The International Olympiad in Informatics Syllabus changelog for the 2015 version and rationale

1 Change in the definition of Excluded topics

The main change to notice in the new version of the Syllabus is the change in how Excluded topics are defined. The previous Syllabus version defined these topics as follows:

> *Some of the harder algorithmic topics are explicitly marked as excluded. It is guaranteed that there will not be a competition task that* requires *the contestants to know these areas. In other words, each competition task will have a perfect solution that can be produced without the knowledge of these topics. This category mainly contains hard textbook algorithms.*

In the new Syllabus, the definition is changed to:

> *Some of the harder algorithmic topics are explicitly marked as excluded. It is guaranteed that there will not be a competition task that* requires *the contestants to know these areas.*
>
> *Furthermore, the tasks will be set with the goal that knowledge of Excluded topics should not help in obtaining simpler solutions / solutions worth more points.*
>
> *This category mainly contains hard textbook algorithms and advanced areas in mathematics.*

Consider the editorial of the Codeforces problem 446E published here: `http://codeforces.com/blog/entry/13036`. Clearly, a problem like this is *not* something we want to see at the IOI. Still, one could argue that this problem (with a few minor modifications) would be admissible under

the previous Syllabus: it can be solved in 80 lines using modular addition/multiplication and divide-and-conquer, and can also be explained elementarily via summations.

The updated definition makes it clear that this is not the ISC's intent. In the cited case, there is a conceptually simpler approach using the Fast Fourier Transform and Hadamard matrices, and the knowledge of these advanced topics does make the task easier to solve. This makes it fall in the Excluded category in the new Syllabus.

2 "Excluded, but open to discussion"

The ISC is currently discussing the fate of a small set of topics that are labeled this way in the current Syllabus. We would appreciate all input from the IOI community.

3 A better definition of prerequisites

It is now explicitly stated that the Syllabus is trying to specify two sets of topics: a small set of topics that are considered prerequisite knowledge and a second, larger set of topics that may occur in the solutions of competition tasks.

The current revision specifies that the prerequisite knowledge falls into the first two categories:

- "Included, unlimited" – e.g., all contestants are expected to know what is a line segment.
- "Included, to be clarified" – e.g., all contestants are expected to know what is a directed graph, and to understand the part of the statement where it is specified whether the graph contains self-loops and/or multiple edges between the same vertices.

4 Changes in the set of topics

In this final section of this document we list the changes made to the set of topics. The main motivation for the changes is to pick a set of topics that is rich enough to generate many interesting problems, and at the same time knowledge beyond the selected topics should be unlikely to help the contestant. The intent here is that focusing on problem solving using a set

of well-defined tools can both ease the preparation of students for the IOI, and remove the need to study out-of-syllabus topics.

4.1 New Explicitly excluded topics

A significant number of topics were added as Explicitly excluded. In effect, this removes them from the implicit Out of focus category.

- Geometry in three or more dimensions.
- Linear programming in 3 or more dimensions and its geometric interpretations.
- Point-line duality in 2-dimensional geometry.
- Halfspace intersection, Voronoi diagrams, Delaunay triangulations.
- Computing coordinates of circle intersections against lines and circles.
- Topics where linear algebraic perspectives can be helpful, including the Fast Fourier Transform.
- Burnside lemma.
- Clustering algorithms (e.g. k-means, k-nearest neighbor).
- Primal-dual graph algorithms (e.g. minimum cost arborescence).
- Lexicographical BFS, maximum adjacency search and their properties.
- Hypergraphs.

Additionally, planar graphs were previously Out of focus. Planar graphs themselves are now Included – a contestant should understand what is a planar graph. However, non-trivial topics related to planar graphs (notably planarity testing and planar separators) are now listed as Explicitly excluded.

4.2 Floating-point numbers

Previously, floating-point numbers were Explicitly excluded. The current Syllabus now lists as Included:

- elementary use of real numbers in numerically stable tasks
- the floating-point representation of real numbers, the existence of precision issues

but keeps as Explicitly excluded:

- analyzing and increasing precision of floating-point computations

- non-trivial calculations on floating point numbers, manipulating precision errors

The reason for this change is that the modular interface currently used in all IOI tasks makes it possible to use tasks where real numbers occur but precision issues don't play a role. For instance, a task in which a contestant computes the lengths of some line segments and outputs the shortest of those lengths should be perfectly viable.

4.3 Data structures

More details were added to the section on data structures. The set of Included topics has been updated to cover some of the data structures used in past IOI tasks, and to add several new data structures that the ISC considers appropriate for future IOI tasks. The additions:

- Composition of data structures, e.g. two-dimensional statically balanced binary trees.

  (These have been used regularly, starting with IOI 2001 task Mobiles, without being explicitly mentioned in the Syllabus.)

- Augmented binary search trees – storing, modifying and using additional information in the BST's nodes.

- Balanced binary search trees.

  (Problems may require the use of an efficient data structure that supports the required operations. There will not be problems that would require the contestants to know a particular implementation. Hence, any single implementation – e.g., treaps, splay trees, AVL trees, or scapegoat trees – should be sufficient knowledge.)

  Past submissions have shown that simple and concise implementations of BBSTs are already known by a significant portion of the target group of contestants. Already before BBSTs were in the Syllabus, some contestants preferred them over more complicated static structures. This ranges back at least to the tasks Elephants (IOI 2011) and Jousting Tournament (IOI 2012).

- $O(\log n)$ time algorithms for answering lowest common ancestor queries in a static rooted tree.

- Creating persistent data structures by path copying or using fat nodes.

4.4 Other additions and reclassifications

- Finding connected components has been explicitly added as Included.

  (This was omitted previously, as it is contained in computing transitive closures, but we decided that it is better to state it explicitly.)

- Among the applications of depth-first search, algorithms to determine an Euler path/cycle are now listed explicitly as Included.

- Pointers and references were shifted from Out of focus to Included. There is no difference between implementations that use them and implementations that use static arrays and indices instead.

  (Additionally, basic understanding of pointers has already been necessary in C to understand the interface of some of the functions provided by the task library. With this exception, pointers and references still won't be used in problem statements.)

- Regarding the running time of implementations, Empirical performance measurements were shifted from Out of focus to Included and Tuning parameters to reduce running time was shifted from Excluded to Out of focus.

  (This is just a better reflecion of the current reality.)

- The basic $O(VE)$ time algorithm for computing maximum bipartite matching is now Included.

  (The algorithm is comparatively simpler than many other algorithms that are Included. Additionally, ISC surveys consistently show that even without being on the Syllabus it is actually known by more contestants than many of the other Included algorithms.)

- Center of mass of a polygon was shifted from Included to (implicitly) Out of focus.

- Algorithms for convex hull are still Included, but now it is clarified that this includes an $\mathcal{O}(n \log n)$ time algorithm.