

## ZFTSH: A SPECIALIST CORRESPONDENCE SCHOOL

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I worked at the intramural department of a Correspondence school at the Moscow Institute of Physics and Technology (MIPT, or Phystech as it was known in Russia)<sup>†</sup> for 3 years between 2002 and 2005, whilst completing my BSc and MSc degrees.

MIPT was founded by the Nobel prize winners P. Kapitsa, L. Landau and N. Semenov in the late 1940s, and is widely renowned as Russia's equivalent of the best technical colleges such as Caltech, MTU and Cambridge. In his 1946 letter to Stalin, Kapitsa argued for the founding of MIPT and outlined the key principles the MIPT system:

- Rigorous selection of gifted and creative young individuals;
- Involvement of leading scientists in students' education;
- An individualized approach to encourage the cultivation of students' creative drive;
- Avoid overloading the students with unnecessary subjects and rote learning common in other schools and necessitated by mass education;
- Conducting their education in an atmosphere of research and creative engineering, using the best existing laboratories in the country.

In its implementation, this system combines highly competitive admissions, extensive fundamental education in mathematics, as well as theoretical and experimental physics in the undergraduate years, and immersion in research work at leading research institutions of the Russian Academy of Sciences starting as early as the second or third year.

For several decades since its establishment, MIPT has been attracting talented students in mathematics and physics from all over Russia and former Soviet Union. It has been one of the main contributors in preparing highly-skilled specialists across all areas of physics and ap-

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2000 *Mathematics Subject Classification* 97C50 (primary), 97D20 (secondary).

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<sup>†</sup><http://phystech.edu/about/aboutmipt.html>.

plied maths, with around 800 students graduating from all faculties each year.

The Correspondence school (ZFTSh)<sup>†</sup> was established at MIPT in 1966 to promote the development of intellectual potential of exceptional pupils and cater for their need of advanced pre-university education, as well as to provide guidance in choosing the profession. The school has three branches: correspondence (individual distance-learning), intramural full-time (evening classes at MIPT itself) and intramural part-time (elective classes in educational institutions across Russia, under guidance of local teachers of physics and mathematics). ZFTSh employs both full-time and part-time staff, with the latter mostly being current undergraduate and postgraduate students of MIPT; the school relies heavily on their contribution. There are up to 600 employees across all the branches of the school in total.

The programmes in all the branches of ZFTSh are similar, and are designed for pupils of forms 8 to 11 (13–17 year-olds), which roughly corresponds to the final 4 years of pre-university education in the UK. It is possible to join the school at any stage within the 4-year course. Admission to ZFTSh is on a competitive basis: prospective students are offered tests in physics and mathematics, which are published annually in the journal “Kvant” and other educational periodicals. Finalists and winners of regional and national Olympiads are automatically granted a place, while students at the intramural departments usually have to pass an oral entrance exam. The education is traditionally free of charge.

During the academic year there are 4 assignments in each subject (maths and physics) for students of the 8th form, and 6–7 assignments in each subject for students of the 9th, 10th and 11th forms. Each assignment contains the relevant theoretical material, key examples with solutions, and typically provides between 10 and 30 problems for the pupils to attempt and post back to ZFTSh before a certain deadline. The scripts then get checked by the staff, and the actual solutions are subsequently posted to the pupils along with the next assignment. Traditionally each ZFTSh pupil is being mentored by the same MIPT student throughout the year, which in line with the key principles of the MIPT system: individual approach as well as intellectually stimulating interaction with senior colleagues.

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<sup>†</sup><http://phystech.edu/education/distance.html>.

Some of the ZFTSh statistics (from 1967 to 2001):

- graduated from ZFTSh: 60,807
- applied for MIPT: 22,170 (36.5% of the graduates)
- passed the entrance exams to MIPT: 15,809 (71.3% of the applicants)
- chose to study at MIPT: 10,470 (66.2% of those who passed the exams, which represents 17.2% of the ZFTSh graduates)
- taught in ZFTSh: over 16,000 undergraduate and postgraduate students of MIPT.

The intramural department of ZFTSh at the Faculty of Aerospace and Flight Engineering located in Zhukovsky, Moscow region, is recruiting pupils from the 9th, 10th and 11th forms. There are normally two or three classes of around 20 individuals for each of the three years. Potential pupils come from Zhukovsky itself (this city is known as the Russian aerospace centre) as well as the nearby towns. To get an admission, the students have to pass an entrance oral exam. The school offers two hours of tutorials in maths and two in physics every week, attended in the evening (after normal school) and taught mostly by MIPT students, with additional two-hour lectures in maths for the pupils of the 9th form (taught by an MIPT staff member).

Typical tutorials begin with a detailed theoretical description of the material, followed by solving a number of relevant problems. The students receive homework each week and are expected to submit the solutions in the following week; the main purpose is to keep the students active and engaged, and to encourage them to solve substantial amounts of challenging problems on their own in order to develop a better feel for the subject. In the end of each term the students have to sit through written and oral exams both in physics and maths (resembling the system of MIPT); satisfactory results are necessary to be transferred to the next term/year. Those who successfully complete the final year receive a certificate, although there is no emphasis on the actual grade.

Throughout the course at ZFTSh, the teaching ultimately focuses on tackling the problems from the entrance exams to MIPT. These problems require deep understanding of the subject as well as mathematical and physical intuition, and the difficulty is often comparable to some of the questions offered at regional Olympiads. It is, therefore, essential to eradicate the culture of rote learning common in most of the schools, and sow the seeds of individual creative thinking instead.

Those students who successfully embrace these ideas whilst at ZFTSh, benefit not only during the entrance exams at MIPT and other leading universities, but also whilst in the higher education and throughout the professional career. The main focus of the entire system of ZFTSh and MIPT has always been on preparing top-class scientists: distinguished MIPT graduates include the 2010 Nobel Prize winners in physics, Andre Geim and Konstantin Novoselov—the latter has also been a student at ZFTSh and says in his autobiography at the official Nobel Prize website<sup>†</sup>:

My participation in the Distance Learning School and Olympiads made entering Phystech in 1991 fairly straightforward.

However, a significant number of MIPT graduates have traditionally been successful in many other areas such as banking, IT technologies, politics and even art.

### *Appendix 1: ZFTSh, Sample problems from Entrance Examination in Mathematics*

Academic year 2012–13<sup>†</sup>

- (1) (7 Form) In the triangle  $ABC$ , the bisector  $CE$  is perpendicular to the median  $AM$ . Find  $AC$ , if  $BC = 2012$ .
- (2) (7 and 8 Forms) A train is going with constant speed, and by 23:08 it passed the distance which is 1.35 times greater than the distance that it had passed by 19:45 on the same day. When did the journey start?
- (3) (8 Form)  $DK$  is a median of the triangle  $DEF$ . Find the angles of the triangle  $DEF$  if  $\angle KDE = 70^\circ$  and  $\angle DKF = 140^\circ$ .
- (4) (8 and 9 Form) At the first stop of a trolley bus route, some passengers entered the empty salon of the trolley, and half of them took seats. How many passengers entered the trolley bus at the first stop, if after the second stop the number of passengers in the bus increased by 8% and it is known that no more than 70 passengers can fit in the bus?
- (5) (8–10 Forms) Find the total number of all three-digit numbers in which the sum of some two digits equals 3.
- (6) (9 and 10 Forms) Simplify

$$\frac{\cos^4 \alpha + \sin^4 \alpha - 1}{\cos^6 \alpha + \sin^6 \alpha - 1}.$$

- (7) (10 Form) Solve the equations

$$\cos 12x = \cos 6x + \sin 6x.$$

(Students in Forms 8–11 are 13–17 years old.)

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<sup>†</sup>[http://www.nobelprize.org/nobel\\_prizes/physics/laureates/2010/novoselov.html](http://www.nobelprize.org/nobel_prizes/physics/laureates/2010/novoselov.html).

<sup>†</sup><http://www.school.mipt.ru/FileDown.asp?ItemId=1194>.

*Appendix 2: MIPT, typical problems from entrance examinations in mathematics and physics*

*Mathematics.* Solve the system of simultaneous equations:

$$\begin{aligned}x + y^4 - 2y^2 &= \ln x \\ 2 \arctan x + \arcsin y &= 0.\end{aligned}$$

*Physics.* A thin wire ring of radius  $r$  is placed in a uniform magnetic field with induction  $B$  perpendicular to the ring's plane. Two radial wire bridges are sliding in opposite directions along the ring with angular velocities  $\omega_1$  and  $\omega_2$ , respectively. Both the radial bridges and the ring are made of the same wire which has electric resistance  $\rho$  per unit length. Determine the magnitude and the direction of the currents through the bridges at the moment when the angle between them is  $\alpha$ . It is assumed that there is an ideal electrical connection between the two bridges (at the centre of the ring) and between the bridges and the ring.

*About the author*

Dmitry Yumashev is a post-doctoral researcher in Applied Mathematics at the University of Manchester. He holds a PhD in Fluid Mechanics and Applied Mathematics from the University of Manchester and MMus in Voice, Opera, from the Royal Northern College of Music.