Recommended Bulgarian TST Problems

To aid self-study, here I've arranged all the theoretical problems that I like, by topic. I've mostly selected for pedagogical value, but I've also attempted to strike a good balance between easier and harder problems. The format I use for this list is "year/exam type/problem number". For each problem, I've added an estimate for the difficulty, as follows:

(●) – easy (●) – moderate (●) – difficult (●) – very difficult

You might disagree, and that's normal! In case you're interested in a specific subject, I've also provided descriptions for what each problem is about. Inevitably, some hints will slip through, so if you prefer to onsight the problems rather than flashing them, consider this your warning.

Mechanics

Statics

2018	T	3	Car suspension (●). This is quite tough if you don't know how cars work, because you'll have to learn on the go. Otherwise the physics isn't too bad.

Not Rotation

2019	T	3	Hodograph (●). A rather pleasant problem which introduces a type of velocity diagram.
2016	T	2	Friction on a rotating disk (●). A problem with a neat final result that tests your approximation skills.
2008	T	3	Deflection (●). An important exercise which shows the utility of the centre of mass frame in collision problems.

Rotation

2019	T	1	Unwinding a string (●). A short exercise on no-slip rotation.
2008	S	1	Ball rolling down a ball (●). A generic rotation problem with friction and normal forces.
2012	S	1	Falling rod (●). A problem which requires you to spot a kinematic constraint. Inspect for geometrical curiosities and proceed from there.
2018	S	1	Falling ladder (●). Similar to the above, albeit a bit more difficult.
2016	T	3	Masses on a rotating spring (●). A neat one – combines a few distinct ideas.
2023	T	3	Pendulum on an incline (●). You should get some practice on 3D rotation (e.g. via Kevin Zhou M8) before attempting this one.

Oscillations

2012	T	2	A sheet of paper (●). Moments of inertia and a physical pendulum.
2016	T	1	Leaning rectangle (●). A somewhat tedious problem which requires you to be very careful. As usual with problems on complicated oscillations, it's better to work with energy rather than Newton's second law.
2018	T	1	Blocks on a spring (●). Solving this rigorously is a nightmare, but you can still obtain some answer which is likely to be right, and promptly give up on analysing the complete motion.

2023	S	1	Two collisions (●). As with the previous problem, you need to be comfortable with differential equations. There's also some neat maths waiting for you at the end.

Gravity

2008	T	1	Drag on a satellite (●). A fun little problem on work and energy.
2016	S	1	Earth and Mars (●). Some standard fare on Kepler's laws.

Fluids

2018	T	2	Spray (●). A useful exercise on ideal fluids and inertial forces.
2008	T	2	Poiseuille's law (●). A standard problem on viscous flow in a cylinder. This pops up often in Olympiads, so you should probably know how to derive this by heart.
2023	T	2	The Danube (●). Viscous flow on an incline.

Heat

Ideal gas processes

2018	S	3	Bose-Einstein condensation (●). A semi-classical treatment of an interesting quantum phenomenon. Not as scary as it looks.
2018	T	8	Fast and slow (●). A key problem on nonquasistatic processes, with some non-trivial maths at the end.

Heat engines

2023	T	10	Three processes (●). This isn't that difficult, but note that you must stay agnostic about the equation of state. Otherwise you'd get zero marks here.

Radiation

2019	T	4	Wien's law (●). This guides you through the derivation of Wien's law from Planck's law. Mostly a maths problem.

Kinetic theory

2018	T	9	Constant collision rate (●). A neat, but somewhat artificial problem on mean free path.
2019	T	10	Helium (●). Two problems on effusion and momentum transfer, respectively. You're not required to get the numerical prefactors exactly right.
2021	S	3	Tea in a vacuum flask (●). An open-ended problem which requres deep insight into both radiation and kinetic theory.

Electromagnetism

Electrostatics

2017	S	1	Charge in a dielectric medium (●). A not-too-involved problem on conservation laws.
2009	T	4	Dipoles (●). Derivations of some standard formulae for electric dipoles.
2018	T	4	Field strength (●). The first part of this is alright, but the second involves a standard trick which is nevertheless hard to figure out on your first encounter.
2019	S	2	Conducting sphere (●). A finicky image charge problem.

Ohm's law

2014	T	4	A microscopic model for resistance (●). A short problem on a variation of the Drude model.
2018	T	5	Accelerating ring (●). A one-off problem about the Tolman-Stewart effect.
2021	S	2	Discharge (●). Electrostatics and Ohm's law.
2013	T	4	Resistivity of water (●). A pedagogical problem on the superposition of current distributions.

Lorentz force

2009	S	2	Crossed fields (●). A classic problem where you need to take components.
2012	T	3	Crossed fields redux (●). This is identical, but with more maths. Still, it's good practice for solving differential equations.

Induction

2015	T	6	Charged disk in a magnetic field (●). A problem on Faraday's law in which you'll need to set up an integral for the net torque.
2023	S	2	Betatron (●). A devious problem on a relativistic particle accelerator.
2018	S	2	Induction motor (●). A very pretty problem on an industrial device. You might reach an intimidating set of equations, but do not despair, they can simplify.

Circuits

2009	T	5	Pyramid (●). A problem on equivalent resistance for which you'll need the usual tricks for simplifying nodes.
2007	T	4	IV curve (●). A standard problem on Kirchoff's laws. It also tests on error propagation formulae.
2007	T	5	LR circuit (●). You'll need to know how inductors work under a sudden change in the circuit, but otherwise it's smooth sailing.
2011	S	2	LCR circuit (●). This one seems quite tedious, but it is possible to avoid the maths if you can spot the trick.
2023	T	4	Voltage rectifier (●). An electronics problem with casework. It's possible to solve it analytically, but making the correct approximations requires strong physical intuition.

Optics and waves

Geometrical optics

2017	T	5	Two images (●). A school problem on the thin lens formula.
2019	T	5	Prism (●). A longer problem on reflection and Snell's law. Lots and lots of trigonometry.
2023	T	6	Optical fiber (●). An elegant problem on signal propagation.

Wave optics

2017	T	6	Coincident maxima (●). Mostly maths, but still somewhat entertaining.
2011	T	6	Rotating the grating (●). A problem on optical path differences which requires prudent approximation.
2009	T	6	Billet split lens (●). A classic setup for observing interference. However, I don't know of a simple solution to Part (c). My own attempt is basically a whole essay, and I still wouldn't call it rigorous!
2018	T	6	Lens and plate (●). A setup for inteference which I haven't seen anywhere else. Think carefully about where the interfering rays might come from.
2007	T	6	The width of a maximum (●). A problem on the intensity distribution of an N-slit setup.
2023	T	5	Convoluted grating (●). A formidable problem which you can still handwave your way around. Try phasors rather than complex numbers.
2013	T	6	Prism monochromator (●). An absolute unit of a problem. For a warm-up, maybe attempt RMPh2017-1A first.

Waves

2019	S	1	Linear crystal (●). A neat introduction to the physics of phonons. I remember finding the problem statement a bit too vague.
2019	S	3	Surface gravity waves (●). A scary-looking variation of the standard problem on wave reflection and transmission.

Modern physics

Relativity

2010	T	3	Beta decay (●). An exercise on the conservation laws.
2023	T	7	Scattering (●). Some more relativistic dynamics, this time in 2D. Try not to give up on the algebra too early.
2018	T	7	Relativistic force (●). A problem on $F = \mathrm{d}p/\mathrm{d}t$ with lots of integration.
2019	T	9	Accelerator (●). A teeny-tiny problem on a particle accelerator. However, take caution as to how you interpret the problem statement.

Heisenberg's uncertainty principle

2018	T	10	Atomic beam (●). A troll problem. If you're not opposed to a major hint, check out IPhO2001 1D first.

Semiclassical atoms and molecules

2023	T	8	Predictions of the Bohr model (●). A conceptually straightforward problem, but getting the numerical values right is quite the ordeal.
2019	T	8	Transition energy (●). A difficult-to-interpret problem on conservation laws and energy levels in hydrogen.
2023	S	3	Yukawa potential (●). A subtle problem on a semiclassical model of the deuteron. Try to adhere to HUP and energy minimisation, and you'll be alright.

Last updated: 6th November 2025
Send comments to sivanov.mail@proton.me