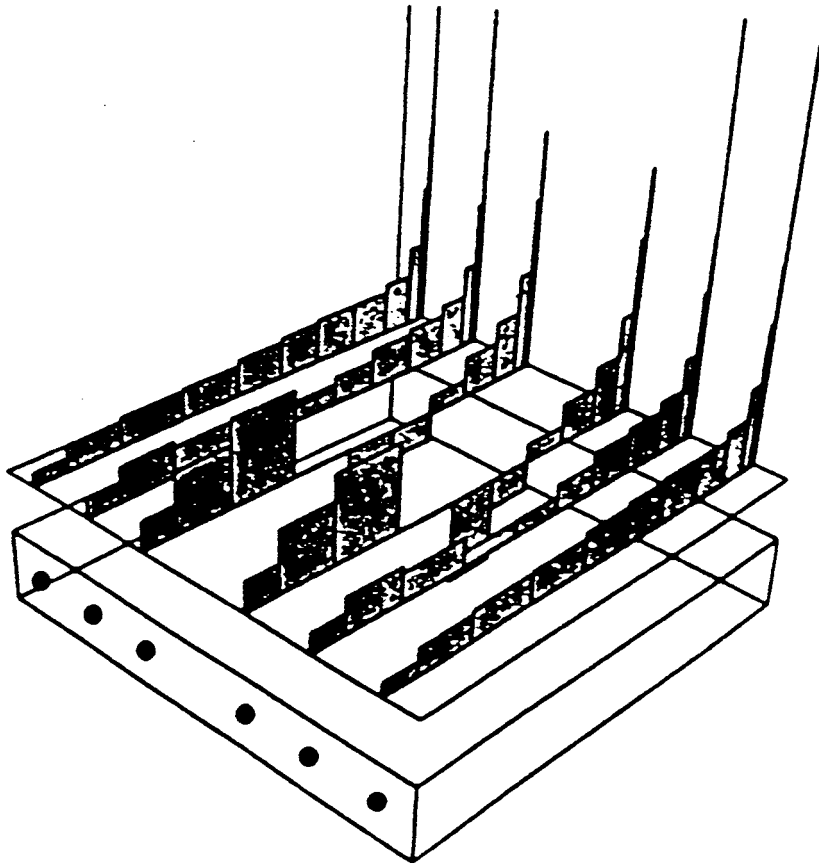


Florentin Smarandache

# ONLY PROBLEMS, NOT SOLUTIONS!



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"ONLY PROBLEMS, NOT SOLUTIONS!", by Florentin Smarandache

Editors: M. Muller (Glendale, Arizona) & C. Dumitrescu

(Univ. of Craiova, Department of Mathematics)

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## MATHEMATICAL PHILOSOPHY ?

### instead of preface ...

The development of mathematics continues in a rapid rhythm, some unsolved problems are elucidated and simultaneously new open problems to be solved appear.

1. "Man is the measure of all things". Considering that mankind will last to infinite, is there a terminus point where this competition of development will end? And, if not, how far can science develop: even so to the infinite? That is . . .

The answer, of course, can be negative, not being an end of development, but a period of stagnation or of small regression. And, if this end of development existed, would it be a (self) destruction? Do we wear the terms of self-destruction in ourselves? (Does everything have an end, even the infinite? Of course, extremes meet.)

I, with my intuitive mind, cannot imagine what this infinite space means (without a beginning, without an end), and its infinity I can explain to myself only by means of a special property of space, a kind of a curved line which obliges me to always come across the same point, something like Moebus Band, or Klein Bottle, which can be put up/down (!)

I am not a specialist in physics, astronomy or philosophy, and I institute the infinite only theoretically

--from the point of view of mathematics (of course unilaterally).

2. Mathematics knows a high degree of abstraction, idealization, and generalization. And I ask, is it possible to build a pure mathematical model for society? You will answer, "it would be too rigid". And you are right because the non-elastic systems stop the progress. But I should replay, "they would be based upon logic". In the future could we become human robots, having the time programmed to the second (or even thousandth of a second!), elements of a mathematical-cybernetical system?

3. How do you imagine mathematics over 1,000 years? What about 1,000,000 year? (I exaggerate, of course.) What other new branches will appear? (Some will be ended, out of date?) (I'm not a futurist [Toepler]).

You may consider these questions too general, or too easy, but what can be more difficult than trying to say a maximum of ideas with a minimum of words? You are right, sometimes a too general idea becomes a common one. Maybe you think that asking questions is easy, but let me contradict you. (R. K. Guy said that asking questions is an art.) And after all, aren't the theories born, at their turn, from questions? (Maybe in this essay the questions are too direct, you are right again.)

4. If we consider "Math (t)", the development of mathematics at a time "t" (considered from the appearance of life on Earth) then

$$(\exists) L = \lim_{t \rightarrow \infty} \text{Math } (t) ?$$

$$t \rightarrow \infty$$

And if it is yes, what is it equal with? With  $\infty$  ? In case of total self-destruction should we obtain  $L = 0$ ? And if life would reappear and the development would start again then should we draw the conclusion that  $(\exists) L$  ? (cyclical development).

5. In case of a total (self) destruction and reappearance of life on Earth, how would they call the Pythagoras' theorem, Euclid's geometry, Birkoff's axioms, Erdős' open problems, and so on? Will mankind pass through the same phases of development? Or, if it would exist, another civilization at the same time, how should they call these results? And how should we call them if these two (or more) civilizations united? (I have arrived in the field of history and of mathematical philosophy, which is not the purpose of this paper.) (All these questions can be also extended to other fields of knowledge.)

I can imagine computers with fantastic memories having the whole mathematics divided like a mosaic: this theorem belongs to X, the other one to Y, this sentence belongs to everybody, the other sentence belongs to nobody--the one who

will invent has not been born yet, but he will be born! A real dictionary of names and ideas, science divided in a finite (but, however, infinite) number of cells, each of them having a strict delimitation, with its own history, and the future generations will add new and new cells.

Although the applied mathematics, the integral calculus, the operator theory are the queens, the primitive arithmetic still fascinates the world because of its apparent elementary problems--very easy to be understood by everybody, but . . .

Why is mankind still interested in these easy problems, of mathematical juggler? I think that it is possible thanks to their simplicity in exposure. ("Ah, it's easy", one says, and to solve it you discover that you plunge into a labyrinth. And, hence, appears a paper: "On a conjecture . . .", "On the unsolved problem . . ." etc.)

I am sure that the "unsolved" problems presented in these pages will be (or have already been before the appearance of this essay) easy for many mathematicians, but for me they were an obsessions. W. Sierpiński was optimistic when he said that if mankind lasted then all these unsolved problems would be solved.

All the material in this paper is original in the author's opinion. He wanted to gather in this paper a variety of material, for the sake of an armony of contraries.

"I want to be a mathematician", as P. R. Halmos, and for the I began to play: rebus + mathematics, literature + mathematics, and even rebus + literature! So, please, do not wonder at this essay.

### References

- [1] R. K. Guy, Unsolved problems in number theory, New York, Heidelberg, Berlin: Springer-Verlag, 1981, p. vii.
- [2] P. R. Halmos, I want to be a mathematician, An Automathography, Berlin, Heidelberg, New York, Tokyo: Lange & Springer, 1985.
- [3] C. Truesdell, An idiot's fugitive essays on sciences, Methods, Criticism, Training, Circumstances: Lange & Springer, 1984.

## UNSOLVED PROBLEM: 1

Find all integer sequences  $\{a_n\}_{n \in \mathbb{N}^*}$  defined as follows:

(I)  $(\forall) i \in \mathbb{N}^*, (\exists) j, k \in \mathbb{N}^*, i \neq j \neq k \neq i$ , such that

$$a_i \equiv a_j \pmod{a_k}.$$

(II)  $(\forall) i \in \mathbb{N}^*, (\exists) j, k \in \mathbb{N}^*, i \neq j \neq k \neq i$ , such that

$$a_j \equiv a_k \pmod{a_i}.$$

## UNSOLVED PROBLEM: 2

Let  $d > 0$ . Questions:

(a) Which is the maximum number of points included in a plane figure (generally: in a space body) such that the distance between any two points to be greater or equal than  $d$ ?

(b) Which is the minimum number of points  $\{A_1, A_2, \dots\}$  included in a plane figure (generally: in a space body) such that if it includes another point  $A$  then there be an  $A_i$  with  $|AA_i| < d$ ?



## UNSOLVED PROBLEM: 3

(a) Let  $a_1, \dots, a_n$  be distinct digits of the set  $\{0, 1, 2, \dots, 9\}$ , for a given  $n$ ,  $1 \leq n \leq 9$ . How many distinct primes can we make up with all these digits? More generally: when  $n \in \mathbb{N}^*$  and  $a_1, \dots, a_n$  are distinct positive integers.

(b) Let  $a \in \{0, 1, \dots, 9\}$ . How many digits of  $a$  does the  $n$ -th prime contain? But  $n!$ ? But  $n^n$ ? More generally: when  $a \in \mathbb{N}$ .

**Comment**

"The sizes  $P_n$ ,  $n!$ ,  $n^n$  have jumps when  $n \rightarrow n + 1$ , hence the analytical expressions are approximate only. Moreover, the results depend on the exact (and not approximate) value of these sizes" (E. Grosswald [1]).

"(a) can be solved quickly on a modern computer" (R. K. Guy [2]).

**References**

- [1] E. Grosswald, University of Pennsylvania, Philadelphia, USA. Letter to the Author; August 3, 1985.
- [2] Richard K. Guy, University of Calgary, Alberta, Canada. Letter to the Author; November 15, 1985.

Digital sequences:

(This a particular case of sequences of sequences.)

General definition:

in any numeration base  $B$ , for any given infinite integer or rational sequence  $S_1, S_2, S_3, \dots$ , and any digit  $D$  from 0 to  $B-1$

it's built up a new integer sequence witch

associates to  $S_1$  the number of digits  $D$  of  $S_1$  in base  $B$ ,  
to  $S_2$  the number of digits  $D$  of  $S_2$  in base  $B$ , and so on...

For exemple, considering the prime number sequence in base 10, then the number of digits 1 (for exemple) of each prime number following their order is: 0,0,0,0,2,1,1,1,0,0,1,0,...  
(the digit-1 prime sequence).

Second exemple if we consider the factorial sequence  $n!$  in base 10, then the number of digits 0 of each factorial number following their order is: 0,0,0,0,0,1,1,2,2,1,3,...  
(the digit-0 factorial sequence).

Third exemple if we consider the sequence  $n^n$  in base 10,  $n=1,2,..$  then the number of digits 5 of each term  $1^1, 2^2, 3^3, \dots$ , following their order is: 0,0,0,1,1,1,1,0,0,0,...  
(The digit-5  $n^n$  sequence)

Construction sequences:

(This a particular case of sequences of sequences.)

General definition:

in any numeration base  $B$ , for any given infinite integer or rational sequence  $S_1, S_2, S_3, \dots$ , and any digits  $D_1, D_2, \dots, D_k$  ( $k < B$ ), it's built up a new integer sequence such that each of its terms  $Q_1 < Q_2 < Q_3 < \dots$  is formed by these digits  $D_1, D_2, \dots, D_k$  only (all these digits are used), and matches a term  $S_i$  of the previous sequence.

For exemple, considering in base 10 the prime number sequence, and the digits 1 and 7 (for exemple), we construct a written-only-with-these-digits (all these digits are used) prime number new sequence: 17,71,... (the digit-1-7-only prime sequence).

Second exemple, considering in base 10 the multiple of 3 sequence, and the digits 0 and 1, we construct a written-only-with-these-digits (all these digits are used) multiple of 3 new sequence: 1011,1101,1110,10011,10101,10110,11001,11010,11100,... (the digit-0-1-only multiple of 3 sequence).

Study this sequence.

Constructive set (of digits 1,2):

1, 2, 11, 12, 21, 22, 111, 112, 121, 122, 211, 212, 221, 222, 1111, 1112,  
1121, 1122, 1211, 1212, 1221, 1222, 2111, 2112, 2121, 2122, 2211, 2212,  
2221, 2222, ...

(Numbers formed by digits 1 and 2 only.)

Definition:

- a1) 1, 2 belong to S;
- a2) if  $a, b$  belong to S, then  $\overline{ab}$  belongs to S too;
- a3) only elements obtained by rules a1) and a2) applied a finite number of times belong to S.

Remark:

- there are  $2^k$  numbers of  $k$  digits in the sequence, for  $k = 1, 2, 3, \dots$ ;
- to obtain from the  $k$ -digits number group the  $(k+1)$ -digits number group, just put first the digit 1 and second the digit 2 in the front of all  $k$ -digits numbers.

Constructive set (of digits 1,2,3):

1,2,3,11,12,13,21,22,23,31,32,33,111,112,113,121,122,123,  
131,132,133,211,212,213,221,222,223,231,232,233,311,312,  
313,321,322,323,331,332,333,...

(Numbers formed by digits 1, 2, and 3 only.)

Definition:

- a1) 1, 2, 3 belong to S;
- a2) if a, b belong to S, then  $\overline{ab}$  belongs to S too;
- a3) only elements obtained by rules a1) and a2) applied  
a finite number of times belong to S.

Remark:

- there are  $3^k$  numbers of k digits in the sequence, for  
k = 1, 2, 3, ... ;
- to obtain from the k-digits number group the (k+1)-digits  
number group, just put first the digit 1, second the digit 2,  
and third the digit 3 in the front of all k-digits numbers.

Generalized constructive set:

(Numbers formed by digits  $d_1, d_2, \dots, d_m$  only,  
all  $d_i$  being different each other,  $1 \leq m \leq 9$ .)

Definition:

- a1)  $d_1, d_2, \dots, d_m$  belong to S;
- a2) if  $a, b$  belong to S, then  $\overline{ab}$  belongs to S too;
- a3) only elements obtained by rules a1) and a2) applied  
a finite number of times belong to S.

Remark:

- there are  $m^k$  numbers of  $k$  digits in the sequence, for  
 $k = 1, 2, 3, \dots$ ;
- to obtain from the  $k$ -digits number group the  $(k+1)$ -digits  
number group, just put first the digit  $d_1$ , second the digit  $d_2$ ,  
 $\dots$ , and the  $m$ -th time digit  $d_m$  in the front of all  $k$ -digits  
numbers.

More general: all digits  $d_i$  can be replaced by numbers as  
large as we want (therefore of many digits each), and also  
 $m$  can be as large as we want.

Study these sequences.

## UNSOLVED PROBLEM: 9

Rationalize the following fraction:

$$1 / \sum_{i=1}^n k_i \sqrt{a_i}.$$

## UNSOLVED PROBLEM: 10

Mathematical Logic:

Is it true that for any question there is at least an answer? Reciprocally: Is any assertion the result of at least a question?

## UNSOLVED PROBLEM: 11

Is it possible to construct a function which obtains all irrational numbers? But all transcendental numbers?

## UNSOLVED PROBLEM: 12

Given  $n$  points in space, four by four noncoplanar, find a maximum  $m$  having the property that there are  $m$  points among  $n$  ones which constitute the vertexes of a convex polyhedron. [An extension of the following conjecture: Anyhow it chooses  $2^{m-2} + 1$  points in plane, three by three noncolinear, there are among these  $m$  joints which are the vertexes of a convex polygon. (Ioan Tomescu, Problems of combinatorics and graph theory [Romanian], Bucharest, EDP, 1983.) For  $m = 5$  the conjecture was proved; it was still proved that it can choose  $2^{m-2}$  points in plane, three by three noncolinear, such that any  $m$  ones among these do not constitute the vertexes of a convex polygon.]



**UNSOLVED PROBLEM: 13**

What is the maximum number of circles of radius 1, at most tangential by twos, which are included into a circle of radius  $n$ ? (Gamma 1/1986). This problem was generalized by Mihaly Bencze, who asks the maximum number of circles of radius  $\phi(n)$ , at the most tangential by twos, which are included into a circle of radius  $n$ , where  $\phi$  is a function of  $n$  (Gamma 3/1986).

Study a similar problem for circles of radius 1 included into a given triangle (on Malfatti's problem). Similar questions for spheres, cones, cylinders, regular pyramids, etc. More generally: planar figures included into a given planar figure. And in the space, too.

**UNSOLVED PROBLEM: 14**

(a) Let  $m \geq 5$  an integer. Find a minimum  $n$  (of course,  $n$  depends on  $m$ ) having the property: anyhow it chooses  $n$  points in space, four by four noncoplanar, there exist  $m$  ones among these which belong to a surface of a sphere.

(b) Same question for an arbitrary spatial figure (for example: cone, cube, etc.).

(c) Similar problems in plane (for  $m \geq 4$ , and the points: three by three noncolinear).



## UNSOLVED PROBLEM: 17

Symmetric sequence:

1, 11, 121, 1221, 12321, 123321, 1234321, 12344321, 123454321,  
 1234554321, 12345654321, 123456654321, 1234567654321,  
 12345677654321, 123456787654321, 1234567887654321,  
 12345678987654321, 123456789987654321, 12345678910987654321,  
 1234567891010987654321, 123456789101110987654321,  
 12345678910111110987654321, ...

How many primes are there among these numbers?

In a general form, the Symmetric Sequence is considered in an arbitrary numeration base B.

**References :**

Arizona State University, Hayden Library, "The Florentin Smarandache papers" special collection, Tempe, AZ 85287-1006, USA.

Student Conference, University of Craiova, Department of Mathematics, April 1979, "Some problems in number theory" by Florentin Smarandache.

# UNSOLVED PROBLEM: 18

Deconstructive sequence:

1, 23, 456, 7891, 23456, 789123, 4567891, 23456789, 123456789, 1234567891, ...  
 |            ||                ||                ||                | |                | |                ||                ...  
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How many primes are there among these numbers?

## References:

Arizona State University, Hayden Library, "The Florentin  
 Smarandache papers" special collection, Tempe, AZ 85287-  
 1006, USA.

# UNSOLVED PROBLEM: 19

Mirror sequence:

1, 212, 32123, 4321234, 543212345, 65432123456, 7654321234567,  
 876543212345678, 98765432123456789, 109876543212345678910,  
 1110987654321234567891011, ...

Question: How many of them are primes?

## UNSOLVED PROBLEM: 20

Permutation sequence:

12,1342,135642,13578642,13579108642,135791112108642,  
 1357911131412108642,13579111315161412108642,  
 135791113151718161412108642,1357911131517192018161412108642,...

Question: Is there any perfect power among these numbers?

(Their last digit should be:

either 2 for exponents of the form  $4k+1$ ,

either 8 for exponents of the form  $4k+3$ , where  $k \geq 0$  .)

Conjecture: no!

Generalized permutation sequence:

If  $g(n)$ , as a function, gives the number of digits of  $a(n)$ ,  
 and  $F$  is a permutation of  $g(n)$  elements, then:

$$a(n) = \overline{F(1)F(2)\dots F(g(n))} .$$

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,

-----

3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14

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Study this sequence.

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, 2, 4, 6, 8, 19, 12, 14, 16, 18,

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0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 0, 5, 10, 15, 20, 25, .
|               |               |               |               |               |
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Study this sequence.

## UNSOLVED PROBLEM: 23

Simple numbers:

2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 17, 19, 21, 22, 23, 25, 26, 27, 29, 31,  
33, 34, 35, 37, 38, 39, 41, 43, 45, 46, 47, 49, 51, 53, 55, 57, 58, 61, 62, 65,  
67, 69, 71, 73, 74, 77, 78, 79, 82, 83, 85, 86, 87, 89, 91, 93, 94, 95, 97, 101, 103, .

(A number  $n$  is called <simple number> if the product of its proper divisors is less than or equal to  $n$ .)

Generally speaking,  $n$  has the form:

$n = p$ , or  $p^2$ , or  $p^3$ , or  $pq$ , where  $p$  and  $q$  are distinct primes.

Study this sequence.

### References:

Student Conference, University of Craiova, Department of Mathematics, April 1979, "Some problems in number theory" by Florentin Smarandache.

## UNSOLVED PROBLEM: 24

Pierced chain:

101,1010101,10101010101,101010101010101,1010101010101010101,  
1010101010101010101010101,1010101010101010101010101,...

$$(c(n) = 101 * 1 \begin{array}{c} 0001 \quad 0001 \quad \dots \quad 0001 \\ | \quad | \quad | \quad | \quad \dots \quad | \quad | \\ \hline 1 \quad \quad 2 \quad \quad \quad n-1 \end{array}, \text{ for } n \geq 1)$$

How many  $c(n)/101$  are primes ?

## References:

Arizona State University, Hayden Library, "The Florentin Smarandache papers" special collection, Tempe, AZ 85287-1006, USA.

Student Conference, University of Craiova, Department of Mathematics, April 1979, "Some problems in number theory" by Florentin Smarandache.

## UNSOLVED PROBLEM: 25

Divisor products:

1,2,3,8,5,36,7,64,27,100,11,1728,13,196,225,1024,17,5832,19,  
8000,441,484,23,331776,125,676,729,21952,29,810000,31,32768,  
1089,1156,1225,10077696,37,1444,1521,2560000,41,...

( $P_d(n)$  is the product of all positive divisors of  $n$ .)

Study this sequence.



## UNSOLVED PROBLEM: 26

Proper divisor products:

1, 1, 1, 2, 1, 6, 1, 8, 3, 10, 1, 144, 1, 14, 15, 64, 1, 324, 1, 400, 21, 22, 1,  
13824, 5, 26, 27, 784, 1, 27000, 1, 1024, 33, 34, 35, 279936, 1, 38, 39,  
64000, 1, ...

( $p_d(n)$  is the product of all positive divisors of  $n$  but  $n$ .)

Study this sequence.

## UNSOLVED PROBLEM: 27

Square complements:

1, 2, 3, 1, 5, 6, 7, 2, 1, 10, 11, 3, 14, 15, 1, 17, 2, 19, 5, 21, 22, 23, 6, 1, 26,  
3, 7, 29, 30, 31, 2, 33, 34, 35, 1, 37, 38, 39, 10, 41, 42, 43, 11, 5, 46, 47, 3,  
1, 2, 51, 13, 53, 6, 55, 14, 57, 58, 59, 15, 61, 62, 7, 1, 65, 66, 67, 17, 69, 70, 71, 2,

Definition:

for each integer  $n$  to find the smallest integer  $k$  such that  
 $nk$  is a perfect square..

(All these numbers are square free.)

Study this sequence.

**UNSOLVED PROBLEM: 28**

Cubic complements:

1, 4, 9, 2, 25, 36, 49, 1, 3, 100, 121, 18, 169, 196, 225, 4, 289, 12, 361, 50,  
441, 484, 529, 9, 5, 676, 1, 841, 900, 961, 2, 1089, 1156, 1225, 6, 1369,  
1444, 1521, 25, 1681, 1764, 1849, 242, 75, 2116, 2209, 36, 7, 20, ...

Definition:

for each integer  $n$  to find the smallest integer  $k$  such that  
 $nk$  is a perfect cub.

(All these numbers are cube free.)

Study this sequence.

**UNSOLVED PROBLEM: 29**

$m$ -power complements:

Definition:

for each integer  $n$  to find the smallest integer  $k$  such that  
 $nk$  is a perfect  $m$ -power ( $m \Rightarrow 2$ ).

(All these numbers are  $m$ -power free.)

Study this sequence.

**Reference:**

Arizona State University, Hayden Library, "The Florentin  
Smarandache papers" special collection, Tempe, AZ 85287-  
1006, USA.

## UNSOLVED PROBLEM: 30

Cube free sieve:

2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 25, 26,  
28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 41, 42, 43, 44, 45, 46, 47, 49, 50,  
51, 52, 53, 55, 57, 58, 59, 60, 61, 62, 63, 65, 66, 67, 68, 69, 70, 71, 73, ...

Definition: from the set of natural numbers (except 0 and 1):

- take off all multiples of  $2^3$  (i.e. 8, 16, 24, 32, 40, ...)
- take off all multiples of  $3^3$
- take off all multiples of  $5^3$
- ... and so on (take off all multiples of all cubic primes).

(One obtains all cube free numbers.)

Study this sequence.

## UNSOLVED PROBLEM: 31

m-power free sieve:

Definition: from the set of natural numbers (except 0 and 1)

- take off all multiples of  $2^m$ , afterwards all multiples of  $3^m$ , .
- and so on (take off all multiples of all m-power primes,  $m \geq 2$ ).

(One obtains all m-power free numbers.)

Study this sequence.

## UNSOLVED PROBLEM: 32

Irrational root sieve:

2, 3, 5, 6, 7, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 26, 28,  
29, 30, 31, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50,  
51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 65, 66, 67, 68, 69, 70, 71, 72, 73,

Definition: from the set of natural numbers (except 0 and 1):

- take off all powers of  $2^k$ ,  $k \geq 2$ , (i.e. 4, 8, 16, 32, 64, ...)
- take off all powers of  $3^k$ ,  $k \geq 2$ ;
- take off all powers of  $5^k$ ,  $k \geq 2$ ;
- take off all powers of  $6^k$ ,  $k \geq 2$ ;
- take off all powers of  $7^k$ ,  $k \geq 2$ ;
- take off all powers of  $10^k$ ,  $k \geq 2$ ;

... and so on (take off all  $k$ -powers,  $k \geq 2$ , of all square free numbers).

One gets all square free numbers by the following method (sieve):

from the set of natural numbers (except 0 and 1):

- take off all multiples of  $2^2$  (i.e. 4, 8, 12, 16, 20, ...)
- take off all multiples of  $3^2$
- take off all multiples of  $5^2$

... and so on (take off all multiples of all square primes);

one obtains, therefore:

2, 3, 5, 6, 7, 10, 11, 13, 14, 15, 17, 19, 21, 22, 23, 26, 29, 30, 31, 33, 34,  
35, 37, 38, 39, 41, 42, 43, 46, 47, 51, 53, 55, 57, 58, 59, 61, 62, 65, 66,  
67, 69, 70, 71, ... ,

which are used for irrational root sieve.

(One obtains all natural numbers those  $m$ -th roots, for any  $m \geq 2$ , are irrational.)

Study this sequence.

**References :**

Arizona State University, Hayden Library, "The Florentin Smarandache papers" special collection, Tempe, AZ 85287-1006, USA.

Student Conference, University of Craiova, Department of Mathematics, April 1979, "Some problems in number theory" by Florentin Smarandache.

## UNSOLVED PROBLEM: 33

Let  $a_1, a_2, \dots, a_m$  be digits. Are there primes, on a base  $b$ , which contain the group of digits  $\overline{a_1 \dots a_m}$  into its writing? (For example, if  $a_1 = 0$  and  $a_2 = 9$  there are primes as 109, 409, 709, 809, ...) But  $n!$  ? But  $n^n$  ?

## UNSOLVED PROBLEM: 34

## Conjecture

Let  $k \geq 2$  a positive integer. The diophantine equation:

$$y = 2 x_1 x_2 \dots x_k + 1$$

has an infinity of solutions of primes. (For example:  $571 = 2 \cdot 3 \cdot 5 \cdot 19 + 1$ ,  $691 = 2 \cdot 3 \cdot 5 \cdot 23 + 1$ , or  $647 = 2 \cdot 17 \cdot 19 + 1$ , when  $k = 4$ , respectively, 3). (Gamma 2/1986).

## UNSOLVED PROBLEM: 35

Let  $d_n$  be the distance between two consecutive primes,

$$d_n = \frac{1}{2} (p_{n+1} - p_n), \quad n = 1, 2, \dots \quad \text{Does } d_n \text{ contain an infinite}$$

number of primes?

Does  $d_n$  contain numbers of the form  $n!$  ? But of the form  $n^n$  ?

$$\begin{aligned} \text{Let } i \in \mathbb{N}^*, \text{ and } d_n^{(i)} &= \frac{1}{2} (p_{n+i} - p_n), \quad \text{and } d_{n,i}^{(j)} = \\ &= \frac{1}{2} (d_{n+j}^{(i)} - d_n^{(i)}) \text{ for } n = 1, 2, \dots \end{aligned}$$

The same questions.

(Gamma 2/1986).

## UNSOLVED PROBLEM: 36

**Conjecture**

Anyhow the points of a plane are colored with  $n$  colors, there exists a color which fulfills all distances [i.e.,  $(\exists)$  a color  $c$ ,  $(\forall) d \geq 0$ ,  $(\exists)$  the points  $A, B$  colored in  $c$ , such that the line  $AB$  is colored in  $c$  and  $|AB| = d$ ].

(The result would implicitly be true in space, too.)

## UNSOLVED PROBLEM: 37

Let  $k, n \in \mathbb{N}^*$ ,  $k < n$ . We define a decreasing sequence of integers:  $n_0 = n$  and  $n_{i+1} = \max \{p, p | n_i - k, p \text{ is a prime}\}$ , for  $i \geq 0$ .

Find the length (the number of terms) of this sequence (Gamma 2-3/1987).

## UNSOLVED PROBLEM: 38

Spreading to infinite van der Waerden's theorem: Is it possible to partition  $\mathbb{N}^*$  into an infinity of arbitrary classes such that at least one class contain an arithmetic progression of  $\ell$  terms ( $\ell \geq 3$ )?

Find a maximum  $\ell$  having this property.



## UNSOLVED PROBLEM: 39

(Inferior) prime part:

2, 3, 3, 5, 5, 7, 7, 7, 7, 11, 11, 13, 13, 13, 13, 17, 17, 19, 19, 19, 19, 23, 23,  
23, 23, 23, 23, 29, 29, 31, 31, 31, 31, 31, 31, 37, 37, 37, 37, 41, 41, 43, 43,  
43, 43, 47, 47, 47, 47, 47, 47, 53, 53, 53, 53, 53, 53, 59, ...

(For any positive real number  $n$  one defines  $p(n)$  as the  
largest prime number less than or equal to  $n$ .)

(Superior) prime part:

2, 2, 2, 3, 5, 5, 7, 7, 11, 11, 11, 11, 13, 13, 17, 17, 17, 17, 19, 19, 23, 23,  
23, 23, 29, 29, 29, 29, 29, 29, 31, 31, 37, 37, 37, 37, 37, 37, 41, 41, 41,  
41, 43, 43, 47, 47, 47, 47, 53, 53, 53, 53, 53, 53, 59, 59, 59, 59, 59, 59, 61, ...

(For any positive real number  $n$  one defines  $P(n)$  as the  
smallest prime number greater than or equal to  $n$ .)

Study these sequences.

**Reference:**

Arizona State University, Hayden Library, "The Florentin  
Smarandache papers" special collection, Tempe, AZ 85287-  
1006, USA.

## UNSOLVED PROBLEM: 40

(Inferior) square part:

0, 1, 1, 1, 4, 4, 4, 4, 4, 9, 9, 9, 9, 9, 9, 9, 9, 16, 16, 16, 16, 16, 16, 16, 16, 16,  
 25, 25, 25, 25, 25, 25, 25, 25, 25, 25, 25, 25, 25, 36, 36, 36, 36, 36, 36, 36, 36, 36,  
 36, 36, 36, 36, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 64, 64, ...

(The largest square less than or equal to  $n$ .)

(Superior) square part:

0, 1, 4, 4, 4, 9, 9, 9, 9, 9, 16, 16, 16, 16, 16, 16, 16, 25, 25, 25, 25, 25, 25,  
 25, 25, 25, 36, 36, 36, 36, 36, 36, 36, 36, 36, 36, 36, 36, 49, 49, 49, 49, 49, 49,  
 49, 49, 49, 49, 49, 49, 49, 64, 64, 64, 64, 64, 64, 64, 64, 64, 64, 64, 64, 64,  
 64, 64, 81, 81, ...

(The smallest square greater than or equal to  $n$ .)

Study these sequences.

## UNSOLVED PROBLEM: 41

(Inferior) cube part:

0,1,1,1,1,1,1,1,8,27,27,  
 27,  
 27,27,27,27,27,27,27,27,27,27,27,27,27,27,27,64,64,64,...

(The largest cube less than or equal to  $n$ .)

(Superior) cube part:

0,1,8,8,8,8,8,8,8,8,27,27,27,27,27,27,27,27,27,27,27,27,  
 27,27,27,27,27,27,64,64,64,64,64,64,64,64,64,64,64,64,64,  
 64,64,64,64,64,64,64,64,64,64,64,64,64,64,64,64,64,64,  
 64,64,64,64,64,125,125,125,...

(The smallest cube greater than or equal to  $n$ .)

Study these sequences.

## UNSOLVED PROBLEM: 42

(Inferior) factorial part:

1, 2, 2, 2, 2, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 24, 24, 24, 24,  
24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, ...

( $F_p(n)$  is the largest factorial less than or equal to  $n$ .)

(Superior) factorial part:

1, 2, 6, 6, 6, 6, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24,  
24, 24, 120, 120, 120, 120, 120, 120, 120, 120, 120, 120, 120, 120, ...

( $f_p(n)$  is the smallest factorial greater than or equal to  $n$ .)

Study these sequences.

## UNSOLVED PROBLEM: 43

Double factorial complements:

1,1,1,2,3,8,15,1,105,192,945,4,10395,46080,1,3,2027025,2560,  
34459425,192,5,3715891200,13749310575,2,81081,1961990553600,  
35,23040,213458046676875,128,6190283353629375,12,...

(For each  $n$  to find the smallest  $k$  such that  $nk$  is a double factorial, i.e.  $nk =$  either  $1*3*5*7*9*...*n$  if  $n$  is odd,  
either  $2*4*6*8*...*n$  if  $n$  is even.)

Study this sequence in interrelation with Smarandache function {  $S(n)$  is the smallest integer such that  $S(n)!$  is divisible by  $n$  }.

## UNSOLVED PROBLEM: 44

Prime additive complements:

1,0,0,1,0,1,0,3,2,1,0,1,0,3,2,1,0,1,0,3,2,1,0,5,4,3,2,1,0,  
1,0,5,4,3,2,1,0,3,2,1,0,1,0,3,2,1,0,5,4,3,2,1,0,...

(For each  $n$  to find the smallest  $k$  such that  $n+k$  is prime.)

Remark: is it possible to get as large as we want  
but finite decreasing  $k, k-1, k-2, \dots, 2, 1, 0$  (odd  $k$ )  
sequence included in the previous sequence -- i.e. for any  
even integer are there two primes whose difference is equal  
to it? I conjecture the answer is negative.

**Reference:**

Arizona State University, Hayden Library, "The Florentin  
Smarandache papers" special collection, Tempe, AZ 85287-  
1006, USA.

## UNSOLVED PROBLEM: 45

Factorial quotients:

1, 1, 2, 6, 24, 1, 720, 3, 80, 12, 3628800, 2, 479001600, 360, 8, 45,  
20922789888000, 40, 6402373705728000, 6, 240, 1814400,  
1124000727777607680000, 1, 145152, 239500800, 13440, 180,  
304888344611713860501504000000, ...

(For each  $n$  to find the smallest  $k$  such that  $nk$  is a factorial number.)

Study this sequence in interrelation with Smarandache function.

**Reference:**

Arizona State University, Hayden Library, "The Florentin  
Smarandache papers" special collection, Tempe, AZ 85287-  
1006, USA.

## UNSOLVED PROBLEM: 46

Double factorial numbers:

1, 2, 3, 4, 5, 6, 7, 4, 9, 10, 11, 6, 13, 14, 5, 6, 17, 12, 19, 10, 7, 22, 23, 6,  
15, 26, 9, 14, 29, 10, 31, 8, 11, 34, 7, 12, 37, 38, 13, 10, 41, 14, 43, 22, 9,  
46, 47, 6, 21, 10, ...

( $d_f(n)$  is the smallest integer such that  $d_f(n)!!$  is a  
multiple of  $n$ .)

Study this sequence in interrelation with Smarandache function.

**Reference:**

Arizona State University, Hayden Library, "The Florentin  
Smarandache papers" special collection, Tempe, AZ 85287-  
1006, USA.



## UNSOLVED PROBLEM: 47

Primitive numbers (of power 2):

2, 4, 4, 6, 8, 8, 8, 10, 12, 12, 14, 16, 16, 16, 16, 18, 20, 20, 22, 24, 24, 24,  
 26, 28, 28, 30, 32, 32, 32, 32, 32, 34, 36, 36, 38, 40, 40, 40, 42, 44, 44, 46,  
 48, 48, 48, 48, 50, 52, 52, 54, 56, 56, 56, 58, 60, 60, 62, 64, 64, 64, 64, 64, 64, 66, ...  
 $(S_2(n))$  is the smallest integer such that  $S_2(n)!$  is divisible by  $2^n$ .

Curious property: this is the sequence of even numbers,  
 each number being repeated as many times as its exponent  
 (of power 2) is.

This is one of irreducible functions, noted  $S_2(k)$ , which  
 helps to calculate the Smarandache function.

Study this sequence.

## UNSOLVED PROBLEM: 48

Primitive numbers (of power 3):

3, 6, 9, 9, 12, 15, 18, 18, 21, 24, 27, 27, 27, 30, 33, 36, 36, 39, 42, 45, 45,  
48, 51, 54, 54, 54, 57, 60, 63, 63, 66, 69, 72, 72, 75, 78, 81, 81, 81, 81, 84,  
87, 90, 90, 93, 96, 99, 99, 102, 105, 108, 108, 108, 111, ...

( $S_3(n)$  is the smallest integer such that  $S_3(n)!$  is divisible by  $3^n$ .)

Curious property: this is the sequence of multiples of 3, each number being repeated as many times as its exponent (of power 3) is.

This is one of irreducible functions, noted  $S_3(k)$ , which helps to calculate the Smarandache function.

Study this sequence.

## UNSOLVED PROBLEM: 49

Primitive numbers (of power  $p$ ,  $p$  prime) {generalization}:

( $S_p(n)$  is the smallest integer such that  $S_p(n)!$  is divisible by  $p^n$ .)

Curious property: this is the sequence of multiples of  $p$ , each number being repeated as many times as its exponent (of power  $p$ ) is. These are the irreducible functions, noted  $S_p(k)$ , for any prime number  $p$ , which helps to calculate the  $S_p$  Smarandache function.

Study this sequence.

## UNSOLVED PROBLEM: 50

Let  $a \in \mathbb{Q} \setminus \{-1, 0, 1\}$ . Solve the equation:

$$xa^{\frac{1}{x}} + \frac{1}{x} a^x = 2a.$$

[A generalization of the problem 0:123, Gazeta Matematică, No. 3/1980, p. 125.]

## UNSOLVED PROBLEM: 51

(a) If  $(a, b) = 1$ , how many primes does the progression  $ap_n + b$ ,  $n = 1, 2, \dots$ , contain? where  $p_n$  is the  $n$ -th prime. But numbers of the form  $n!$ ? But  $n^n$ ?

(b) Same questions for  $a^n + b$ ,  $a \notin \{\pm 1, 0\}$ .

(c) Same questions for  $k^k + 1$  and  $k^k - 1$ ,  $k \in \mathbb{N}^*$ .

(Gamma 2/1986)

## UNSOLVED PROBLEM: 52

(a) Let  $n$  be a non-null positive integer and  $d(n)$  the number of positive divisors of  $n$ . Of course,  $d(n) \leq n$ , and  $d(n) = 1$  if and only if  $n = 1$ . For  $n \geq 2$  we have  $d(n) \geq 2$ . Find the smallest  $k$  such that

$$\underbrace{d(d(\dots d(n)\dots))}_{k \text{ times}} = 2$$

(b) Let  $\sigma(n) = \sum_{\substack{d|n \\ d>0}} d$  and  $m$  a given positive integer

Find the smallest  $k$  such that

$$\underbrace{\sigma(\sigma(\dots \sigma(2)\dots))}_{k \text{ times}} \geq m.$$

## UNSOLVED PROBLEM: 53

Let  $a_1, a_2, \dots$  be a strictly increasing sequence of positive integers, and  $N(n)$  the number of terms of the sequence not greater than  $n$ .

(1) Find the smallest  $k$  such that

$$\underbrace{N(N(\dots N(n)\dots))}_{k \text{ times}} \text{ is constant, for a given } n.$$

(2) If  $a_1 \notin \{0, 1\}$ , find the smallest  $k$  such that

$$k \sum_{i=1}^t \frac{a_i}{a_1} \geq n, \text{ for a given } n.$$

### Particular Cases

- (a) When  $\{a_i\}_i$  is the sequence of primes.
- (b) When  $\{a_i\}_i$  is the sequence of  $m$ -th powers, for a given  $m$  :  $0, 1, 2^m, 3^m, \dots$   
For example, the sequence of perfect squares.
- (c)  $\{a_i\}_i$  is anyone of the well known sequences of positive integers, for example Fibonacci (or Lucas, Fermat, Bernoulli, Mersenne, van der Waerden, etc.) numbers.

### UNSOLVED PROBLEM: 54

Let  $k$  be a non-zero integer. There are only a finite number of solutions in integers  $p, q, x, y$ , each greater than 1, of the equation  $x^p - y^q = k$ .

(On Catalan's conjecture) [For  $k = 1$  this was conjectured by Cassels (1953) and proved by Tijdeman (1976).]

(Gamma 2/1986)

## UNSOLVED PROBLEM: 55

Let  $\{x_n\}_{n \geq 1}$  be a sequence of integers, and  $0 \leq k \leq q$  a digit. We define a sequence of position:

$$U_n^{(k)} = U^{(k)}(X_n) = \begin{cases} i, & \text{if } k \text{ is the } i\text{-th digit of } x_n; \\ 0, & \text{in the other ones} \end{cases}$$

(For example: if  $x_1 = 5$ ,  $x_2 = 17$ ,  $x_3 = 715$ , ... and  $K = 7$ , then

$$U_1^{(7)} = U^{(7)}(x_1) = 0, \quad U_2^{(7)} = 2, \quad U_3^{(7)} = 1, \quad \dots)$$

(1) Study  $\{U^{(k)}(p_n)\}_n$ , where  $\{p_n\}_n$  is the sequence of primes. Convergence, monotony.

The same questions for the sequences:

$$(2) \quad x_n = n!, \quad n = 1, 2, \dots$$

$$(3) \quad x_n = n^n, \quad n = 1, 2, \dots$$

Do the sequences of position  $U_n^{(k)}$  contain an infinity of primes?

More generally: when  $\{x_n\}_n$  is a sequence of rational numbers and  $k \in \mathbb{N}$ .

## UNSOLVED PROBLEM: 56

Let  $M$  be a number in a base  $b$ . All distinct digits of  $M$  are named generalized period of  $M$ . (For example, if  $M = 104001144$ , its generalized period is  $g(M) = \{0, 1, 4\}$ ). Of course,  $g(M) \subseteq \{0, 1, 2, \dots, b-1\}$ .

The number of generalized period of  $M$  is equal to the number of groups of  $M$  such that each group contain all digits of  $g(M)$ . (For example,  $n_g(M) = 2$ ,  $M = \frac{104}{1} \frac{001144}{2}$ ).

Length of the generalized period is equal to the number of its digits. (For example,  $\ell_g(M) = 3$ .)

**Questions**

- (1) Find  $n_g$ ,  $\ell_g$  for  $p_n$ ,  $n!$ ,  $n^n$ ,  $\sqrt[n]{n}$ .
- (2) For a given  $k \geq 1$ , is there an infinity of primes  $p_n$ , or  $n!$ , or  $n^n$ , or  $\sqrt[n]{n}$  which have a generalized period of length  $k$ ? But which have the number of generalized periods equal to  $k$ ?
- (3) Let  $a_1, a_2, \dots, a_h$  distinct digits. Is there an infinity of primes  $p_n$ , or  $n!$ , or  $n^n$ , or  $\sqrt[n]{n}$  which have as generalized period the set  $\{a_1, a_2, \dots, a_h\}$ ?

**Remark**

There exist arithmetic and geometrical progressions which contain an infinity of terms of given generalized period. For example, if  $g = \{6, 7\}$ , we construct an arithmetic progression: 67, 167, 267, ... and a geometrical one: 67, 670, 6700, ...

## UNSOLVED PROBLEM: 57

Find the maximum  $r$  such that: the set  $\{1, 2, \dots, r\}$  can be partitioned into  $n$  classes such that no class contains integers  $x, y, z$  with  $xy = z$ .

(On Schur's Problem)

Same question when  $x^y = z$ .

Same question when no integer can be the sum of another integer of its class. (A generalization of Schur's Problem.)

## UNSOLVED PROBLEM: 58

Let  $N = \{1, 2, \dots, n\}$ . Find the maximum number of elements extracted from  $N$  such that any  $m$  from these be not an arithmetic progression ( $n > m > 2$ ).

Same question when the  $m$  elements must not be a geometrical progression.

More generally: Let  $R$  be a given  $m$ -ary relation on a field  $N$ . What is the maximum number of elements extracted from  $N$  such that any  $m$  from these be not in this relation? What happens when  $N$  has continuation power (for example when  $N$  is an interval from  $R$ )? [On van der Waerden's theorem.]



## UNSOLVED PROBLEM: 59

Let  $\omega$  numbers be  $a + b\omega$ , where  $\omega$  is a complex  $n$ -th root of unity,  $\omega^{n-1} + \omega^{n-2} + \dots + 1 = 0$ , which enjoy unique factorization. The units are:  $\pm 1, \pm \omega, \pm \omega^2, \dots, \pm \omega^{n-1}$ .

**Conjecture**

The configuration of  $\omega$  primes are symmetric of the  $2n$  regular polygon.

(On Gaussian primes. A generalization of Einstein's integers.)

**Reference**

- [1] R. K. Guy, Unsolved Problems in Number Theory, Springer-Verlag, New York, Heidelberg, Berlin, 1981, pp. 20-22, A16.

## UNSOLVED PROBLEM: 60

The equation  $x^3 + y^3 + z^3 = 1$  has as solutions  $(9, 10, -12)$  and  $(-6, -8, 9)$ . How many other nontrivial integer solutions are there?

## References

- [1] V. L. Gardiner, R. B. Lazarus, and P. R. Stein, Solution of the Diophantine Equation  $x^3 + y^3 = z^3 - d$ , Math. Comput. 18 (1964) 408-413; MR 31 #119.
- [2] J. C. P. Miller and M. F. C. Woollett, Solutions of the Diophantine Equation  $x^3 + y^3 + z^3 = k$ , J. London: Math. Soc. 30 (1955) 101-110; MR 16, 979.
- [3] R. K. Guy. Unsolved Problems in Number Theory. Springer-Verlag, New York, Heidelberg, Berlin, 1981, p. 84, D5.

## UNSOLVED PROBLEM: 61

Daniel Silverman asked if  $\prod_{n=1}^m \frac{p_n+1}{p_n-1}$ , where  $p_n$  is the  $n$ -th

prime, is an integer for others  $m \in \{1, 2, 3, 4, 8\}$ . We conjecture that

$$R_m = \prod_{n=1}^m \frac{p_n+k}{p_n-k}, \text{ with } K \in \mathbb{N}^*,$$

is an integer for a finite number of values of  $m$ . There is an infinite number of  $k$  for which no  $R_m$  is an integer.

## Reference

- [1] R. K. Guy, Unsolved Problems in Number Theory, Springer-Verlag, New York, Heidelberg, Berlin, 1981, p. 57, B48.

## UNSOLVED PROBLEM: 62

## ON A PROBLEM WITH INFINITE SEQUENCES

Let  $1 \leq a_1 < a_2 < \dots$  be an infinite sequence of integers such that any three members do not constitute an arithmetical progression. Is it true that always  $\sum_{n \geq 1} 1/a_n \leq 2$ ? Is the function

$$S(\{a_n\}_{n \geq 1}) = \sum_{n \geq 1} 1/a_n$$

bijective? (biunivocal)

For example,  $a_n = p^{n-1}$ ,  $n \geq 1$ ,  $p$  is an integer  $> 1$ , has the property of the assumption, and  $\sum_{n \geq 1} 1/a_n = 1 + \frac{1}{p-1} \leq 2$ .

Analogously for geometrical progressions.

More generally: let  $f$  be a function  $f: R_+^m \rightarrow R_+^*$ . We construct a sequence  $0 < a_1 < a_2 < \dots$  such that there is no  $(a_{i_1}, \dots, a_{i_m}, a_{i_{m+1}})$  with  $f(a_{i_1}, \dots, a_{i_m}) = a_{i_{m+1}}$ . Find

$$\max_{\{a_n\}_{n \geq 1}} \sum_{n \geq 1} \frac{1}{a_n}.$$

(It's a generalization of a question from the problem E28, R. K. Guy, Unsolved Problems in Number Theory, Springer-Verlag, 1987, p. 127.)

Is the function

$$S(\{a_n\}_{n \geq 1}) = \sum_{n \geq 1} 1/a_n$$

bijective?

## UNSOLVED PROBLEM: 63

Square residues:

1, 2, 3, 2, 5, 6, 7, 2, 3, 10, 11, 6, 13, 14, 15, 2, 17, 6, 19, 10, 21, 22, 23, 6,  
5, 26, 3, 14, 29, 30, 31, 2, 33, 34, 35, 6, 37, 38, 39, 10, 41, 42, 43, 22, 15,  
46, 47, 6, 7, 10, 51, 26, 53, 6, 14, 57, 58, 59, 30, 61, 62, 21, ...

( $s_r(n)$  is the largest square free number which divides  $n$ .)

Or,  $s_r(n)$  is the number  $n$  released of its squares:

if  $n = (p_1^{a_1}) * \dots * (p_r^{a_r})$ , with all  $p_i$  primes and all  $a_i \geq 1$   
then  $s_r(n) = p_1 * \dots * p_r$ .

Remark: at least the  $(2^2)*k$ -th numbers ( $k = 1, 2, 3, \dots$ )  
are released of their squares;  
and more general: all  $(p^2)*k$ -th numbers (for all  $p$  prime,  
and  $k = 1, 2, 3, \dots$ ) are released of their squares.

Study this sequence.

## UNSOLVED PROBLEM: 64

Cubical residues:

1, 2, 3, 4, 5, 6, 7, 4, 9, 10, 11, 12, 13, 14, 15, 4, 17, 18, 19, 20, 21, 22, 23,  
12, 25, 26, 9, 28, 29, 30, 31, 4, 33, 34, 35, 36, 37, 38, 39, 20, 41, 42, 43,  
44, 45, 46, 47, 12, 49, 50, 51, 52, 53, 18, 55, 28, ...

( $c_r(n)$  is the largest cube free number which divides  $n$ .)

Or,  $c_r(n)$  is the number  $n$  released of its cubicals:

if  $n = (p_1^{a_1}) * \dots * (p_r^{a_r})$ , with all  $p_i$  primes and all  $a_i \geq 1$   
then  $c_r(n) = (p_1^{b_1}) * \dots * (p_r^{b_r})$ , with all  $b_i = \min \{2, a_i\}$ .

Remark: at least the  $(2^3)*k$ -th numbers ( $k = 1, 2, 3, \dots$ )  
are released of their cubicals;

and more general: all  $(p^3)*k$ -th numbers (for all  $p$  prime,  
and  $k = 1, 2, 3, \dots$ ) are released of their cubicals.

Study this sequence.

## UNSOLVED PROBLEM: 65

m-power residues (generalization):

$m_r(n)$  is the largest m-power free number which divides n.)

Or,  $m_r(n)$  is the number n released of its m-powers:

if  $n = (p_1^{a_1}) \cdot \dots \cdot (p_r^{a_r})$ , with all  $p_i$  primes and all  $a_i \geq 1$   
 then  $m_r(n) = (p_1^{b_1}) \cdot \dots \cdot (p_r^{b_r})$ , with all  $b_i = \min \{ m-1, a_i \}$

Remark: at least the  $(2^m) \cdot k$ -th numbers ( $k = 1, 2, 3, \dots$ )

are released of their m-powers;

and more general: all  $(p^m) \cdot k$ -th numers (for all p prime,

and  $k = 1, 2, 3, \dots$ ) are released of their m-powers.

Study this sequence.

## UNSOLVED PROBLEM: 66

Exponents (of power 2):

0,1,0,2,0,1,0,3,0,1,0,2,0,1,0,4,0,1,0,2,0,1,0,2,0,1,0,2,0,  
 1,0,5,0,1,0,2,0,1,0,3,0,1,0,2,0,1,0,3,0,1,0,2,0,1,0,3,0,1,  
 0,2,0,1,0,6,0,1,...

$e_2(n)$  is the largest exponent (of power 2) which divides n.)

Or,  $e_2(n) = k$  if  $2^k$  divides n but  $2^{(k+1)}$  does not.

## UNSOLVED PROBLEM: 67

Exponents (of power 3):

0,0,1,0,0,1,0,0,2,0,0,1,0,0,1,0,0,2,0,0,1,0,0,1,0,0,3,0,0,  
1,0,0,1,0,0,2,0,0,1,0,0,1,0,0,2,0,0,1,0,0,1,0,0,2,0,0,1,0,  
0,1,0,0,2,0,0,1,0,...

( $e_3(n)$  is the largest exponent (of power 3) which divides  $n$ .)

Or,  $e_3(n) = k$  if  $3^k$  divides  $n$  but  $3^{(k+1)}$  does not.

## UNSOLVED PROBLEM: 68

Exponents (of power  $p$ ) {generalization}:

( $e_p(n)$  is the largest exponent (of power  $p$ ) which divides  $n$ ,  
where  $p$  is an integer  $\geq 2$ .)

Or,  $e_p(n) = k$  if  $p^k$  divides  $n$  but  $p^{(k+1)}$  does not.

Study these sequences.

**Reference:**

Arizona State University, Hayden Library, "The Florentin  
Smarandache papers" special collection, Tempe, AZ 85287-  
1006, USA.

## UNSOLVED PROBLEM: 69

Pseudo-primes:

2, 3, 5, 7, 11, 13, 14, 16, 17, 19, 20, 23, 29, 30, 31, 32, 34, 35, 37, 38, 41,  
43, 47, 50, 53, 59, 61, 67, 70, 71, 73, 74, 76, 79, 83, 89, 91, 92, 95, 97, 98,  
101, 103, 104, 106, 107, 109, 110, 112, 113, 115, 118, 119, 121, 124, 125,  
127, 128, 130, 131, 133, 134, 136, 137, 139, 140, 142, 143, 145, 146, ...

(A number is pseudo-prime if some permutation of the digits  
is a prime number, including the identity permutation.)

(Of course, all primes are pseudo-primes,  
but not the reverse!)

Study this sequence.



## UNSOLVED PROBLEM: 70

Pseudo-squares:

1, 4, 9, 10, 16, 18, 25, 36, 40, 46, 49, 52, 61, 63, 64, 81, 90, 94, 100, 106,  
 108, 112, 121, 136, 144, 148, 160, 163, 169, 180, 184, 196, 205, 211, 225,  
 234, 243, 250, 252, 256, 259, 265, 279, 289, 295, 297, 298, 306, 316, 324,  
 342, 360, 361, 400, 406, 409, 414, 418, 423, 432, 441, 448, 460, 478, 481,  
 484, 487, 490, 502, 520, 522, 526, 529, 562, 567, 576, 592, 601, 603, 604,  
 610, 613, 619, 625, 630, 631, 640, 652, 657, 667, 675, 676, 691, 729, 748,  
 756, 765, 766, 784, 792, 801, 810, 814, 829, 841, 844, 847, 874, 892, 900,  
 904, 916, 925, 927, 928, 940, 952, 961, 972, 982, 1000, ...

(A number is a pseudo-square if some permutation of the digits is a perfect square, including the identity permutation.)

(Of course, all perfect squares are pseudo-squares,  
 but not the reverse!)

One listed all pseudo-squares up to 1000.

Study this sequence.

## UNSOLVED PROBLEM: 71

Pseudo-cubes:

1, 8, 10, 27, 46, 64, 72, 80, 100, 125, 126, 152, 162, 207, 215, 216, 251,  
261, 270, 279, 297, 334, 343, 406, 433, 460, 512, 521, 604, 612, 621,  
640, 702, 720, 729, 792, 800, 927, 972, 1000, ...

(A number is a pseudo-cube if some permutation of the digits is a cube, including the identity permutation.)

(Of course, all perfect cubes are pseudo-cubes, but not the reverse!)

One listed all pseudo-cubes up to 1000.

## UNSOLVED PROBLEM: 72

Pseudo-m-powers:

(A number is a pseudo-m-power if some permutation of the digits is m-power, including the identity permutation;  $m \geq 2$ .)

Study these sequences.

**Reference:**

Arizona State University, Hayden Library, "The Florentin Smarandache papers" special collection, Tempe, AZ 85287-1006, USA.

## UNSOLVED PROBLEM: 73

Pseudo-factorials:

1, 2, 6, 10, 20, 24, 42, 60, 100, 102, 120, 200, 201, 204, 207, 210, 240, 270,  
402, 420, 600, 702, 720, 1000, 1002, 1020, 1200, 2000, 2001, 2004, 2007,  
2010, 2040, 2070, 2100, 2400, 2700, 4002, 4005, 4020, 4050, 4200, 4500,  
5004, 5040, 5400, 6000, 7002, 7020, 7200, ...

(A number is a pseudo-factorial if some permutation of the digits is a factorial number, including the identity permutation.)

(Of course, all factorials are pseudo-factorials, but not the reverse!)

One listed all pseudo-factorials up to 10000.

Procedure to obtain this sequence:

- calculate all factorials with one digit only ( $1!=1$ ,  $2!=2$ , and  $3!=6$ ), this is line\_1 (of one digit pseudo-factorials):  
1, 2, 6;
- add 0 (zero) at the end of each element of line\_1, calculate all factorials with two digits ( $4!=24$  only) and all permutations of their digits:  
this is line\_2 (of two digits pseudo-factorials):  
10, 20, 60; 24, 42;
- add 0 (zero) at the end of each element of line\_2 as well as anywhere in between their digits, calculate all factorials with three digits ( $5!=120$ , and  $6!=720$ ) and all permutations of their digits:

this is line\_3 (of three digits pseudo-factorials):

100,200,600,240,420,204,402; 120,720, 102,210,201,702,270,720;

and so on ...

to get from line\_k to line\_(k+1) do:

- add 0 (zero) at the end of each element of line\_k as well as anywhere in between their digits,
- calculate all factorials with (k+1) digits
- and all permutations of their digits;

The set will be formed by all line\_1 to the last line elements in an increasing order.

Study this sequence.

#### UNSOLVED PROBLEM: 74

Pseudo-divisors:

1,10,100,1,2,10,20,100,200,1,3,10,30,100,300,1,2,4,10,20,40,  
100,200,400,1,5,10,50,100,500,1,2,3,6,10,20,30,60,100,200,  
300,600,1,7,10,70,100,700,1,2,4,8,10,20,40,80,100,200,400,  
800,1,3,9,10,30,90,100,300,900,1,2,5,10,20,50,100,200,500,1000,...

(The pseudo-divisors of n.)

(A number is a pseudo-divisor of n if some permutation of the digits is a divisor of n, including the identity permutation.)

(Of course, all divisors are pseudo-divisors,  
but not the reverse!)

A strange property: any integer has an infinity of  
pseudo-divisors !!

because  $10\dots 0$  becomes  $0\dots 01 = 1$ , by a circular permutation  
of its digits, and 1 divides any integer !

One listed all pseudo-divisors up to 1000 for the numbers 1, 2, 3,  
..., 10.

Procedure to obtain this sequence:

- calculate all divisors with one digit only,  
this is line\_1 (of one digit pseudo-divisors);
- add 0 (zero) at the end of each element of line\_1,  
calculate all divisors with two digits  
and all permutations of their digits:  
this is line\_2 (of two digits pseudo-divisors);
- add 0 (zero) at the end of each element of line\_2 as well  
as anywhere in between their digits,  
calculate all divisors with three digits  
and all permutations of their digits:  
this is line\_3 (of three digits pseudo-divisors);

and so on ...

to get from line\_k to line\_(k+1) do:

- add 0 (zero) at the end of each element of line\_k as well

as anywhere in between their digits,  
 calculate all divisors with  $(k+1)$  digits  
 and all permutations of their digits;  
 The set will be formed by all line<sub>1</sub> to the last line elements  
 in an increasing order.

Study this sequence.

#### UNSOLVED PROBLEM: 75

Pseudo-odd numbers:

1, 3, 5, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 23, 25, 27, 29, 30,  
 31, 32, 33, 34, 35, 36, 37, 38, 39, 41, 43, 45, 47, 49, 50, 51, 52, 53, 54,  
 55, 56, 57, 58, 59, 61, 63, 65, 67, 69, 70, 71, 72, 73, 74, 75, 76, ...

(Some permutation of digits is an odd number.)

Study this sequence.

## UNSOLVED PROBLEM: 76

Pseudo-triangular numbers:

1, 3, 6, 10, 12, 15, 19, 21, 28, 30, 36, 45, 54, 55, 60, 61, 63, 66, 78, 82,  
87, 91, ...

(Some permutation of digits is a triangular number.)

A triangular number has the general form:  $n(n+1)/2$ .

Study this sequence.

## UNSOLVED PROBLEM: 77

Pseudo-even numbers:

0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,  
32, 34, 36, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 52, 54, 56, 58,  
60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 72, 74, 76, 78, 80, 81, 82, 83,  
84, 85, 86, 87, 88, 89, 90, 92, 94, 96, 98, 100, ...

(The pseudo-even numbers.)

(A number is a pseudo-even number if some permutation of  
the digits is a even number, including the identity permutation.)

(Of course, all even numbers are pseudo-even numbers,  
but not the reverse!)

A strange property: an odd number can be a pseudo-even  
number!

One listed all pseudo-even numbers up to 100.

Study this sequence.



## UNSOLVED PROBLEM: 78

Pseudo-multiples (of 5):

0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59,  
60, 65, 70, 75, 80, 85, 90, 95, 100, 101, 102, 103, 104, 105, 106, 107,  
108, 109, 110, 115, 120, 125, 130, 135, 140, 145, 150, 151, 152, 153,  
154, 155, 156, 157, 158, 159, 160, 165, ...

(The pseudo-multiples of 5.)

(A number is a pseudo-multiple of 5 if some permutation of the digits is a multiple of 5, including the identity permutation.)

(Of course, all multiples of 5 are pseudo-multiples, but not the reverse!)

## UNSOLVED PROBLEM: 79

Pseudo-multiples of  $p$  ( $p$  is an integer  $\geq 2$ )

{generalizations}:

(The pseudo-multiples of  $p$ .)

(A number is a pseudo-multiple of  $p$  if some permutation of the digits is a multiple of  $p$ , including the identity permutation.)

(Of course, all multiples of  $p$  are pseudo-multiples, but not the reverse!)

Procedure to obtain this sequence:

- calculate all multiples of  $p$  with one digit only (if any),  
this is  $\text{line\_1}$  (of one digit pseudo-multiples of  $p$ );
  - add 0 (zero) at the end of each element of  $\text{line\_1}$ ,  
calculate all multiples of  $p$  with two digits (if any)  
and all permutations of their digits:  
this is  $\text{line\_2}$  (of two digits pseudo-multiples of  $p$ );
  - add 0 (zero) at the end of each element of  $\text{line\_2}$  as well  
as anywhere in between their digits,  
calculate all multiples with three digits (if any)  
and all permutations of their digits:  
this is  $\text{line\_3}$  (of three digits pseudo-multiples of  $p$ );
- and so on ...

to get from  $\text{line\_k}$  to  $\text{line\_}(k+1)$  do:

- add 0 (zero) at the end of each element of  $\text{line\_k}$  as well  
as anywhere in between their digits,  
calculate all multiples with  $(k+1)$  digits (if any)  
and all permutations of their digits;

The set will be formed by all  $\text{line\_1}$  to the last line elements  
in an increasing order.

Study this sequence.

## UNSOLVED PROBLEM: 80

Square roots:

0, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5,  
 5, 5, 5, 5, 5, 5, 5, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 7, 7, 7, 7, 7, 7, 7, 7, 7,  
 7, 7, 7, 7, 7, 7, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 9, 9, 9, 9, 9, 9,  
 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10,  
 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, ...

( $s_q(n)$  is the superior integer part of square root of  $n$ .)

Remark: this sequence is the natural sequence, where each number is repeated  $2n+1$  times,

because between  $n^2$  (included) and  $(n+1)^2$  (excluded) there are  $(n+1)^2 - n^2$  different numbers.

Study this sequence.



## UNSOLVED PROBLEM: 83

Let  $\sigma(n)$  be sum of divisors of  $n$ ,  $\Pi(x)$  number of primes not exceeding  $x$ ,  $\omega(n)$  number of distinct prime factors of  $n$ ,  $d(n)$  number of positive divisors of  $n$ ,  $p(n)$  the largest prime factor of  $n$ .

Let  $f^{(k)}$  note  $\underbrace{f \circ f \circ \dots \circ f}_{k \text{ times}}$ , for all function  $f$ .

Find the smallest  $k$  for which:

- (a) for fixed  $n$  and  $m$ , we have  $\sigma^{(k)}(n) > m$ .
- (b) for a fixed real  $x$ , with  $x \geq 2$ , we have  $\Pi^{(k)}(x) = 1$ .
- (c) for a fixed  $n$ , we have  $\omega^{(k)}(n) = 1$ .
- (d) for fixed  $n$  and  $m$ , we have  $d^{(k)}(n) > m$ .
- (e) for a fixed  $n$ , we have

$$\underbrace{p(p(\dots(p(n)-1)\dots)-1)-1}_{k \text{ times}} = 1.$$

Generalize for  $\sigma_r(n)$ ,  $\Pi(x; a, b)$ ,  $\Omega(n)$ .

## Reference

- [1] R. K. Guy, Unsolved Problems in Number Theory, Springer-Verlag, 1981; the problems: B2, B5, B8, B9; A17, E4; B11, B36, B38, B39, B12, B18, B32, B46.

## UNSOLVED PROBLEM: 84

## AN EXTENSION OF CARMICHAEL'S CONJECTURE

## Conjecture

$\forall a \in \mathbb{N}^*, \forall b \in \mathbb{N}^*, \exists c \in \mathbb{N}^*: \varphi(a) \cdot \varphi(b) = \varphi(c)$ . For  $a = 1$  it results Carmichael's conjecture. If this conjecture is true, then by mathematical induction it finds:

$$\forall a_1, \dots, a_n \in \mathbb{N}^*, \exists b \in \mathbb{N}^*: \varphi(a_1) \dots \varphi(a_n) = \varphi(b).$$

## Reference

- [1] R. K. Guy, Unsolved Problems in Number Theory,  
Springer-Verlag, 1981, p. 53, B39.

## UNSOLVED PROBLEM: 85

## ON CRITTENDEN AND VANDEN EYNDEN'S CONJECTURE

Is it possible to cover all (positive) integers with  $n$  geometrical progressions of integers?

\*Find a necessary and sufficient condition for a general class of positive integer sequences such that, for a fixed  $n$ , there are  $n$  (distinct) sequences of this class which cover all integers.

## Comment

(a) No. Let  $a_1, \dots, a_n$  be respectively the first term of each geometrical progression, and  $q_1, \dots, q_n$

respectively their ratios. Let  $p$  be a prime,  $p \notin \{a_1, \dots, a_n, q_1, \dots, q_n\}$ . Then  $p$  does not belong to the union of these  $n$  geometrical progressions.

(b)\* For example, the class of progressions:

$$A_f = \{\{a_n\}_{n \geq 1} : a_n = f(a_{n-1}, \dots, a_{n-i}) \text{ for } n \geq i + 1, \text{ and} \\ i, a_1, \dots, a_i \in \mathbb{N}^*\}$$

with the property:

$$\exists y \in \mathbb{N}^*, \forall (x_1, \dots, x_i) \in \mathbb{N}^{*i} : f(x_1, \dots, x_i) \neq y,$$

does it cover all integers?

But, if we change the property:

$$\forall y \in \mathbb{N}^*, \exists (x_1, \dots, x_i) \in \mathbb{N}^{*i} : f(x_1, \dots, x_i) = y?$$

(Generally no; see the geometrical progressions.)

This (solved and unsolved) problem remembers Crittenden and Vanden Eynden's conjecture.

## Reference

- [1] R. B. Crittenden and C. L. Vanden Eynden, Any  $n$  Arithmetic Progressions Covering the First  $2^n$  Integers Covers All Integers, Proc. Amer. Math. Soc. 24 (1970) 475-481.
- [2] R. B. Crittenden and C. L. Vanden Eynden, The Union of Arithmetic Progressions with Differences Not Less than  $k$ , Amer. Math. Monthly 79(1972) 630.
- [3] R. K. Guy, Unsolved Problems in Number Theory, Springer-Verlag, New York, Heidelberg, Berlin, 1981, E23, 126.

## UNSOLVED PROBLEM: 86

Consider the following equation:

$$(a - b \sqrt[m]{n}) x + c \sqrt[p]{n} \cdot y + \sqrt[q]{q} \cdot z + (d + e \cdot w) \sqrt[r]{s} = 0,$$

where  $a, b, c, d, e$  are constant integers; and the  $m$ -th,  $p$ -th and  $r$ -th roots are irrational distinct numbers. What conditions must the parameters  $m, n, p, q, r$  and  $s$  accomplish such that the equation admits integer solutions ( $x, y, z$  and  $w$  being variables)?



## UNSOLVED PROBLEM: 87

Find the maximum number of interior points inside a parallelogram having an angle of  $\pi/3$  such that the distance between any two points is greater or equal than 1. (The same question for a prism where all the faces are parallelograms with an angle of  $\pi/3$ .)

More generally: let  $d > 0$ . Questions:

(a) Which is the maximum number of points included in a plane figure (a space body) such that the distance between any two points is greater or equal than  $d$ ?

(b) Which is the minimum number of points  $\{A_1, A_2, \dots\}$  included in a plane figure (a space body) such that if another point  $A$  is added then there is an  $A_i$  with  $|AA_i| < d$ ?

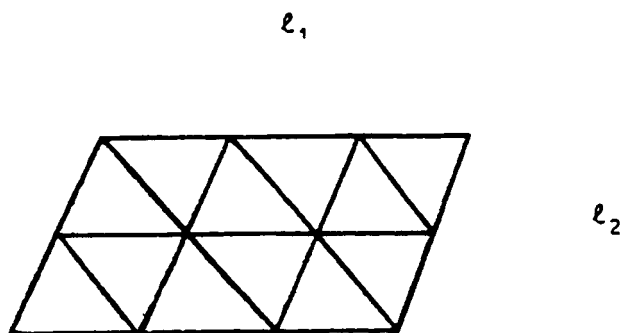
(c) Other variants of these questions if it considers:  
 (1) only interior points; (2) interior and frontier points;  
 (3) points on frontier only; (4) the distance is strictly greater than  $d$ ; and (5)  $|AA_i| \leq d$ .

**Solution**

(I) We consider an equilateral triangle's network as indicated in the diagram displayed below, where  $\ell_1$  and  $\ell_2$  are the sides of our parallelogram. Clearly, this network gives the optimum construction of interior and frontier points keeping our property. It finds  $(\lfloor \ell_1 \rfloor + 1)(\lfloor \ell_2 \rfloor + 1)$  points, where  $\lfloor x \rfloor$  is the greatest integer less or equal than

x. If  $\ell_1, \ell_2 \in \mathbb{N}^*$  we cannot take more than  $\ell_1$  interior points on a rule and  $\ell_2$  interior points on the other one, because it is not permitted to take points on the frontier.

If, for example,  $\ell_1 \in \mathbb{N}$ , we can take  $\lfloor \ell_1 \rfloor + 1$  interior points on a side. In conclusion:  $n_{\max} = \lceil \ell_1 \rceil \cdot \lceil \ell_2 \rceil$  interior points, where  $\lceil x \rceil$  is the little integer greater or equal than  $x$ .



(II) For the prism of our problem, having the sides  $\ell_1, \ell_2, \ell_3$ , of course,  $n_{\max} = \lceil \ell_1 \rceil \cdot \lceil \ell_2 \rceil \cdot \lceil \ell_3 \rceil$  [it results from (I) by considering the parallelograms  $(\ell_1, \ell_2)$  and  $(\ell_2, \ell_3)$ ].

(III) These are generally open (unsolved) questions. For particular cases see [1].

#### Reference:

- [1] Smarandache, Florentin, Problèmes avec et sans ... problèmes! (problems 5.43 [p. 67], respectively 5.44 [p. 62]), Somipress, Fès, Morocco, 1983 (M. R.: 84R: 00003).

## UNSOLVED PROBLEM: 88

\*Find all real solutions of the equation  $x^y - \lfloor x \rfloor = y$ , where  $\lfloor x \rfloor$  is the greatest integer less or equal than  $x$ .

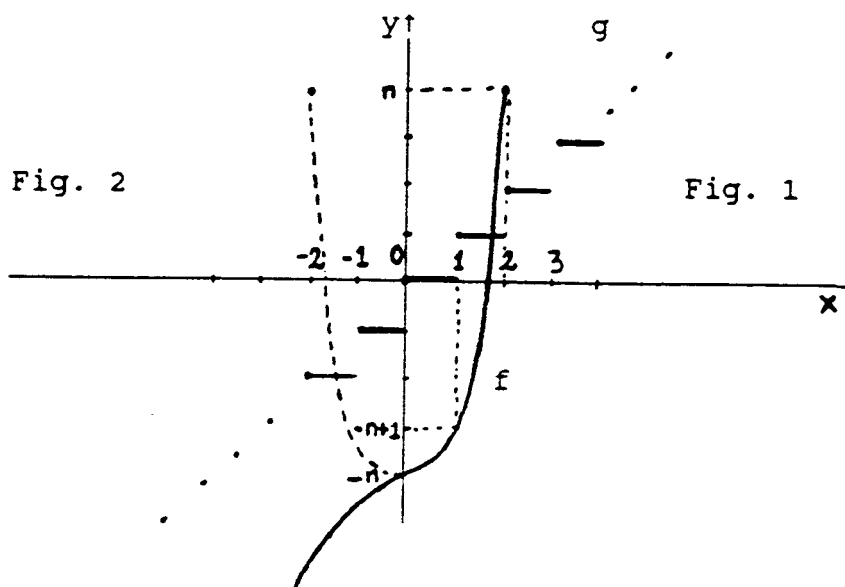
Solution: It is a generalization of a Putnam competition:  $(x^3 - \lfloor x \rfloor = 3)$ .

- (1) When  $y \in \mathbb{R} \setminus \mathbb{Q}$  the author is not able to answer.
- (2) If  $y = 0$  then  $x \in [1, 2)$ .
- (3) If  $y = 1$ ,  $\exists x \in \mathbb{R}$ .
- (4) If  $y$  is an odd integer  $> 1$ , then  $x = \sqrt[y]{y+1} \in (1, 2)$ , is the unique solution of our equation:

Let us use the functions

$f(x) = x^n - n$ ,  $n \in \mathbb{N}$ ,  $n > 1$ , where  $n$  is an odd integer,

$g(x) = \lfloor x \rfloor$ ,  $f, g: \mathbb{R} \rightarrow \mathbb{R}$ , and their graphics:



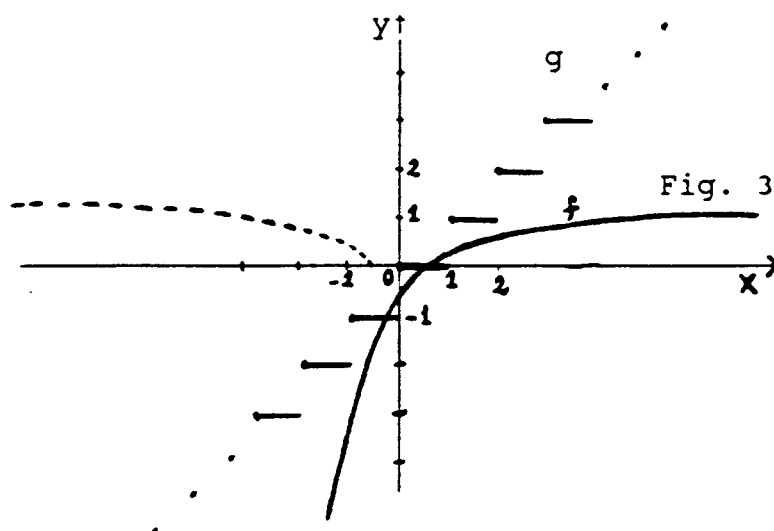
- (5) If  $y = 2$ , then  $x_1 = \sqrt[2]{3}$  and  $x_2 = -1$ .
- (6) If  $y \in \mathbb{N}$  and  $y$  is an even integer  $\geq 4$ , then

$x_1 = \sqrt[y]{y+1}$ ,  $x_2 = -\sqrt[y]{y-2}$ . (It is sufficient to observe that  $f(x) = x^n - n$ , where  $n$  is an even integer  $\geq 4$ , is an even function; we consider  $f: \mathbb{R} \rightarrow \mathbb{R}$  (Fig. 2).).

(7) If  $y = -1$  the  $x = -1/2$ , because it results in  $1/x \in \mathbb{Z}^*$ , hence  $x = 1/k$  with  $k \in \mathbb{Z}^*$ , whence  $k = -2$ .

(8) If  $y \in \mathbb{Z}$ ,  $y < -1$ ,  $\exists x \in \mathbb{R}$ , because it results  $1/x^m \in \mathbb{Z}^*$ , whence  $x^m = 1/k$ ,  $k \in \mathbb{Z}^*$ , where  $m = -y > 0$ . For an even  $m$ , we have  $x = \pm \sqrt[m]{1/k}$  with  $k \geq 1$ , but  $[\pm \sqrt[m]{1/k}] \in \{0, \pm 1\}$  and  $k + m \geq 2$ ; hence  $\exists x \in \mathbb{R}$ . For an odd  $m$ , we have  $x = \sqrt[m]{1/k}$  with  $k \in \mathbb{Z}^*$ ; hence  $k - [\sqrt[m]{1/k}] = -m$  whence  $k = -m - 1 < 0$  and  $x = -\sqrt[m]{1/(m+1)} = -(1-y)^{1/y}$ .

(9) Let  $y = 1/n$ ,  $n \in \mathbb{N}$ ,  $n$  is odd  $\geq 3$ , then  $x_1 = (1/n)^n$ ,  $x_2 = (\frac{1-n}{n})^n$ . Because the function  $f(x) = x^n - \frac{1}{n}$ ,  $n \in \mathbb{N}$ ,  $n$  is odd  $\geq 3$ ,  $f: \mathbb{R} \rightarrow \mathbb{R}$ , has the following graphic:



For  $x \geq 2$ ,  $h(x) = x^{\frac{1}{n}} - x + 1 - \frac{1}{n} < 0$  (because  $h'(x) <$

$< 0$  when  $x \geq 2$ , hence  $h(x) \leq h(2) < 0$  for  $x \geq 2$ ). There exists an unique positive real solution.

For  $x \leq -1$ ,  $k(x) = x^{\frac{1}{n}} - \frac{1}{n} - x > 0$ ; there exists an unique negative real solution.

(10) If  $y = 1/n$ ,  $n \in \mathbb{N}$ ,  $n$  is even  $\geq 2$ , then  $x \geq 0$  involves  $x = (1/n)^n$ , because  $f$  is an even function (Fig. 4).

(11) If  $y = -1/n$ ,  $n \in \mathbb{N}$ ,  $n \geq 2$ .

$$1/x^{1/n} + 1/n = \lfloor x \rfloor.$$

Whence  $x^{1/n} \in \mathbb{Q}$ , it results  $x = a^n$ ,  $a \in \mathbb{Q}$ . Hence  $1/a + 1/n$

$\in \mathbb{Z}$ , whence  $1/a = k - 1/n$ ,  $k \in \mathbb{Z}$ , thus  $a = \frac{n}{kn-1}$  or

$k = \lfloor \left( \frac{n}{kn-1} \right)^n \rfloor$ . Of course  $k \neq 0$ . If  $k = 1$ , we have

$\left( 1 + \frac{1}{n-1} \right)^n > 2$ . If  $k \geq 2$ , we have  $\left( \frac{n}{kn-1} \right)^n < 1$ .

(a) If  $n$  is odd then  $k = -1$ , whence  $x = \left( -\frac{n}{n+1} \right)^n$

is a solution.

(b) If  $n$  is even, there is no  $x \in \mathbb{R}$ . For

$k \leq -2$ , we have  $\left( \frac{n}{kn-1} \right)^n > -1$ .

(12)  $y = \frac{m}{n} \in \mathbb{Q} \setminus \mathbb{Z}$ ,  $m \neq 1$ .

\* The author is not able to solve the equation in this case.

## UNSOLVED PROBLEM: 89

Prove that on a circular disk of radius  $r$  there are least  $n$  points such that the distance between any two is greater or equal than  $d$ , where:

$$n = \left\lceil \frac{r}{d} \right\rceil \sum_{k=0}^{\left\lceil \frac{r}{d} \right\rceil - 1} [\pi / \arcsin d / (2(r - kd))] \text{ if } \frac{r}{d} \notin \mathbb{N},$$

or

$$n = 1 + \sum_{k=0}^{\frac{r}{d} - 1} [\pi / \arcsin d / (2(r - kd))] \text{ if } \frac{r}{d} \in \mathbb{N}.$$

Is  $n$  equal to the maximum number of points on the disk with this property?\*

Generalize for an arbitrary figure in plane.\*\*

Generalize also for an arbitrary corps in space.\*\*

**Proof**

(a) Let  $\zeta_d(r)$  be the maximum number of points on the circumference of a circle of radius  $r$  such that the distance between any two is greater or equal than  $d$ . Hence, the cord which unites two points from these is  $\geq d$  (see the picture 1). We take it precisely  $d$ .

$$\frac{d}{\sin x} = \frac{r}{\sin \left( \frac{\pi}{2} - x \right)} \text{ whence } \sin \frac{x}{2} = \frac{d}{2r} \text{ hence}$$

$$x = 2 \arcsin \frac{d}{2r} \quad (\text{in radians}). \quad \text{We divide } 2\pi \text{ to } x$$

and it results in:

$$\zeta_d(r) = \left[ \pi / \arcsin \frac{d}{2r} \right].$$

We proceed analogously with the circle  $C_1$  of radius  $r-d$ , concentric with the first  $C_0$ , obtaining  $\zeta_d(r-d)$ , etc. This method ends at the step  $k = \left[ \frac{r}{d} \right]$  for which  $0 < r-kd < d$ .

When  $\frac{r}{d}$  is an integer, the last drawn circle will be a point, precisely the center of these circles.

This construction mode (with point networks lying on concentric circles such that between two some circles the distance is equal to  $d$ ) ensures the distance condition of all points.

It remarks that if since start  $d > 2r$  the arcsin there is not, therefore our problem is impossible (there is no point). And, if  $d = 0$ , we obtain an infinite of points.

(b) \*This construction is close to an optimum one (in the author's conception). But the author cannot prove if this is or is not optimum. There are many constructions of point networks [on squares, on (equilatera) triangles,

etc.]. For which point networks is  $n$  maximum? (Here it is an open question).

In our problem, when  $\frac{r}{d}$  is very great perhaps the

following construction is more advantageous (see picture 2):

We take a point  $P_1$  on the circumference  $F_0$  of our disk  $Z_0$ . With a compass we draw a circle arc  $A_1$  (of radius  $d$ , having the center in  $P_1$ ) which cuts  $F_0$  in  $P_2$  (to right). Afterwards we again draw a circle arc  $A_2$  (of radius  $d$ , having the center in  $P_2$ ) which cuts  $F_0$  in  $P_3$  (to right), etc. On  $F_0$  we find  $\zeta_0$  points.

We can still take another points in the hachured zone  $Z_1$  only. We construct these points on the frontier  $F_1$  of  $Z_1$ , analogous: with a compass of radius  $d$ , of center  $R_1$  at the start, etc. ( $R_1 = A_1 \cap A_4$ , where  $A_4$  is the last circle arc). On  $F_1$  we find  $\zeta_1$  points.

This method ends when  $Z_k = \emptyset$ . It obtains at least  $n$  points having the property of our assumption. But, does it obtain more points than  $n$ ?

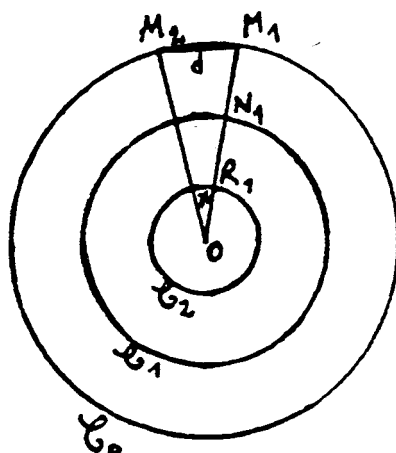
(c) \*\*These are two general open questions. For particular cases see [1].

#### Reference:

- [1] Smarandache, Florentin, "Problèmes avec et sans ... problèmes!", the problems 5.43 (p. 61), respectively 5.44 (p. 62); Somipress, Fès, Morocco, 1983 (see MR:84K:00003).



Fig. 1



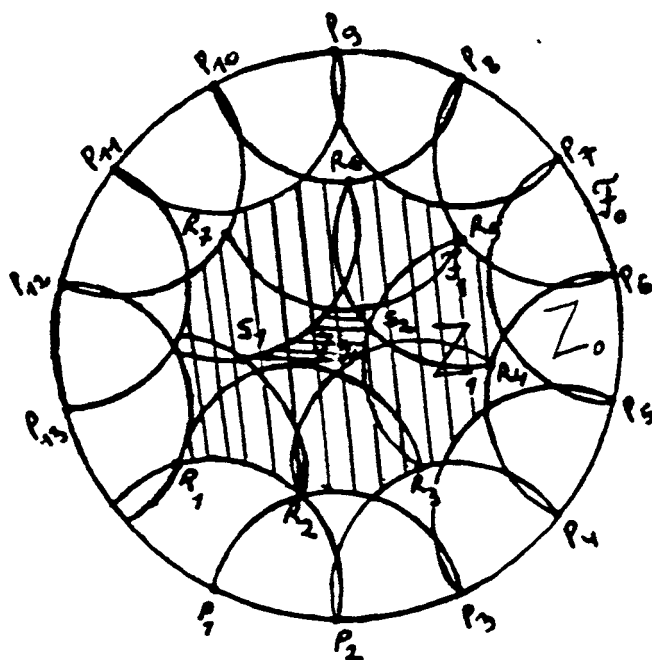
$$OM_1 = r$$

$$M_1M_2 = d$$

$$\angle M_1OM_2 = x$$

$$M_1N_1 = N_1R_1 = d$$

Fig. 2



## UNSOLVED PROBLEM: 90

Prime base:

0, 1, 10, 100, 101, 1000, 1001, 10000, 10001, 10010, 10100, 100000,  
 100001, 1000000, 1000001, 1000010, 1000100, 10000000, 10000001,  
 100000000, 100000001, 100000010, 100000100, 1000000000, 1000000001,  
 1000000010, 1000000100, 1000000101, ...

(Each number  $n$  written in the prime base.)

(I define over the set of natural numbers the following infinite  
 base:  $p_0 = 1$ , and for  $k \geq 1$   $p_k$  is the  $k$ -th prime number.)

Every positive integer  $A$  may be uniquely written in  
 the prime base as:

$$A = \overbrace{(a_n \dots a_1 a_0)}^{(SP)} \stackrel{\text{def}}{=} \frac{\prod_{i=0}^n a_i p_i}{\prod_{i=0}^n p_i}, \text{ with all } a_i = 0 \text{ or } 1, \text{ (of course } a_n = 1),$$

in the following way:

- if  $p_n \leq A < p_{n+1}$  then  $A = p_n + r_1$ ;
  - if  $p_m \leq r_1 < p_{m+1}$  then  $r_1 = p_m + r_2$ ,  $m < n$ ;
- and so on untill one obtains a rest  $r_j = 0$ .

Therefore, any number may be written as a sum of prime numbers +  $e$ ,  
 where  $e = 0$  or  $1$ .

If we note by  $p(A)$  the superior part of  $A$  (i.e. the largest  
 prime less than or equal to  $A$ ), then

$A$  is written in the prime base as:

$$A = p(A) + p(A - p(A)) + p(A - p(A) - p(A - p(A))) + \dots$$

This base is important for partitions with primes.

Study this sequence.

## UNSOLVED PROBLEM: 91

Square base:

0, 1, 2, 3, 10, 11, 12, 13, 20, 100, 101, 102, 103, 110, 111, 112, 1000, 1001, 1002, 1003, 1010, 1011, 1012, 1013, 1020, 10000, 10001, 10002, 10003, 10010, 10011, 10012, 10013, 10020, 10100, 10101, 100000, 100001, 100002, 100003, 100010, 100011, 100012, 100013, 100020, 100100, 100101, 100102, 100103, 100110, 100111, 100112, 101000, 101001, 101002, 101003, 101010, 101011, 101012, 101013, 101020, 101100, 101101, 101102, 1000000, ...

(Each number  $n$  written in the square base.)

(I define over the set of natural numbers the following infinite base: for  $k \geq 0$   $s_k = k^2$ .)

Every positive integer  $A$  may be uniquely written in the square base as:

$$A = (\overbrace{a_n \dots a_1 a_0}^{(S_2)}) \stackrel{\text{def}}{=} \sum_{i=0}^n a_i s_i, \text{ with } a_i = 0 \text{ or } 1 \text{ for } i \geq 2,$$

$0 \leq a_0 \leq 3$ ,  $0 \leq a_1 \leq 2$ , and of course  $a_n = 1$ ,  
in the following way:

- if  $s_n \leq A < s_{n+1}$  then  $A = s_n + r$ ;  
- if  $s_m \leq r < s_{m+1}$  then  $r = s_m + r_1$ ,  $m < n$ ;  
and so on untill one obtains a rest  $r_j = 0$ .

Therefore, any number may be written as a sum of squares  
(1 not counted as a square -- being obvious) +  $e$ , where  
 $e = 0, 1$ , or  $3$ .

If we note by  $s(A)$  the superior square part of  $A$  (i.e. the largest square less than or equal to  $A$ ), then  $A$  is written in the square base as:

$$A = s(A) + s(A-s(A)) + s(A-s(A)-s(A-s(A))) + \dots$$

This base is important for partitions with squares.

Study this sequence.

### UNSOLVED PROBLEM: 92

m-power base (generalization):

(Each number  $n$  written in the m-power base, where  $m$  is an integer  $\geq 2$ .)

(I define over the set of natural numbers the following infinite m-power base: for  $k \geq 0$   $t_k = k^m$ .)

Every positive integer  $A$  may be uniquely written in the m-power base as:

$$A = \overbrace{(a_n \dots a_1 a_0)}^{(SM)} \quad \text{def} \quad \frac{\sum_{i=0}^n a_i t_i}{\sum_{i=0}^n t_i}, \text{ with } a_i = 0 \text{ or } 1 \text{ for } i \geq m,$$

$$0 \leq a_i \leq \left\lfloor \frac{(i+2)^m - 1}{(i+1)^m} \right\rfloor \quad (\text{integer part})$$

for  $i = 0, 1, \dots, m-1$ ,  $a_i = 0$  or  $1$  for  $i \geq m$ , and of course  $a_n$

in the following way:

- if  $t_n \leq A < t_{n+1}$  then  $A = t_n + r$ ;
  - if  $t_m \leq r < t_{m+1}$  then  $r = t_m + r_1$ ,  $m < n$ ;
- and so on until one obtains a rest  $r_j = 0$ .

Therefore, any number may be written as a sum of  $m$ -powers  
(1 not counted as an  $m$ -power -- being obvious) +  $e$ , where  
 $e = 0, 1, 2, \dots$ , or  $2^m - 1$ .

If we note by  $t(A)$  the superior  $m$ -power part of  $A$  (i.e. the  
largest  $m$ -power less than or equal to  $A$ ), then  $A$  is written in the  
 $m$ -power base as:

$$A = t(A) + t(A - t(A)) + t(A - t(A) - t(A - t(A))) + \dots$$

This base is important for partitions with  $m$ -powers.

Study this sequence.

### UNSOLVED PROBLEM: 93

Generalized base:

(Each number  $n$  written in the generalized base.)

(I define over the set of natural numbers the following infinite

generalized base:  $1 = g_0 < g_1 < \dots < g_k < \dots$ .)

Every positive integer  $A$  may be uniquely written in  
the generalized base as:

$$A = \left( \overbrace{a_n \dots a_1 a_0}^{(SG)} \right) \stackrel{\text{def}}{=} \sum_{i=0}^n a_i g_i, \text{ with } 0 \leq a_i \leq \left\lfloor (g_{i+1} - 1) / g_i \right\rfloor$$

(integer part) for  $i = 0, 1, \dots, n$ , and of course  $a_n \geq 1$ ,  
in the following way:

- if  $g_n \leq A < g_{n+1}$  then  $A = g_n + r_1$ ;  
- if  $g_m \leq r_1 < g_{m+1}$  then  $r_1 = g_m + r_2$ ,  $m < n$ ;  
and so on untill one obtains a rest  $r_j = 0$ .

If we note by  $g(A)$  the superior generalized part of  $A$  (i.e. the largest  $g_i$  less than or equal to  $A$ ), then  $A$  is written in the  $m$ -power base as:

$$A = g(A) + g(A - g(A)) + g(A - g(A) - g(A - g(A))) + \dots$$

This base is important for partitions: the generalized base may be any infinite integer set (primes, squares, cubes, any  $m$ -powers, Fibonacci/Lucas numbers, Bernoulli numbers, etc.) those partitions are studied.

A particular case is when the base verifies:  $2g_i \geq g_{i+1}$  for any  $i$ , and  $g_0 = 1$ , because all coefficients of a written number in this base will be 0 or 1.

Study this sequence.

#### UNSOLVED PROBLEM: 94

Odd sieve:

7, 13, 19, 23, 25, 31, 33, 37, 43, 47, 49, 53, 55, 61, 63, 67, 73, 75, 79, 83, 85, 91, 93, 97, ...

(All odd numbers that are not equal to the difference of two primes.)

A sieve is used to get this sequence:

- subtract 2 from all prime numbers and obtain a temporary sequence;
- choose all odd numbers that do not belong to the temporary one.

Study this sequence.

## UNSOLVED PROBLEM: 95

Binary sieve:

1, 3, 5, 9, 11, 13, 17, 21, 25, 27, 29, 33, 35, 37, 43, 49, 51, 53, 57, 59, 65,  
67, 69, 73, 75, 77, 81, 85, 89, 91, 97, 101, 107, 109, 113, 115, 117, 121,  
123, 129, 131, 133, 137, 139, 145, 149, ...

(Starting to count on the natural numbers set at any step from 1:

- delete every 2-nd numbers
- delete, from the remaining ones, every 4-th numbers
- ... and so on: delete, from the remaining ones, every  
( $2^k$ )-th numbers,  $k = 1, 2, 3, \dots$ .)

Conjectures:

- there are an infinity of primes that belong to this sequence;
- there are an infinity of numbers of this sequence which  
are not prime.

## UNSOLVED PROBLEM: 96

Trinary sieve:

1, 2, 4, 5, 7, 8, 10, 11, 14, 16, 17, 19, 20, 22, 23, 25, 28, 29, 31, 32, 34, 35,  
 37, 38, 41, 43, 46, 47, 49, 50, 52, 55, 56, 58, 59, 61, 62, 64, 65, 68, 70, 71,  
 73, 74, 76, 77, 79, 82, 83, 85, 86, 88, 91, 92, 95, 97, 98, 100, 101, 103, 104,  
 106, 109, 110, 112, 113, 115, 116, 118, 119, 122, 124, 125, 127, 128, 130,  
 131, 133, 137, 139, 142, 143, 145, 146, 149, ...

(Starting to count on the natural numbers set at any step from 1:

- delete every 3-rd numbers
- delete, from the remaining ones, every 9-th numbers
- ... and so on: delete, from the remaining ones, every
- $(3^k)$ -th numbers,  $k = 1, 2, 3, \dots$ .)

Conjectures:

- there are an infinity of primes that belong to this sequence;
- there are an infinity of numbers of this sequence which are not prime.



## UNSOLVED PROBLEM: 97

n-ary sieve (generalization,  $n \geq 2$ ):

(Starting to count on the natural numbers set at any step from 1:

- delete every  $n$ -th numbers;
- delete, from the remaining ones, every  $(n^2)$ -th numbers;
- ... and so on: delete, from the remaining ones, every  $(n^k)$ -th numbers,  $k = 1, 2, 3, \dots$ .)

Conjectures:

- there are an infinity of primes that belong to this sequence;
- there are an infinity of numbers of this sequence which are not prime.

## UNSOLVED PROBLEM: 98

Consecutive sieve:

1, 3, 5, 9, 11, 17, 21, 29, 33, 41, 47, 57, 59, 77, 81, 101, 107, 117, 131, 149.  
 153, 173, 191, 209, 213, 239, 257, 273, 281, 321, 329, 359, 371, 401, 417,  
 441, 435, 491, ...

(From the natural numbers set:

- keep the first number,  
     delete one number out of 2 from all remaining numbers;
- keep the first remaining number,  
     delete one number out of 3 from the next remaining numbers;
- keep the first remaining number,  
     delete one number out of 4 from the next remaining numbers;
- ... and so on, for step  $k$  ( $k \geq 2$ ):
- keep the first remaining number,  
     delete one number out of  $k$  from the next remaining numbers;
- ... .)

This sequence is much less dense than the prime number sequence,  
 and their ratio tends to  $p : n$  as  $n$  tends to infinity.

For this sequence we choosed to keep the first remaining  
 number at all steps,

but in a more general case:

the kept number may be any among the remaining  $k$ -plet  
 (even at random).

Study this sequence.

## UNSOLVED PROBLEM: 99

General-sequence sieve:

Let  $u_i > 1$ , for  $i = 1, 2, 3, \dots$ , a strictly increasing positive integer sequence. Then:

From the natural numbers set:

- keep one number among  $1, 2, 3, \dots, u_1 - 1$ ,  
and delete every  $u_1$ -th numbers;
- keep one number among the next  $u_2 - 1$  remaining numbers,  
and delete every  $u_2$ -th numbers;
- ... and so on, for step  $k$  ( $k \geq 1$ ):
- keep one number among the next  $u_k - 1$  remaining numbers,  
and delete every  $u_k$ -th numbers;
- ...

Problem: study the relationship between sequence  $u_i$ ,  $i = 1, 2, 3, \dots$ , and the remaining sequence resulted from the general sieve.

$u_i$ , previously defined, is called sieve generator.

Study this sequence.

## UNSOLVED PROBLEM: 100

General residual sequence:

$(x + C_1) \dots (x + C_{F(m)}), m = 2, 3, 4, \dots,$   
 where  $C_i, 1 \leq i \leq F(m)$ , forms a reduced set of  
 residues mod  $m$ ,

$x$  is an integer, and  $F$  is Euler's totient.

The General Residual Sequence is induced from the

The Residual Function (see <Libertas Mathematica>):

Let  $L : \mathbb{Z} \times \mathbb{Z} \rightarrow \mathbb{Z}$  be a function defined by

$L(x, m) = (x + C_1) \dots (x + C_{F(m)}),$   
 where  $C_i, 1 \leq i \leq F(m)$ , forms a reduced set of  
 residues mod  $m$ ,  
 $m \geq 2, x$  is an integer, and  $F$  is Euler's totient.

The Residual Function is important because it generalizes  
 the classical theorems by Wilson, Fermat, Euler, Wilson,  
 Gauss, Lagrange, Leibnitz, Moser, and Sierpinski all  
 together.

For  $x=0$  it's obtained the following sequence:

$L(m) = C_1 \dots C_{F(m)},$  where  $m = 2, 3, 4, \dots$   
 (the product of all residues of a reduced set mod  $m$ ):  
 1, 2, 3, 24, 5, 720, 105, 2240, 189, 3628800, 385, 479001600, 19305,  
 896896, 2027025, 20922789888000, 85085, 6402373705728000,  
 8729721, 47297536000, 1249937325, ...

which is found in "The Handbook of Integer Sequences", by N.  
 J. A. Sloane, Academic Press, USA, 1973.

The Residual Function extends it.

Study this sequence.

### References:

Fl. Smarandache, "A numerical function in the congruence theory",  
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12, pp. 181-185, 1992;

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Fl. Smarandache, "Collected Papers" (Vol. 1), Ed. Tempus,  
Bucharest, 1994 (to appear);

Arizona State University, Hayden Library, "The Florentin  
Smarandache papers" special collection, Tempe, AZ 85287-  
1006, USA.

Student Conference, University of Craiova, Department of  
Mathematics, April 1979, "Some problems in number  
theory" by Florentin Smarandache.

## UNSOLVED PROBLEM: 101

Code puzzle:

151405, 202315, 2008180505, 06152118, 06092205, 190924, 1905220514,  
0509070820, 14091405, 200514, 051205220514, ...

Using the following letter-to-number code:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

then  $c(n) =$  the numerical code of the spelling of  $n$  in English  
language; for exemple:  $1 = \text{ONE} = 151405$ , etc.

Find a better codification (one sign only for each letter).

## UNSOLVED PROBLEM: 102

Numerical carpet:

has the general form

```

      .
      .
      .
      1
     1a1
    1aba1
   1abcba1
  1abcdcba1
 1abcdedcba1
1abcdefedcba1
...1abcdefgfedcba1...
 1abcdefedcba1
 1abcdedcba1
 1abcdcba1
 1abcba1
 1aba1
 1a1
 1
  .
  .
  .

```

On the border of level 0, the elements are equal to "1";

they form a rhomb.

Next, on the border of level 1, the elements are equal to "a",

where "a" is the sum of all elements of the previous border;

the "a"s form a rhomb too inside the previous one.

Next again, on the border of level 2, the elements are equal to "b",

where "b" is the sum of all elements of the previous border;

the "b"s form a rhomb too inside the previous one.

And so on...

The numerical carpet is symmetric and esthetic, in its middle g is the sum of all carpet numbers (the core).

Look at a few terms of the Numerical Carpet:

```

      1
    1
  141
    1
      1
    1  8  1
  1  8 40  8  1
    1  8  1
      1
    1  12  1
  1  12 108 12  1
1 12 108 540 108 12 1
    1  12 108 12  1
      1  12  1
    1
      1  16  1
    1  16 208 16  1
  1  16 208 1872 208 16  1
    1  16 208 1872 208 16  1
      1  16 208 16  1
    1  16  1
      1
    1  20  1
  1  20 340 20  1
1 20 340 4420 39780 4420 340 20  1
    1  20 340 4420 39780 4420 340 20  1
      1  20 340 4420 340 20  1
    1  20  1
      1  20  1
    1  20  1
      1
    .
    .
    .

```



Or, under other form:

```

1
1 4
1 8 40
1 12 108 504
1 16 208 1872 9360
1 20 340 4420 39780 198900
1 24 504 8568 111384 1002456 5012280
1 28 700 14700 249900 3248700 29238300 146191500
1 32 928 23200 487200 8282400 107671200 969040800 4845204000
.....
.
.
.

```

General Formula:

$k$

$$C(n, k) = 4n \prod_{i=1}^k (4n - 4i + 1) \text{ for } 1 \leq k \leq n,$$

$$\text{and } C(n, 0) = 1.$$

Study this multi-sequence.

### References :

Arizona State University, Hayden Library, "The Florentin Smarandache papers" special collection, Tempe, AZ 85287-1006, USA.

Student Conference, University of Craiova, Department of Mathematics, April 1979, "Some problems in number theory" by Florentin Smarandache.

Fl. Smarandache, "Collected Papers" (Vol. 1), Ed. Tempus, Bucharest, 1994 (to appear);

## UNSOLVED PROBLEM: 103

Table:

6, 10, 14, 18, 26, 30, 38, 42, 42, 54, 62, 74, 74, 90, ...

( $t(n)$  is the largest even number such that any other even number not exceeding it is the sum of two of the first  $n$  odd primes.)

It helps to better understand Goldbach's conjecture:

- if  $t(n)$  is unlimited, then the conjecture is true;
- if  $t(n)$  is constant after a certain rank, then the conjecture is false.

Also, the table gives how many times an even number is written as a sum of two odd primes, and in what combinations. Of course,  $t(n) \leq 2p_n$ , where  $p_n$  is the  $n$ -th odd prime,  $n = 1, 2, 3, \dots$ .

Here is the table:

+	3	5	7	11	13	17	19	23	29	31	37	41	43	47
3	6	8	10	14	16	20	22	26	32	34	40	44	46	50
5		10	12	16	18	22	24	28	34	36	42	46	48	52
7			14	18	20	24	26	30	36	38	44	48	50	54
11				22	24	28	30	34	40	42	48	52	54	58
13					26	30	32	36	42	44	50	54	56	60
17						34	36	40	46	48	54	58	60	64
19							38	42	48	50	56	60	62	66
23								46	52	54	60	64	66	70
29									58	60	66	70	72	76
31										62	68	72	74	78
37											74	78	80	84
41												82	84	88
43													86	90
47														94

.....

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.

.

Study this table and table sequence.

## UNSOLVED PROBLEM: 104

Second table:

9, 15, 21, 29, 39, 47, 57, 65, 71, 93, 99, 115, 129, 137, ...

( $v(n)$  is the largest odd number such that any odd number  $\geq 9$  not exceeding it is the sum of three of the first  $n$  odd primes.)

It helps to better understand Goldbach's conjecture for three primes:

- if  $v(n)$  is unlimited, then the conjecture is true;
- if  $v(n)$  is constant after a certain rank, then the conjecture is false.

(Vinogradov proved in 1937 that any odd number greater than  $3^{(3^{15})}$  satisfies this conjecture.

But what about values less than  $3^{(3^{15})}$  ?)

Also, the table gives you in how many different combinations an odd number is written as a sum of three odd primes, and in what combinations.

Of course,  $v(n) \leq 3p_n$ , where  $p_n$  is the  $n$ -th odd prime,  $n = 1, 2, 3, \dots$ . It is also generalized for the sum of  $m$  primes, and how many times a number is written as a sum of  $m$  primes ( $m > 2$ ).

This is a 3-dimensional 14x14x14 table, that we can expose only as 14 planar 14x14 tables (using the previous table):

[illegible][illegible]















## UNSOLVED PROBLEM: 105

Second table sequence:

0,0,0,0,1,2,4,4,6,7,9,10,11,15,17,16,19,19,23,25,26,26,28,  
33,32,35,43,39,40,43,43,...

( $a(2k+1)$  represents the number of different combinations  
such that  $2k+1$  is written as a sum of three odd primes.)

This sequence is deduced from the second table.

Study the second table and the second table sequence.

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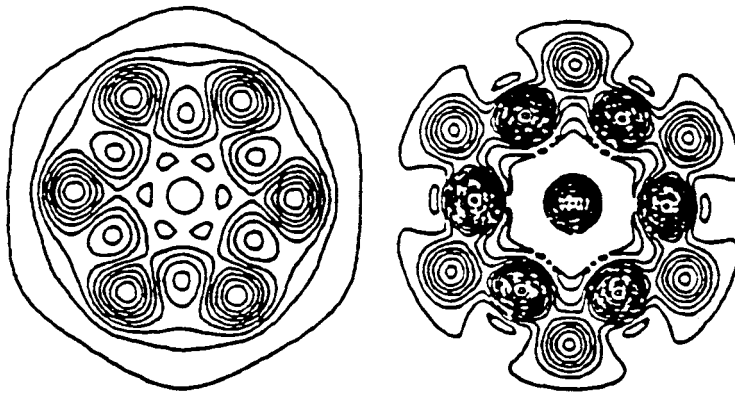
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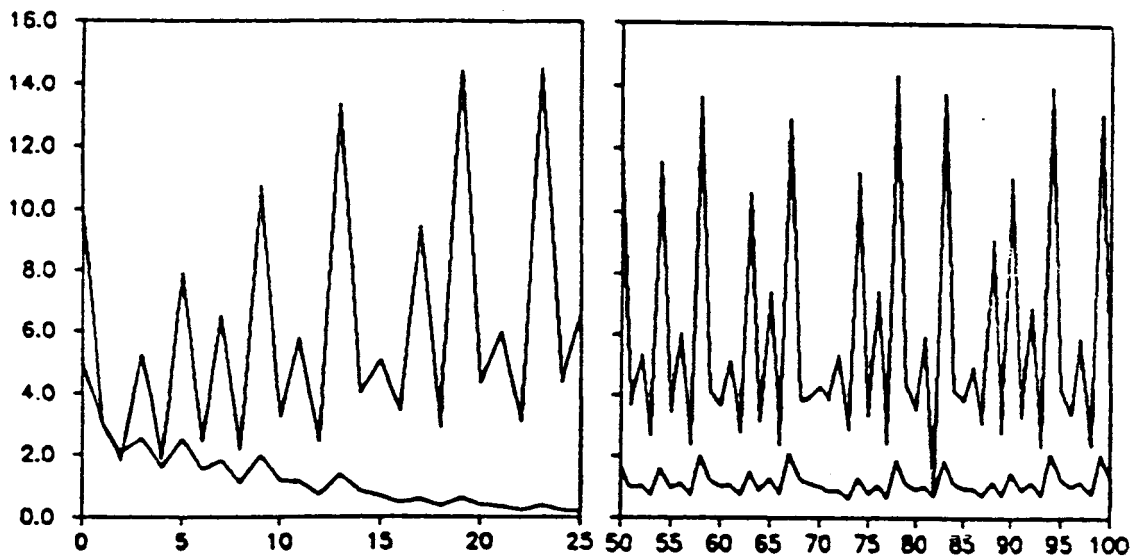
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easy easy problems



but



still still unsolved!