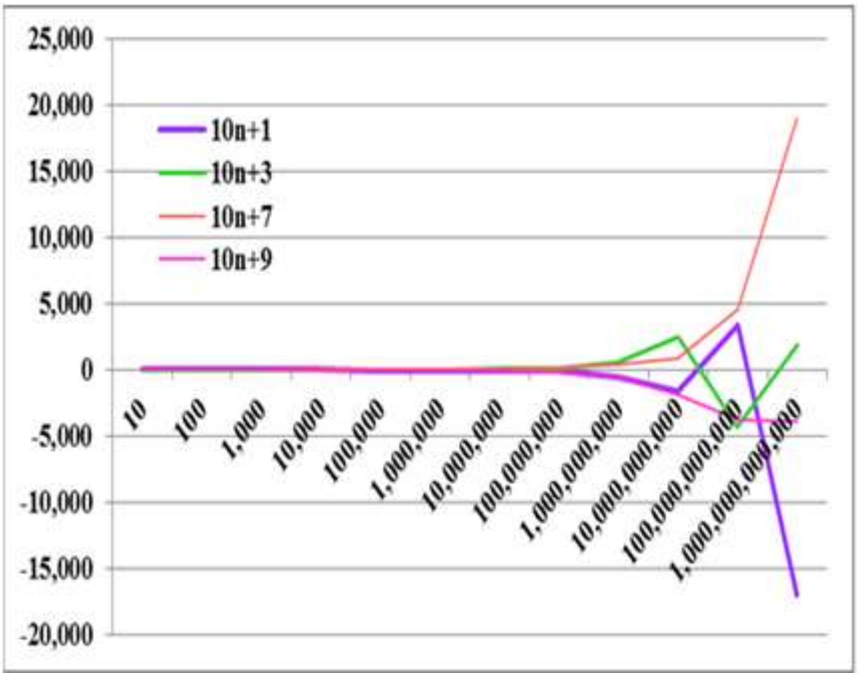

Figure 1 : Deviation of $\pi_{10,k}(x)$ from Average

The number of primes of the form $10n + 7$ and $10n + 3$ seem most of the times ahead of the average, while those of the form $10n + 9$ always lag behind, up to 10^{12} in discrete blocks of 10 powers. This trend is a subject matter of confirmation in intermediate and higher ranges.

V. BLOCK-WISE DISTRIBUTION OF PRIMES

Because primes cannot be generalized by any formula, nor their distribution is uniform, we continue with the approach of following them in blocks of powers of 10 as

1-10, 11-20, 21-30, 31-40, · · ·
1-100, 101-200, 201-300, 301-400, · · ·
1-1000, 1001-2000, 2001-3000, 3001-4000, · · ·
⋮

For total range of 1-10^{12}, there will be 10^{12-n} number of blocks of size 10^n for every $1 \le n \le 12$.

A. THE FIRST AND THE LAST PRIMES IN THE FIRST BLOCKS OF 10 POWERS

Within our range of 1 to 1 trillion, for aforementioned initial blocks of all sizes, the smallest and the largest primes haven determined to be as follows.

Table 2 : First Primes of form 10*n* + *k* First Blocks of 10 Powers

Sr. No.	Range 1-*x* (1 to *x*)	First Prime in the First Block			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	Not Found	3	7	Not Found
2.	1-100	11	3	7	19
3.	1-1,000	11	3	7	19
4.	1-10,000	11	3	7	19
5.	1-100,000	11	3	7	19
6.	1-1,000,000	11	3	7	19
7.	1-10,000,000	11	3	7	19
8.	1-100,000,000	11	3	7	19
9.	1-1,000,000,000	11	3	7	19
10.	1-10,000,000,000	11	3	7	19
11.	1-100,000,000,000	11	3	7	19
12.	1-1,000,000,000,000	11	3	7	19

The last primes within these blocks go on increasing with increasing block sizes.

Table 3 : Last Primes of form 10*n* + *k* First Blocks of 10 Powers

Sr. No.	Range 1-*x* (1 to *x*)	Last Prime in the First Block			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	Not Found	3	7	Not Found
2.	1-100	71	83	97	89
3.	1-1,000	991	983	997	929
4.	1-10,000	9,941	9,973	9,967	9,949
5.	1-100,000	99,991	99,923	99,907	99,989
6.	1-1,000,000	999,961	999,983	999,917	999,979
7.	1-10,000,000	9,999,991	9,999,973	9,999,937	9,999,929
8.	1-100,000,000	99,999,971	99,999,773	99,999,847	99,999,989
9.	1-1,000,000,000	999,999,761	999,999,893	999,999,937	999,999,929
10.	1-10,000,000,000	9,999,999,881	9,999,999,943	9,999,999,967	9,999,999,929
11.	1-100,000,000,000	99,999,999,871	99,999,999,943	99,999,999,977	99,999,999,829
12.	1-1,000,000,000,000	999,999,999,961	999,999,999,863	999,999,999,937	999,999,999,989

So long as the omitted forms 10*n* + 2 and 10*n* + 5 are concerned, since they contain unique primes 2 and 5, respectively, the same happen to be the first and last primes of these forms in every block of 10 power starting with 10^1 going virtually till ∞.

Now follows the graphical representations of first and last primes of the important 4 forms of type 10*n* + *k*.

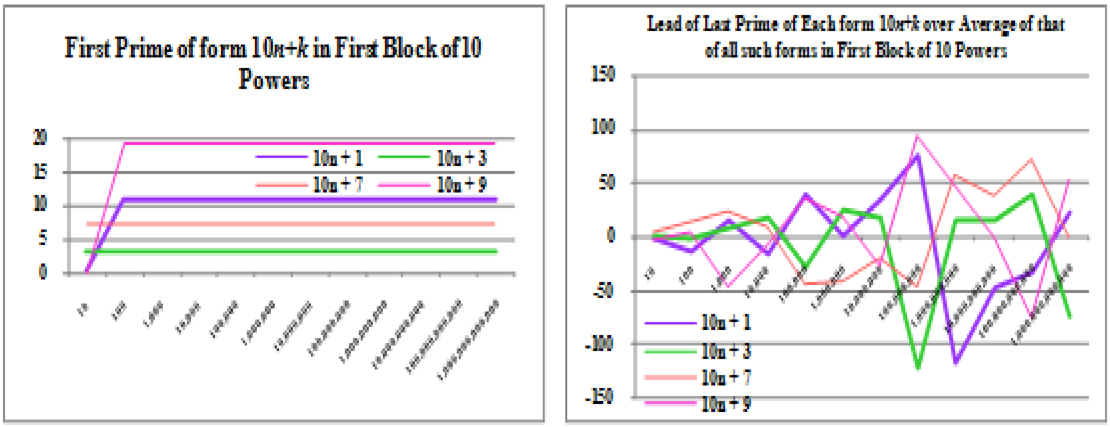

Figure 2: First & Last Primes of form 10*n* + *k* in First Blocks of 10 Powers.

B. Minimum Number Of Primes In Blocks Of 10 Powers

For the same sized blocks, the minimum number of primes of each form found in each of them is next point analysis.

Table 4 : Minimum Number of Primes of form 10*n* + *k* in Blocks of 10 Powers

Sr. No.	Range 1-*x* (1 to *x*)	Minimum Number of Primes in Blocks			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	0	0	0	0
2.	1-100	0	0	0	0
3.	1-1,000	0	0	0	0
4.	1-10,000	50	50	48	49
5.	1-100,000	795	803	801	794
6.	1-1,000,000	8,748	8,789	8,772	8,734
7.	1-10,000,000	89,851	89,904	89,846	89,846
8.	1-100,000,000	903,380	903,467	903,712	903,526
9.	1-1,000,000,000	9,046,766	9,046,777	9,046,962	9,046,857
10.	1-10,000,000,000	90,495,945	90,493,544	90,493,875	90,494,057
11.	1-100,000,000,000	906,486,613	906,472,632	906,481,722	906,483,465
12.	1-1,000,000,000,000	9,401,960,980	9,401,979,904	9,401,997,000	9,401,974,132

The block-wise percentage deviation of minimum number of primes found there from respective averages is given in the figure next.

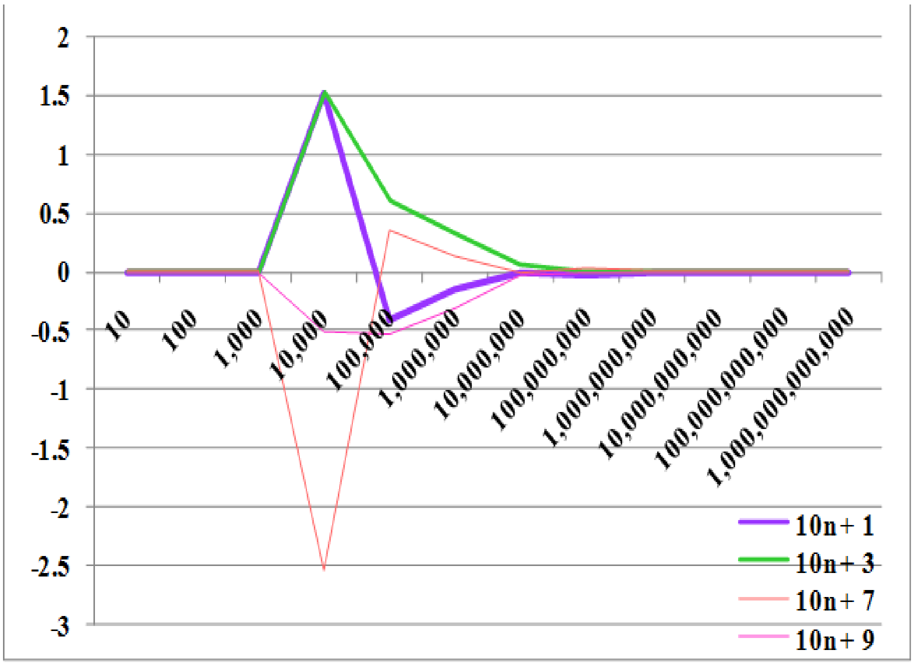

Figure 3 : % Deviation in Minimum Number of Primes of form 10*n* + *k* in Blocks of 10*ⁿ* from Average

The first blocks each of these sizes in our range of 10^{12} containing minimum number of primes of these forms in them are found be as follows.

Table 5 : First Blocks of 10 Powers with Minimum Number of Primes of form 10*n* + *k* in Them

Sr. No.	Range 1-*x* (1 to *x*)	First Block with Minimum Number of Primes			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	0	30	20	0
2.	1-100	10,400	13,200	8,900	13,500
3.	1-1,000	1,992,636,000	1,054,256,000	2,174,469,000	1,036,101,000
4.	1-10,000	681,769,270,000	200,077,450,000	657,874,630,000	625,725,710,000
5.	1-100,000	967,423,100,000	924,727,600,000	979,846,600,000	918,734,500,000
6.	1-1,000,000	957,750,000,000	956,012,000,000	957,617,000,000	995,465,000,000
7.	1-10,000,000	994,560,000,000	985,230,000,000	994,120,000,000	989,830,000,000
8.	1-100,000,000	997,800,000,000	981,100,000,000	996,300,000,000	997,000,000,000
9.	1-1,000,000,000	997,000,000,000	998,000,000,000	998,000,000,000	999,000,000,000
10.	1-10,000,000,000	990,000,000,000	990,000,000,000	990,000,000,000	990,000,000,000
11.	1-100,000,000,000	900,000,000,000	900,000,000,000	900,000,000,000	900,000,000,000

And the last such blocks till 10^{12} are also found.

Table 6 : Last Blocks of 10 Powers with Minimum Number of Primes of form 10*n* + *k* in Them

Sr. No.	Range 1-*x* (1 to *x*)	Last Block with Minimum Number of Primes			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	999,999,999,990	999,999,999,990	999,999,999,990	999,999,999,990
2.	1-100	999,999,999,800	999,999,999,900	999,999,999,300	999,999,999,700
3.	1-1,000	999,945,413,000	999,969,741,000	999,936,675,000	999,928,156,000
4.	1-10,000	681,769,270,000	909,482,100,000	657,874,630,000	625,725,710,000
5.	1-100,000	967,423,100,000	924,727,600,000	979,846,600,000	918,734,500,000
6.	1-1,000,000	957,750,000,000	994,187,000,000	993,599,000,000	995,465,000,000
7.	1-10,000,000	994,560,000,000	985,230,000,000	994,120,000,000	989,830,000,000
8.	1-100,000,000	997,800,000,000	981,100,000,000	996,300,000,000	997,000,000,000
9.	1-1,000,000,000	997,000,000,000	998,000,000,000	998,000,000,000	999,000,000,000
10.	1-10,000,000,000	990,000,000,000	990,000,000,000	990,000,000,000	990,000,000,000
11.	1-100,000,000,000	900,000,000,000	900,000,000,000	900,000,000,000	900,000,000,000

Here comes their graphical comparison.

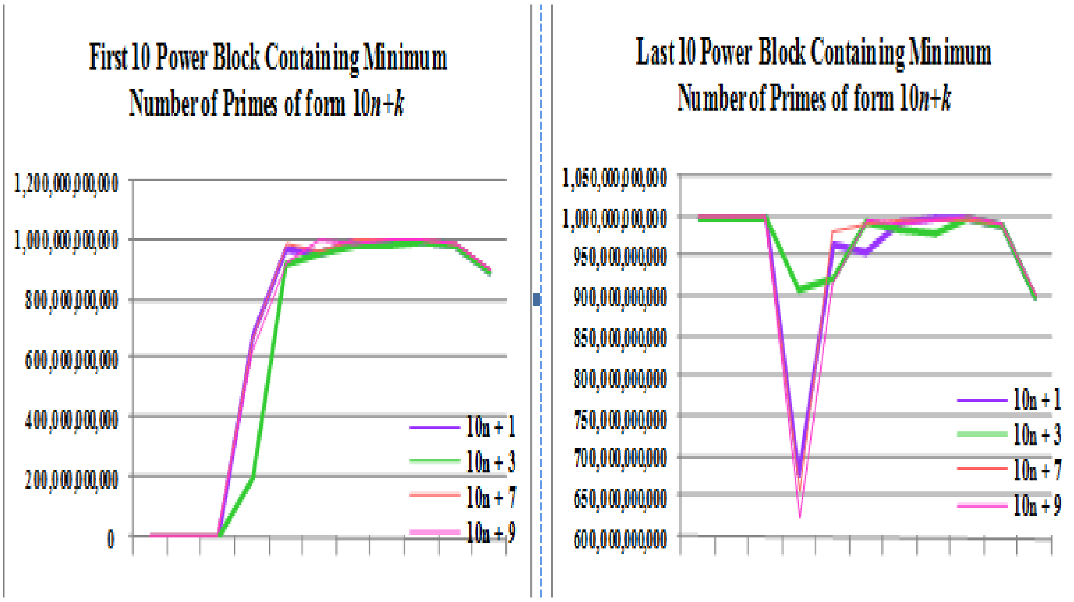

Figure 4 : First & Last Blocks of 10 Powers with Minimum Number of Primes of form 10*n* + *k*.

The values for forms 10*n* + 2 and 10*n* + 5 are missing here. They are parallel to corresponding values for arithmetical progression 8*n* + 2 given in [9].

It was also necessary to find out the as to how many times do these minimum number of primes of different forms in various 10^n sized blocks occur till 10^{12}.

Table 7 : Frequency of 10 Power Blocks with Minimum Number of Primes of form 10*n* + *k* in them

Sr. No.	Range 1-*x* (1 to *x*)	No. of Times Minimum No. of Primes Occurring in Blocks			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	90,598,039,020	90,598,020,096	90,598,003,000	90,598,025,868
2.	1-100	3,549,112,098	3,549,128,343	3,549,105,296	3,549,101,467
3.	1-1,000	18,529	18,764	18,534	18,709
4.	1-10,000	1	3	1	1
5.	1-100,000	1	1	1	1
6.	1-1,000,000	1	2	2	1
7.	1-10,000,000	1	1	1	1
8.	1-100,000,000	1	1	1	1
9.	1-1,000,000,000	1	1	1	1
10.	1-10,000,000,000	1	1	1	1
11.	1-100,000,000,000	1	1	1	1
12.	1-1,000,000,000,000	1	1	1	1

Graphical representation of the block-wise percentage deviation of frequency of occurrence of minimum number of primes from respective averages is due.

*Corresponding Author: Neeraj Anant Pande[1]

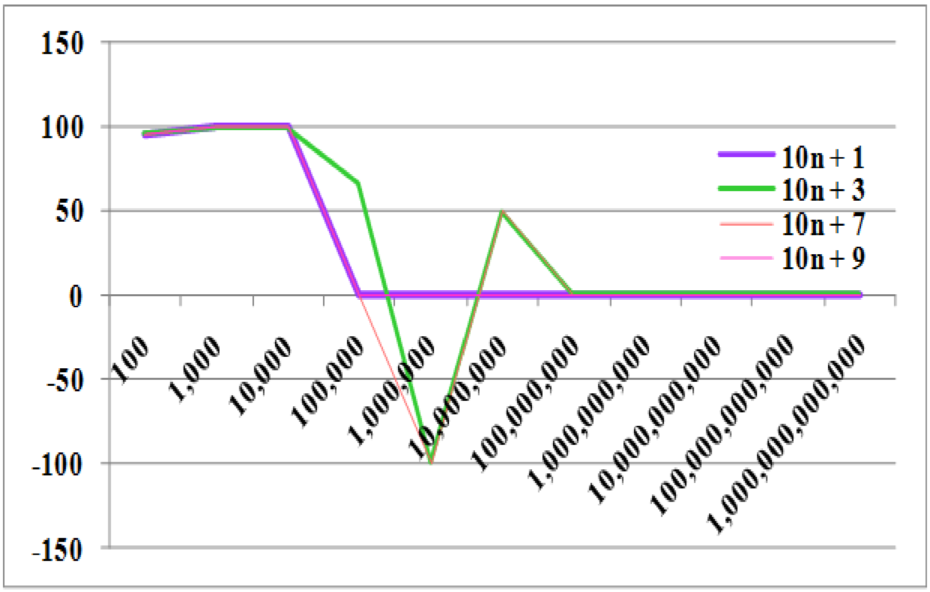

Figure 5 : % Decrease in Occurrences of Minimum Number of Primes of form $10n + k$ in Blocks of 10^n.

C. Maximum Number Of Primes In Blocks Of 10 Powers

After investigation for the minimum number of primes in 10^n sized blocks, now maximality is under critical analysis.

Table 8 : Maximum Number of Primes of form $10n + k$ in Blocks of 10 Powers

Sr. No.	Range 1-*x* (1 to *x*)	Maximum Number of Primes in Blocks			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	1	1	1	1
2.	1-100	7	7	7	7
3.	1-1,000	40	42	46	38
4.	1-10,000	306	310	308	303
5.	1-100,000	2,387	2,402	2,411	2,390
6.	1-1,000,000	19,617	19,665	19,621	19,593
7.	1-10,000,000	166,104	166,230	166,211	166,032
8.	1-100,000,000	1,440,298	1,440,474	1,440,495	1,440,186
9.	1-1,000,000,000	12,711,386	12,712,499	12,712,314	12,711,333
10.	1-10,000,000,000	113,761,519	113,765,625	113,764,039	113,761,326
11.	1-100,000,000,000	1,029,517,130	1,029,509,448	1,029,518,337	1,029,509,896
12.	1-1,000,000,000,000	9,401,960,980	9,401,979,904	9,401,997,000	9,401,974,132

Average deviation analysis is presented graphically.

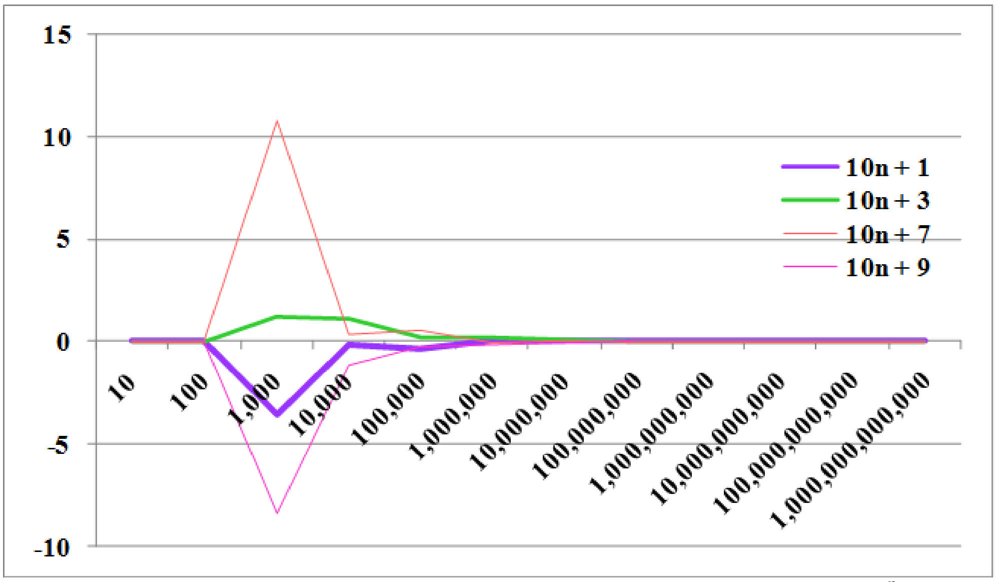

Figure 6 : % Deviation in Maximum Number of Primes of form $10n + k$ in Blocks of 10^n from Average.

The First & last blocks till 10^{12} with max number of primes of these four forms in them are determined.

Table 9 : First Blocks of 10 Powers with Maximum Number of Primes of form 10*n* + *k* in Them

Sr. No.	Range 1-*x* (1 to *x*)	First Block with Maximum Number of Primes			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	10	0	0	10
2.	1-100	8,056,200	0	22,424,100	21,169,600
3.	1-1,000	0	0	0	0
4.	1-10,000	0	0	0	0
5.	1-100,000	0	0	0	0
6.	1-1,000,000	0	0	0	0
7.	1-10,000,000	0	0	0	0
8.	1-100,000,000	0	0	0	0
9.	1-1,000,000,000	0	0	0	0
10.	1-10,000,000,000	0	0	0	0
11.	1-100,000,000,000	0	0	0	0
12.	1-1,000,000,000,000	0	0	0	0

Table 10 : Last Blocks of 10 Powers with Maximum Number of Primes of form 10*n* + *k* in Them

Sr. No.	Range 1-*x* (1 to *x*)	Last Block with Maximum Number of Primes			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	999,999,999,960	999,999,999,860	999,999,999,930	999,999,999,980
2.	1-100	996,503,865,600	999,318,647,900	998,658,215,200	998,726,687,000
3.	1-1,000	0	0	0	0
4.	1-10,000	0	0	0	0
5.	1-100,000	0	0	0	0
6.	1-1,000,000	0	0	0	0
7.	1-10,000,000	0	0	0	0
8.	1-100,000,000	0	0	0	0
9.	1-1,000,000,000	0	0	0	0
10.	1-10,000,000,000	0	0	0	0
11.	1-100,000,000,000	0	0	0	0
12.	1-1,000,000,000,000	0	0	0	0

As the prime density has a decreasing trend for higher range of numbers, for larger block sizes, the first and the last occurrences of maximum number of primes in them starts in the very first block of 0.

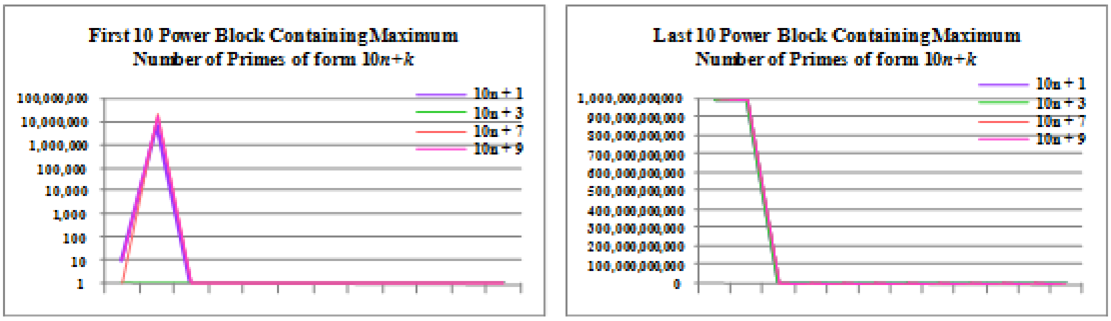

Figure 7 : First & Last Blocks of 10 Powers with Maximum Number of Primes of form 10*n* + *k*.

The same decreasing density of primes leads to lesser frequencies of maximality occurrences for higher sized blocks.

Table 11 : Frequency of 10 Power Blocks with Maximum Number of Primes of form 10*n* + *k* in them

Sr. No.	Range 1-*x* (1 to *x*)	No. of Times Maximum No. of Primes Occurring in Blocks			
		Form 10*n* + 1	Form 10*n* + 3	Form 10*n* + 7	Form 10*n* + 9
1.	1-10	9,401,960,980	9,401,979,904	9,401,997,000	9,401,974,132
2.	1-100	1,158	1,266	1,138	1,241
3.	1-1,000	1	1	1	1
4.	1-10,000	1	1	1	1
5.	1-100,000	1	1	1	1
6.	1-1,000,000	1	1	1	1
7.	1-10,000,000	1	1	1	1
8.	1-100,000,000	1	1	1	1
9.	1-1,000,000,000	1	1	1	1
10.	1-10,000,000,000	1	1	1	1
11.	1-100,000,000,000	1	1	1	1
12.	1-1,000,000,000,000	1	1	1	1

Finally their graphical representation remains.

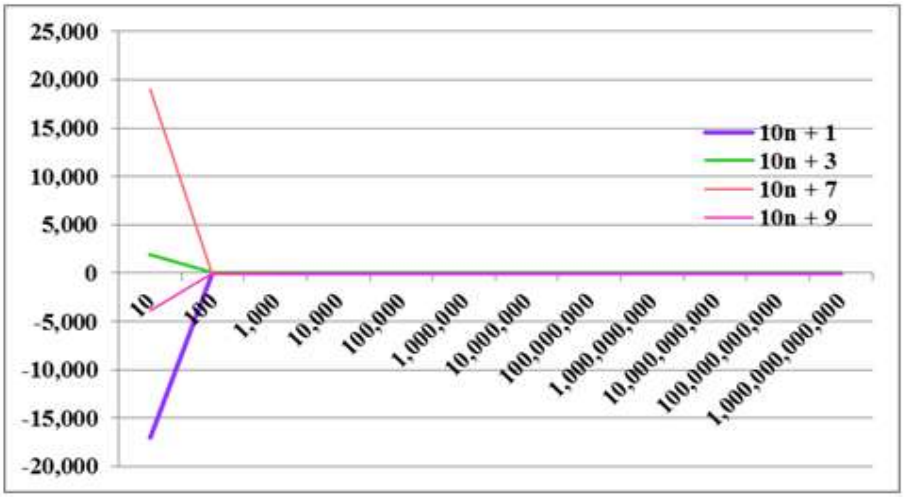

Figure 8 : Deviation in Frequency of Maximum Number of Primes in Blocks from Average.

The values for forms $10n + 2$ and $10n + 5$ are dropped here also. They are same as corresponding values for arithmetical progression $8n + 2$ in [9].

ACKNOWLEDGEMENTS

The author acknowledges extensive use of Java Programming Language, NetBeans IDE & Microsoft Office Excel for which their Development Teams must be thanked.

The computer systems of the Department of Mathematics & Statistics of the author's own institution and the uninterrupted power supply facility by the Department of Electronics both were instrumental in getting this heavy work done.

Special thanks are due to the University Grants Commission (U.G.C.), New Delhi of the Government of India which funded this work under a Research Project (F.No. 47-748/13(WRO)).

The anonymous referee doing his/her painstaking work is also acknowledged.

REFERENCES

[1]. Euclid (of Alexandria), Elements, Book IX (300 BC).
[2]. P.G.L. Dirichlet, Beweis des Satzes, dass jede unbegrenzte arithmetische Progression, deren erstes Glied und Differenz ganze Zahlen ohne gemeinschaftlichen Factor sind, unendlich viele Primzahlen enthält, Abhand. Ak. Wiss. Berlin, 1837.
[3]. Neeraj Anant Pande, Analysis of Primes Less Than a Trillion, International Journal of Computer Science & Engineering Technology, Vol. 6, No. 06, 2015, 332-341.
[4]. Neeraj Anant Pande, Analysis of Primes in Arithmetical Progressions 3n + k up to a Trillion, IOSR Journal of Mathematics, Volume 11, Issue 3 Ver. IV, 2015, 72-85.
[5]. Neeraj Anant Pande, Analysis of Primes in Arithmetical Progressions 4n + k up to a Trillion, International Journal of Mathematics and Computer Applications Research, Vol. 5, Issue 4, 2015, 1-18.
[6]. Neeraj Anant Pande, Analysis of Primes in Arithmetical Progressions 5n + k up to a Trillion, Journal of Research in Applied Mathematics, Volume 2, Issue 5, 2015, 14-29.
[7]. Neeraj Anant Pande, Analysis of Primes in Arithmetical Progressions 6n + k up to a Trillion, International Journal of Mathematics and Computer Research, Volume 3, Issue 6, 2015, 1037-1053.
[8]. Neeraj Anant Pande, Analysis of Primes in Arithmetical Progressions 7n + k up to a Trillion, International Journal of Mathematics and Its Applications, Accepted, 2016.
[9]. Neeraj Anant Pande, Block-wise Distribution of Primes less than a Trillion in Arithmetical Progressions 8n + k, IOSR Journal of Mathematics, 2016, Accepted.
[10]. Neeraj Anant Pande, Spacings Between and Units & Tens Place Digits in Primes till One Trillion in Arithmetical Progressions 8n + k, American International Journal of Research in Science, Technology, Engineering and Mathematics, 2016, Communicated.
[11]. Neeraj Anant Pande, Block-wise Density Distribution of Primes less than a Trillion in Arithmetical Progressions 9n + k, International Journal of Advances in Mathematics and Statistics, 2016, Communicated.
[12]. Neeraj Anant Pande, Spacings Between and Units & Tens Place Digits in Primes till One Trillion in Arithmetical Progressions 9n + k, International Journal of Mathematics and Statistics Invention, 2016, Communicated.
[13]. Andrew Granville, Greg Martin, Prime Number Races, American Mathematical Monthly, 113 (1), 2006, 1–33.
[14]. Neeraj Anant Pande, Evolution of Algorithms: A Case Study of Three Prime Generating Sieves, Journal of Science and Arts, Year 13, No.3(24), 2013, 267-276.
[15]. Neeraj Anant Pande, Algorithms of Three Prime Generating Sieves Improvised Through Nonprimality of Even Numbers (Except 2), International Journal of Emerging Technologies in Computational and Applied Sciences, Issue 6, Volume 4, 2013, 274-279.
[16]. Neeraj Anant Pande, Algorithms of Three Prime Generating Sieves Improvised by Skipping Even Divisors (Except 2), American International Journal of Research in Formal, Applied & Natural Sciences, Issue 4, Volume 1, 2013, 22-27.
[17]. Neeraj Anant Pande, Prime Generating Algorithms through Nonprimality of Even Numbers (Except 2) and by Skipping Even Divisors (Except 2), Journal of Natural Sciences, Vol. 2, No.1, 2014, 107-116.
[18]. Neeraj Anant Pande, Prime Generating Algorithms by Skipping Composite Divisors, International Journal of Computer Science & Engineering Technology, Vol. 5, No. 09, 2014, 935-940.

[19]. Neeraj Anant Pande, Improved Prime Generating Algorithms by Skipping Composite Divisors and Even Numbers (Other Than 2), Journal of Science and Arts, Year 15, No.2(31), 2015, 135-142.
[20]. Neeraj Anant Pande, Refinement of Prime Generating Algorithms, International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 6, 2015, 21-24.
[21]. Herbert Schildt, Java : The Complete Reference, 7th Edition, (Tata McGraw Hill, 2006).