PRACTICAL COURSE ON BASICS OF MATHEMATICS AND PHYSICS:

FROM ZERO TO HERO!

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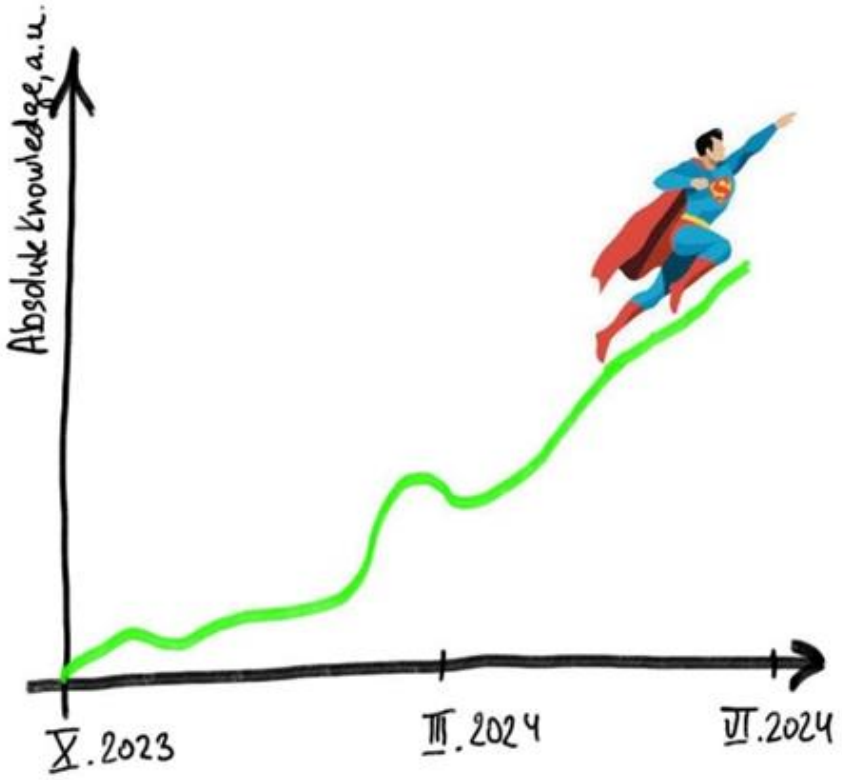
Two-part course devoted to explaining Mathematics and Physics **absolutely from scratch** for the Physical Chemists. After every lecture we will have short practical sets of problems, so that we join theoretical "what it is?" with practical "how to use it?". Moreover, attendees are more than welcome to bring their own problems from research / courses / "never understood that fully" to consult how to understand and solve them. Winter part belongs to the Mathematics, and summer part – to Physics. The outline depicts the topics covered each week. **ECTS: 3 per semester.**



WINTER SEMESTER – START OCTOBER 2023!

MATHEMATICS

1. Basic definitions: what is a function, an argument, a complex number? Theory and history of numbers.
2. Solving linear equations, systems of linear equations (**necessary for any modelling in science!**), and introduction to trigonometry.
3. Introduction to limits and derivatives – basic rules of calculating a derivative of a given function.
4. Introduction to approximations: power series (aka Taylor expansions): how to **approximate a "complicated" function** with **a few simpler ones**?
5. Extrema of functions *f(x)*: maxima, minima and inflection points.
6. The "mythical integral" aka inverse of derivative: what is it, simple methods of calculating integrals (substitution / by parts or "magical" Wolfram Alpha software package).
7. Ordinary differential equation: how to solve (variable separation / integrating factors / Wolfram Alpha)?
8. Complex functions put simply.
9. Linear algebra (matrices, vectors, Wolfram Alpha).
10. 2-D and 3-D analysis: partial derivative, extrema, coordination systems (cartesian *xyz* / polar / cylindrical / spherical).
11. Simple partial differential equations – solving via Fourier's method and, of course, Wolfram Alpha.
12. How to utilise Wolfram Alpha even better – introduction to Wolfram Mathematica and its magic (numerical solutions to equations, plotting analytical and numerical results, presenting data).

SUMMER SEMESTER – START MARCH 2024!

PHYSICS

1. How does it move and why? – Introduction to the Newtonian mechanics (trajectories, relative velocities, forces, Newton's laws).
2. Spinning and vibing around – rotational and oscillatory motions (inertial and non-inertial frames of reference, centrifugal and centripetal forces).
3. Save it up for later – conserved quantities, symmetries and other descriptions of classical physics (momentum, angular momentum and energy conservation laws, symmetries in physics, Lagrange / Hamilton descriptions, Noether's theorem).
4. Why cannot we have liquid CO_2 under atmospheric pressure? (Definition of temperature, laws of thermodynamics, simple thermodynamic processes, phase diagrams).
5. My hair stands on end – electrostatics (electric charges, potential and field; capacitors and Gauss' law).
6. Why does a frog levitate over the magnet? (Electric current, magnetic field induction, Ampere's law, dia- / para- / ferro- / antiferromagnetism).
7. AC/DC – time-dependent electromagnetic fields and introduction to optics (Maxwell's equations, refraction/reflection, geometrical optics).
8. $E = mc^2$ and why superfast particles live longer? – Introduction to the special relativity (Einstein's postulates, Lorentz's transformation, and its consequences).
9. From an abacus to a smartphone – semiconductor physics (diodes, transistors, doped and undoped semiconductors).
10. Understanding the world – introduction to modelling in physics (a few interesting examples of counterintuitive phenomena explained and modelled with Wolfram Mathematica).