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Latent and Evident Knowledge to Compose and to Solve Tasks in Informatics

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Abstract. On the base of the IOI Syllabus, the following problem was stated: what additional mathematical knowledge (including one invented by jury before OI and by contestants during OI) and other branches of knowledge are permissible in tasks? Socrates' idea (a human has vast latent knowledge which can be extracted by corresponding quests) is involved. Mathematical knowledge, special (physics, chemistry, geography) knowledge, general, or common knowledge are considered. It is demonstrated that the well-known notion "Turing-complete language" does not include time and cannot be called computationally universal. The Time dependent tasks and the corresponding time checker are proposed.

Keywords: Informatics, Olympiad, latent knowledge, special knowledge, time task.

1. Introduction

The International Olympiad in Informatics Syllabus (2022) (`https://ioinformatics.org/page/syllabus/12`) provides all necessary knowledge ("included topics") in mathematics to be involved in Olympiad tasks and "forbidden to be necessary" knowledge ("excluded topics").

Consider arising problems on example of the ancient.

Task 1 *"Heads-feet". Given natural numbers H, F in 2 .. 1000. Geese and cats together have H heads and F feet. How many geese and how many cats are there? If it is impossible, output 0 0.*

Firstly, the task must be "culturally neutral". For instance, "Geese and platypuses" belong to Australian culture (although "wombats" were at IOI'2013).

"Included topics" are not enough to solve this task. The contestant is to use "latent knowledge" not related to mathematics and informatics. It is also stipulated in Syllabus (2022): *Contestants are not expected to have knowledge of these topics. ... However ... The ISC may wish to include such a competition task in order to broaden the scope of the IOI… the ISC will make sure that the task can reasonably be solved without prior knowl-*

edge of the particular topic, and that the task can be stated in terms of √ … concepts in a precise, concise, and clear way.

If we add an explanation: *a goose has one head and two feet; a cat has one head and four feet* then the task losses sense: arbitrary numbers can be substituted (*fabulous geese and cats…* is used to be added; we proposed "naturalness" (Pankov, 2008) to avoid such technique). Also, such addition violate the demand "short and elegant formulations" (Dagienė *et al.*, 2007).

If we add, as usually, strict mathematical formulation of task: *find such natural numbers G and C that $G + C = H$ and $2 \cdot G + 4 \cdot C = F$* then, firstly, it becomes almost a solution, and secondly, Linear algebra is an "explicitly excluded topic" in Syllabus (2022).

Meanwhile, if this task is given without such addition and the contestant (or their coach) protests: *Linear algebra is an "explicitly excluded topic" in Syllabus (2022) that is why I could not solve this task"* then the jury may respond: *Neither linear equations nor other notions of Linear algebra are mentioned in the task. If you reduce the task to a system of linear equations then it's your problem. The task can be solved, for instance, by brute force method.*

We will consider the tasks without redundant mathematical formulation; "thin", "light", "little", ratio of car length to road length … mean "neglectable".

The general problem arises: What "latent knowledge" not related to mathematics and informatics is permitted?

Besides of "included topics" and "explicitly excluded topics" listed in Syllabus (2022), there are unbounded mathematical topics including ones invented by the authors of tasks and the jury before the OI and by contestants during the OI (Pankov *et al.*, 2015; Pankov *et al.*, 2018). What mathematical topics can be meant latently?

In Section 2 we discuss various mathematical topics including such "discoverable ones".

We proposed wider use of the achievements of science and technologies to create tasks (Pankov, 2010). Section 3 discusses "special knowledge" being necessary to solve such tasks.

Section 4 reviews the "latent general knowledge" of life and imagery ability for successfully solving of the tasks.

In Section 5 we propose a new type of tasks on measuring real time, discuss and improve "universal algorithmic language".

Remark. Issues under discussion in this article cannot be covered by any general definitions or explanations. They can be demonstrated by examples only.

2. Mathematical Knowledge

The following tasks use topics which are not mentioned or are explicitly excluded from Syllabus (2022). Nevertheless, they can be posted and be solved successfully.

A popular at initial stages of OIs and of mathematical Olympiads (with a fixed large N)

Task 2 *"Last digit". Given integer number N in 2 .. 10^12, what is F(N) := (last digit of 7^N in decimal system)?*

Most of contestants will be successful in such a task.

If the contestant (or their coach) protests: *"Fermat's little theorem is not included in Syllabus (2022) that is why I could not solve this task*" then the jury may respond: "*You could count F(2), F(3), F(4), F(5)… and note a regularity*". That is, the ability to make small mathematical discoveries in addition to knowledge within Syllabus (2022) is meant at OIs.

Geometry in 3D is explicitly excluded in (Syllabus, 2022). But

Task 3 *"Null-transportation". There are three distinct 10^6 × 10^6-squares A, B, C on a plane, crossing a boundary of a square is prohibited. Each square has its own coordinate system 0 <= x, y <= 10^6. All numbers are integer. The cost of passing from a point A(i, j) to points A(i + 1, j) or A(i − 1, j) or A(i, j + 1) or A(i, j − 1) (if they belong to the square), as well as for squares B and C, is 2 Euros. The cost of null-transportations A(i, j) ↔ B(i, j) or C(i, j) ↔ B(i, j) is 10 Euros. Given numbers x, y, u, v in 0 .. 10^6, find the minimal cost of passing from the point A(x, y) to the point C(u, v).*

Obviously, any way of "common" search in the graph with 3·(10^6 + 1)^2 vertices is hopeless. However, most of contestants will be successful in this task.

Remark. If the contestant protests: "*3D-Manhattan metrics is explicitly excluded in Syllabus (2022) that is why I could not solve this task*" then the jury may respond: "*Neither a 3D-space nor Manhattan metrics are mentioned in the text of task. If you interpret the media as a 3D-space then it is your problem*". If the contestant protests: "*There are not algorithms to find an optimal way in such a vast graph during one second*" then the jury may respond: "*If you interpret the media as a graph then it's your problem*".

Euler's formula for planar graphs is not mentioned in Syllabus (2022).

Task 4 *"Triangles". Let us call an intersection (point only) of two drawn segments as "node", the drawn segment between two nodes without inner nodes as "fragment" and a drawn triangle without drawn inner points as "domain". Let a triangle UVW be drawn, number N of nodes is 3, number F of fragments is 3, number D of domains is 1. The operation "draw a segment splitting any domain into two domains" was executed some times. Given numbers N and D in 10 .. 10^6, N − 2 <= D <= 2N − 6, find number F. If it is impossible, output 0.*

Example 4.1. 1st operation: draw segment UP, point P is in VW; 2nd operation: draw segment VQ, point Q is in UP; 3rd operation: draw segment WQ. The result is N = 5; F = 8; D = 4.

At first, contestants will be frightened by arbitrariness but after some attempts most of them will be successful in this task.

Remark. If the contestant's coach protests: *"Euler's formula for planar graphs is not an included topic in Syllabus (2022)"* then the jury may respond: *"There are other ways to solve the task, for instance, constructing a sequence of operations yielding given N and D."*

For convenience, we will use the denotation [·] also for rounding down to integer.

"Calculus" is explicitly excluded in Syllabus (2022).

Nevertheless, we (Pankov, 2013) proposed tasks of type.

Task 5 *"Minimization". Given a natural number F in 1 .. 10^300; find such natural number X that the expression H(X) := X^3 + F / (X + 1) is minimal; if there are some such numbers then output the greatest of them.*

The author of the task is obliged to calculate the derivative H′(X) and to prove that it increases for (real) X > 0. But the contestant who does not know the notion "derivative" can easily guess (feel) that H(X) is a unimodal function, guess and implement the following effective algorithm. H(0) = F + 1, H(X) > X^3. Hence, it is enough to consider X between L = 0 and M = 10^100.

Algorithm: Repeat {Let P := [(3*L + M)/4]; Q := [(L + 3*M)/4]; if H(P) > H(Q) then L := P else M := Q} until M − L <= 5. Calculate and compare H(L), …, H(M).

"Non-trivial calculations on floating point numbers, manipulating precision errors; trigonometric functions" are explicitly excluded in Syllabus (2022).

Some countries, organizations, companies, firms (alleged sponsors) have central-symmetric elements on their coat-of-arms, logos.

Corresponding modifications of the following task may be in their honor (Pankov *et al.*, 2009).

Task 6 *"Regular polygon". Given integer numbers N in 2..2023, K in 1..64. The center of the regular 64-polygon is in (0; 0), the 1st vertex is in (N; 0), vertices are numbered counterclockwise. Find such integers X and Y that the Kth vertex is within the square (X, X + 2) × (Y, Y + 2). If there exist some such pairs output one of them.*

Remark. The task to find a square [X, X + 1) × [Y, Y + 1) is close to unresolvable one due to the following theorem of constructive mathematics: the problem of distinguishing a computable real number from zero is unsolvable.

The author's solution of the task is a little rational-numbers-interval-analysis-soft. Trigonometric functions are not used in the solution; coordinates of vertices are calculated by formulas for vectors, such as V[1] := (N; 0); V[17] := (0; N); V[9] := (V[1] + V[17]) / |(V[1] + V[17])| * N … (Euclidean distances, Pythagorean theorem are included in Syllabus (2022)).

But such solution takes about half of hour to type even for an experienced contestant. And the contestant writes a program for floating point numbers X1, Y1 in a minute:

Let X1 := N * cos(2.*pi/64.*(K − 1)); Y1 := N*sin(2.*pi/64.*(K − 1));

X := floor(X1); If X1 − X < 0.5 then X := X − 1; Y := floor(Y1); If Y1 − Y < 0.5 then Y := Y − 1;

Output (X, Y).

Because of high accuracy of the built-in functions *cos* and *sin* such program should pass all tests successfully.

Will the jury accept this solution? Checking of texts of programs is permitted only to detect (Cheating, 2022): *contestants must not attempt to submit illegal programs as* *discussed above [not perform explicit input and output operations…] … to gain access …to store information…to access any machine … to reboot…*

3. Special Knowledge

In our opinion, the tasks based on real facts and scientific laws are useful for the contestants because they are natural, they demonstrate the diversity of the world and prepare for a future fruitful activity.

Consider some branches of knowledge.

3.1. *Physics*

Velocity is a common physical notion. Nevertheless, by our experience, even simple tasks with piecewise-uniform speed are very difficult for contestants (see Section 5 below for probable reason of it).

Task 7 *“Villages”. (Kyrgyzstan, Republican OI, IV stage, 2022). There are five villages on a straight road. The car started from the beginning of the road at 5.00 am. From 6.00 am to 7.00 am the cattle go to the pasture along villages, so the car speed within villages is 6 km/h, otherwise the car speed is 60 km/h. Find the coordinates (in meters) of the car in M minutes after 5.00 am.*

Input: $M < 216$; coordinates of villages (km) $0 < B1 < A1 < B2 < A2 < B3 < A3 < B4 < A4 < B5 < A5 < 216$.

Gravitation, the lever law (by our opinion, it is natural and can be felt or guessed from the example).

Task 8 *“Weighing” (Kyrgyzstan, National OI, I stage, 2023). Points … −3, −2, −1, 0, 1, 2, … are marked on a long ruler at equal distances between them. The ruler is suspended in the middle, at the point 0. There is plenty of a flour, a light bag for flour, and weights of natural numbers (given) P kg and (given) Q kg. A bag of flour and weights can be hung on a ruler, only at marked points. There cannot be two loads at same point. It is required to weigh (given) Z kg of flour.*

Find the minimum possible length of the segment occupied by the weights. Example 8.1. (with comments): P = 2 (hung at “1”), Q = 50 (hung at “2”), Z = 102 (hung at “−1”) → 3.

Task 9 *“Non-symmetrical scale” (Kyrgyzstan, Republican OI, III stage, 2023). Given natural numbers P, Q, Z in 1 .. 2023. The (very light) bowls of the scale are suspended at distances P and Q (horizontally) from the suspension point of the scale. To weigh Z kg how many 1-kg-kettlebells are necessary? Example 9.1. P = 20, Q = 10, Z = 1993 → 998.*

Gravitation, properties of liquid.

Task 10 *"Rain". (Kyrgyzstan, Republican OI, II stage, 2023). Given integer number K in 4 .. 6. K thin rectangular walls were built on the plane in "north-south" or "east-west" directions (two walls can be intersected). It is raining, raining… How much water do the walls hold? ("zero" can also be).*

Input. The first row contains K. The next K rows contain five natural numbers X1, Y1, X2, Y2, Z in 1 .. 10, the coordinates of the end-points and height of the i-th wall, i = 1 .. K.

Properties of snow (snow is not "solid" in physical terminology; it is a unique object).

Task 11 *"Snow" (Kyrgyzstan, Republican OI, III stage, 2006). Let the streets in the city [Bishkek] form a rectangular grid (with coordinates), all blocks are 1 × 1. The firm Logic [sponsor] is located at a given crossing (X, Y). Two friends wish to come to Logic. Now the first is at the crossing (X1, Y1), the second is at the crossing (X2, Y2). Because of the plentiful snowing they wish to minimize the trampled path (the sum of paths trampled by the first, by the second and by the both going together). Write a program calculating the minimal length of path.*

Law of reflection.

Task 12 *"Mirrors". Given integer numbers P and Q in 1 .. 10^6. The rectangle ABCD is made of four mirror segments, |AB| = |CD| = P, |AC| = |B| = Q. The ray came out of the vertex A along the bisector of the angle BAC. What vertex will the ray come in?*
Example 12.1.: 6000 1500 → B

If the contestant is doubt in their memory or guessing on the law then the example confirms it.

Law of impulse conservation.

Task 13 *"Carts". (Kyrgyzstan, Republican OI, III stage, 2023). All data are integer. The "zero" point was marked on a horizontal long straight road. Two small carts move without friction along the road. If they collide then they concatenate and then move together. Their weights S1 and S2 (kilograms), initial locations J1 ≠ J2 (meters), and initial velocities Y1 and Y2 (meters/second) are given. Where will the first cart be after U(seconds)? Give the answer as a fraction.*

Example 13.1. U = 8, S1 = 7, S2 = 7, J1 = 50, J2 = 51, Y1 = 1, Y2 = 0 → 9/2

X-rays, tomography.

General task 14 *"Restoration". To restore an object (an image) by its projections (by sums along columns, rows).*

3.2. *Chemistry*

Task 15 *"Equalization". Chemical elements are denoted by an uppercase letter or by an uppercase letter and a lowercase letter; number of such atoms in the mole-*

cule (less than 100), if it is greater than one, is written after. Given molecules M1, M2, M3. Find such a non-negative (the least possible) integer numbers N1, N2, N3 that N1 · M1 + N2 · M2 = N3 · M3. If it is impossible, output 0 0 0.

Example 15.1. H2 O2 H2O → 2 1 2. Example 2. Bb17Bb3 Sx2 Bb22 → 11 0 10.

Remark. "Chemical language for molecules" is non-formal, writings may be more or less detailed. To avoid questions, "Bb" is written twice in one molecule and "Sx" is not used.

3.3. *Geography, Astronomy*

Task 16 *"Above the equator". All numbers are integer. Western longitude is denoted with "−". Given (N in 2..360) distinct points with latitudes (in −179..180 degrees) on the equator. A geostationary satellite can cover (K in 1..30) degrees on the equator. How many geostationary satellites are necessary to cover all points? Example 16.1. K = 2, N = 4 / 50 −179 179 −45 → 3.*

Task 17 *"Satellite". Angles are measured in degrees. All numbers (except V) are integer. There is a planet P (its center C) with a satellite (S) far from the Earth (E). The straight-line EC is in the plane of the circular orbit of S. Denote the angle between EC and CS as A (if S is to the left of EC then let "−A" be written). When S is before or behind P (|A| < K), S is not seen. When S is seen, we can measure A but we cannot detect whether S is farer or nearer than C. Suppose that the angular velocity of S be (rational number) V /hour.*

By results of series of N observations on A at 0, 1, 2, ...N − 1 hours find the minimal value of V.

Input: numbers K in 2..45, N in 2..5 / N numbers in −90..90 ("0" means "not seen") .

Example 17.1. 30 2 / −84 −84 → 12/1. Example 17.2. 30 2 / 84 86 → 2/1.

Example 17.3. 30 3 / 31 0 −32 → 63/2.

3.4. *Linguistics*

Similar tasks for Kyrgyz language were used to be given. To be "culturally neutral":

General Task 18 *"Ciphering". A number in 1..99 (without the sign "−") was written in lowercase letters. Each letter was changed (bijective) to an uppercase letter. One of the letters was erased (or: One of the letters was changed; or Any letter was added ...). Restore the greatest possible value of the number.*

Example 18.1. WZ → 10. Example 18.2. QWQZSKKG → 59.

4. General, or Common Terminology and Knowledge

Notions of language, odometer are mentioned in Syllabus (2022) as examples.

Traditional notions are persons (IOI participants, players, travelers), animals (it is better that their properties in the task be similar to their actual ones, for instance, jumping frog at IOI'2002; hounds and moths with GPS; warms as mathematical tasks characters from ancient times), ways, roads, crosses, villages (as points or segments on highways) and cities (large, with rectangular street grid), walls (as segments on a plane), cars (as points), pixels …

We proposed voxels, timexels, 2D-printers, 3D-printers, future (3D + T)-printers for wider using (Pankov *et al.*, 2021).

Various natural tasks can be composed on the notions of (ideal, thin, inextensible) rope and other idealized household items.

Task 19 *"Rope". Given a rope of length L and a graph, all its arcs have lengths 1 and are thin tubes. Rope is arranged within arcs, without touching itself. Can Rope be drawn through all arcs without self-touching? If it is possible, find the minimal time to do it.*

Every language carries its own specific notions. Examples:

Latin "formula", "registration", "optimization" and many others; Ancient Greek "program", "axiom" and many others. It is difficult to explain them but they became international and can be used.

Fijian "taboo" (and its versions in other Pacific Ocean languages) is convenient to be used in some Olympiad tasks but it would not be "culturally neutral".

Kyrgyz "irgöö" is more general than the word "synergetic" (Kenenbaeva, 2014). It yields self-ordering in stochastic processes. As statistics is an "explicitly excluded topic" in Syllabus (2022), such process can be imitated by "arbitrary operations, operations in arbitrary order", as in Task 4. Will such task be "culturally neutral"?

The next layer is "relations": neighbors, friends, teacher and students, teammates…

Many verbs mean various facts, laws, operations: glue, cut, paint (are used for graphs), pour (see Task 10), fold …

Task 20 *"Folding". Given a number N and a (large) polygon glued of equal 1 × 1-squares. We can fold it by lines of gluing. How many foldings are necessary to obtain a (multi-layer) polygon with area not greater than N?*

Every native speaker has vast knowledge about and some skills. What of it can be used in tasks?

For example, is latent knowledge in Task 1 related to common one or to zoological one?

Are properties of water (liquid) in Task 10 physical or obvious?

Properties of snow cannot be explained formally, mathematically. By what knowledge do contestants solve Task 11?

Obviously, for successful solving of Task 10 the contestant is to have the property of measuring imagery (Pankov, 1996).

5. On Universal Algorithmic Languages, Time Tasks and Random Phenomena

Nowadays computers cover anyway almost all universe known to the mankind. In our turn, we are to cover more aspects of life by Olympiad tasks. Firstly, what algorithmic language is suitable for such purposes?

Well-known statements which are also meant in OI:

> *"a system of data-manipulation rules (such as a computer's instruction set, a programming language, or a cellular automaton) is said to be Turing-complete or computationally universal if it can be used to simulate any Turing machine"* (`https://en.wikipedia.org/wiki/Turing_completeness`).

But by our opinion, such language is neither "complete" nor "universal". A simple command "in (2 ± 0.01) second output 2023" or a natural condition "if (1.99 < time < 2.01) and (5.01 < X < 5.02) then …" cannot be written in such language.

Probably, "time" was not included in "universal language" because a human does not have a built-in timer unlike some animals. But various automats and devices since XIX century had. It turns out that developers of this important notion in middle of XX century did not pay attention to them.

To broaden the horizons of participants we propose to include the following type of tasks in initial stages of OI:

Task 21 *"Just-in-time"*
Given natural numbers A, B and N. Write a program to output (A + B) in (N +/− 10) milliseconds.

Input: A, B in −10^9 .. 10^9, N in 100 .. 1000.

Output: Sum (A + B) and an integer number denoting actual time from running the program (milliseconds)

Example 21.1. Input: 5 6 900 Output: 11 905 or 11 897 or ...

The full text of the task is at `https://cloud.mail.ru/public/S9wJ/dqzHxWPNa`

The checker is at `https://cloud.mail.ru/public/DTgK/QFx8mrP7K`

A text of program is at `https://cloud.mail.ru/public/gn17/hpnoEJWjG`

This task is also included in:

`https://olymp.krsu.edu.kg/GeneralProblemset.aspx`

Remark. To support the idea of Turing-complete language, the physical Church-Turing thesis was proposed, for instance, (Arrighi *et al.*, 2012): any function that can be computed by a physical system can be computed by a Turing Machine.

The following physical system (Pankov *et al.*, 2018a) refutes this thesis.

The surface (made of tin) consists of six triangles with the following seven vertices (in cylindrical coordinates: radial distance; angle; height): A[0] := (0″; 0; 0″); A[K] := (15″; π * i/3; (5 + 2 * (−1)^K)″); K = 1 .. 6.

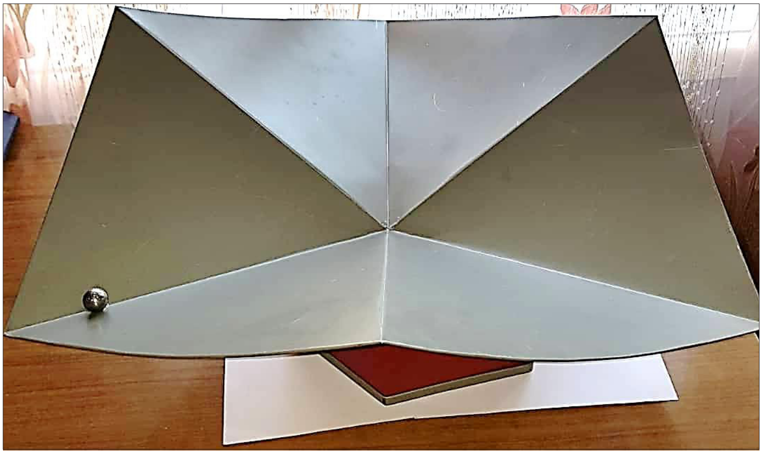

Fig. 1. Pavel Pankov, Sabina Tagaeva © 2018 Made by Nuraly Niyasbekov.

The little ball (made of steel) is launched from the point A[1]. It rolls down along the "valley" to the point A[0], rolls up a bit along the "ridge" A[0] – A[4], falls off left to "valley" A[5] – A[0] or right to "valley" A[3] – A[0] randomly, rolls down to the point A[0], rolls up a bit along the "ridge" A[0] – A[2] or along the "ridge" A[0] – A[6] respectively etc. Actually, the ball rolls up trice before stop in the point A[0] (for instance, in 4 second). Each launch initiates another function $[0, 4] \to R^3$ and none Turing Machine can calculate it.

6. Conclusion

We hope that this paper would draw attention to more general problem (especially for international students): what latent and evident knowledge and skills are necessary for successful life, study and work in our changing world?

> *Results from the focus group discussions showed that international students face challenges in their everyday life, dormitory life, campus life, social life and academic life.* (Gebru *et al.*, 2020)

Eynullayeva *et al.* (2021) examined whether the cultural adaptation levels of international students vary according to gender, place of residence, academic achievement level, education level, faculty they attend, and their age.

And how can OIs (covering millions young people at initial stages) contribute to this problem?

References

Arrighi P., Dowek G. (2012). The physical Church-Turing thesis and the principles of quantum theory. *International Journal of Foundations of Computer Science*, 23(5), 1131–1145.

Cheating (2022). `https://ioi2022.id/competition-rules/`

Dagienė, V., Skupienė, J. (2007). Contests in programming: quarter century of Lithuanian experience. *Olympiads in Informatics: Country Experiences and Developments*, 1, 37–49.

Eynullayeva, K., Gökalp, M., Hatunoglu, B.Y. (2021). Investigation of the Turkish Cultural Adaptation of International Students Living in Turkey. *European Educational Researcher*, 2(2), 155–169.

Gebru, M. S., Yuksel-Kaptanoglu, I. (2020). Adaptation Challenges for International Students in Turkey. *Open Journal of Social Sciences*, 8, 262–278.

Kenenbaeva G. (2014). Framework Definitions of Effects and Phenomena and Examples in Differential and Difference Equations. *Journal of Mathematics and System Science*, 4, 766–768.

Pankov P.S. (1996). Independent learning for open society. *Collection of papers as results of seminars conducted within the frames of the program "High Education Support"*. Foundation «Soros-Kyrgyzstan», Bishkek, issue 3, 27–38.

Pankov, P.S. (2008). Naturalness in Tasks for Olympiads in Informatics. *Olympiads in Informatics: Country Experiences and Developments*, 2**,** 16–23.

Pankov, P.S. (2010). Real Processes as Sources for Tasks in Informatics. *Olympiads in Informatics*, 4**,** 95–103.

Pankov, P.S. (2013). Tasks in Informatics of Continuous Content. *Olympiads in Informatics*, 7**,** 101–112.

Pankov, P.S., Baryshnikov, K.A. (2009). Representational Means for Tasks in Informatics. *Olympiads in Informatics*, 3**,** 101–111.

Pankov, P.S., Imanaliev, T.M., Kenzhaliev, A.A. (2021). Automatic Makers as a Source for Olympiad Tasks. *Olympiads in Informatics*, 15**,** 75–82.

Pankov, P., Janalieva, J., Naimanova, A. (2015). Inductive and experimental studying of mathematical subjects (mathematical facts and notions which can be discovered independently), *LAP Lambert Academic Publishing*, Saarbrücken.

Pankov, P.S., Kenzhaliev, A.A. (2018). Combinatorial property of sets of boxes in Euclidean spaces and theorems in Olympiad tasks. *Olympiads in Informatics,* 12, 111–117.

Pankov, P.S., Tagaeva, S.B. (2018a). Computer and real simulation of phenomenon of strange attractor by system of differential equations. *Herald of Institute of Mathematics of National Academy of Sciences of Kyrgyz Republic*, 1, 17–23.

Syllabus (2022). *The International Olympiad in Informatics Syllabus*.
`https://ioinformatics.org/ page/syllabus/12`

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