Nexus Physics Signature Track

Two-Year University Physics Learning

AP readiness, F=ma mechanics training, and university-level physics reasoning

AP is the minimum. University-level physical reasoning is the goal.

Program Overview
Nexus Physics Signature Track is a two-year physics sequence for students who want more than standard AP preparation. The program builds a complete introductory physics foundation across mechanics, fluids, waves, thermodynamics, electromagnetism, optics, relativity, quantum ideas, nuclear physics, and modern physics. Students learn to derive, model, explain, and solve – not merely memorize formulas.

Who This Program Is For

- Students preparing for AP Physics 1, AP Physics 2, AP Physics C Mechanics, or AP Physics C Electricity and Magnetism.
- Students interested in F=ma, Physics Bowl, Olympiad-style mechanics, or advanced STEM competitions.
- Strong middle-school students seeking early exposure to serious high-school and university physics.
- High-school students planning future study in engineering, physics, computer science, math, medicine, or quantitative fields.
- Students who want to understand why equations work instead of memorizing formula lists.

Two-Year Roadmap

Stage	Main Focus	Student Outcome
Year 1, Sem. 1	Vectors, kinematics, Newton's laws, work, energy, momentum	AP Physics 1 mechanics foundation; AP Physics C Mechanics preparation begins; F=ma thread starts
Year 1, Sem. 2	Rotation, equilibrium, fluids, gravitation, oscillations, waves, thermodynamics	Full AP Physics 1 coverage; strong mechanics base for AP C and F=ma-style contests
Summer Bridge	Calculus for physics and mechanics consolidation	Students connect algebra-based mechanics with calculus-based university physics
Year 2, Sem. 1	Electricity, magnetism, circuits, induction, EM waves	AP Physics C E&M and AP Physics 2 E&M readiness
Year 2, Sem. 2	Optics, relativity, quantum, atomic, nuclear, condensed matter, particle physics, cosmology	Full AP Physics 2 modern physics coverage and broad university physics literacy

What Makes the Track Different

First-principles reasoning. Students begin with systems, assumptions, interactions, diagrams, and conservation laws before selecting equations.

Derivation-based learning. Major equations are derived and interpreted, so students know when and why they apply.

F=ma competition thread. Year 1 includes recurring timed mechanics drills, shortcut reasoning, trap analysis, and contest-style problem recognition.

University physics breadth. The course moves from Newtonian mechanics to fields, waves, optics, quantum ideas, nuclear physics, and cosmology.

AP alignment. AP Physics 1, AP Physics 2, AP Physics C Mechanics, and AP Physics C E&M are fully covered as minimum benchmarks.

Communication and modeling. Students practice explaining physics verbally, graphically, mathematically, and experimentally.

Year 1: Mechanics, Fluids, Waves, and Thermodynamics

Year 1 is the foundation of the entire program. Students build deep mechanics intuition while training for AP Physics 1, AP Physics C Mechanics, and F=ma-style contest problems.

Area	Major Topics
Mathematical Language	Units, dimensions, uncertainty, estimation, vectors, components, dot product, cross product
Kinematics	One-dimensional and two-dimensional motion, projectile motion, circular motion, relative velocity, graph interpretation
Newtonian Dynamics	Forces, free-body diagrams, friction, pulleys, inclines, circular dynamics, constraint systems
Energy and Momentum	Work, kinetic energy, potential energy, power, impulse, collisions, center of mass, conservation laws
Rotation and Equilibrium	Torque, moment of inertia, rolling motion, angular momentum, static equilibrium, elasticity
Fluids and Gravitation	Pressure, buoyancy, Bernoulli's equation, Newtonian gravitation, orbits, Kepler's laws, escape speed
Oscillations and Waves	SHM, springs, pendulums, resonance, mechanical waves, standing waves, sound, beats, Doppler effect
Thermodynamics	Heat, temperature, ideal gases, kinetic theory, PV diagrams, first law, second law, heat engines, entropy

Year 1 F=ma Competition Thread

The F=ma thread is embedded into Year 1 so students learn contest mechanics alongside deeper university-style mechanics. The emphasis is not just knowing topics, but recognizing hidden problem structure quickly.

Training Area	Skills Developed
Speed Recognition	Identify whether a problem is best solved by force, energy, momentum, torque, rotation, fluids, or scaling
Mechanics Shortcuts	Use ratios, limiting cases, symmetry, clever axes, and conservation laws to avoid unnecessary algebra
Trap Analysis	Detect common mistakes involving normal force, friction direction, pseudo-equilibrium, circular motion, and sign conventions
Timed Drills	Weekly F=ma-style questions, monthly mini-contests, and a full 25-question mock contest near the end of Year 1
Mistake Log	Students maintain a personal record of missed patterns, wrong assumptions, and time-management errors

Year 1 Outcome
By the end of Year 1, serious students should have complete AP Physics 1 coverage, strong AP Physics C Mechanics readiness, and meaningful exposure to F=ma-style competition mechanics. Students should be able to solve mechanics problems using more than one method and explain why a method works.

Summer Bridge: Calculus for Physics

The optional summer bridge connects algebra-based mechanics with calculus-based university physics. Topics include derivatives in kinematics, integrals in work and impulse, simple differential equations in oscillations, exponential functions, vector products, line integrals, flux intuition, and AP Physics C Mechanics readiness.

Year 2: Electromagnetism, Optics, and Modern Physics

Year 2 completes the university-physics arc. Students move from particles and forces into fields, circuits, waves, light, quantum ideas, and modern physics.

Year 2, Semester 1: Electricity and Magnetism

Area	Major Topics
Electric Fields	Charge, Coulomb's law, electric fields, continuous charge distributions, field lines, electric dipoles
Gauss's Law	Electric flux, symmetry, conductors, spherical, cylindrical, and planar charge distributions
Electric Potential	Potential energy, potential, equipotential surfaces, field-potential relationship, potential gradients
Capacitance and Circuits	Capacitors, dielectrics, energy storage, current, resistance, EMF, Kirchhoff's rules, power, RC circuits
Magnetism	Magnetic fields, magnetic force, charged-particle motion, current-carrying wires, current loops, Hall effect
Sources of Magnetic Field	Biot-Savart law, Ampere's law, wires, loops, solenoids, toroids, magnetic materials
Induction and AC	Faraday's law, Lenz's law, motional EMF, inductance, RL/LC/LRC circuits, AC circuits, transformers, EM waves

Year 2, Semester 2: Optics and Modern Physics

Area	Major Topics
Geometric Optics	Reflection, refraction, Snell's law, total internal reflection, mirrors, lenses, cameras, eye, microscopes, telescopes
Physical Optics	Interference, double slit, thin films, Michelson interferometer, diffraction, gratings, X-ray diffraction, resolving power
Relativity	Simultaneity, time dilation, length contraction, Lorentz transformations, relativistic momentum and energy
Photons and Matter Waves	Photoelectric effect, Compton scattering, wave-particle duality, uncertainty, atomic spectra, Bohr model, lasers
Quantum Mechanics	Wave functions, Schrodinger equation, particle in a box, tunneling, harmonic oscillator, hydrogen atom, spin, exclusion principle
Condensed Matter	Molecular bonds, spectra, solids, energy bands, metals, semiconductors, devices, superconductivity
Nuclear and Particle Physics	Radioactivity, half-life, binding energy, fission, fusion, radiation, Standard Model, quarks, cosmology

Year 2 Outcome
By the end of Year 2, students should be prepared for AP Physics 2 and AP Physics C Electricity and Magnetism while also gaining broad literacy in modern physics topics usually encountered in university-level introductory physics.

Calculus Integration

Calculus Use	Examples
Derivatives	Velocity, acceleration, angular velocity, angular acceleration, force from potential energy
Integrals	Displacement from velocity, work by variable forces, impulse, center of mass, moment of inertia
Differential Equations	Simple harmonic motion, RC circuits, RL circuits, LC oscillations, radioactive decay
Line and Flux Integrals	Electric potential, electric flux, Gauss's law, magnetic circulation, Faraday's law
Field Thinking	Electric fields, magnetic fields, potential, energy density, electromagnetic waves

Assessment and Learning Evidence

Weekly

- Core lesson problems
- Conceptual questions
- Derivation practice
- F=ma-style mechanics drills in Year 1
- Cumulative review problems

Monthly

- Timed mini-assessments
- Mixed-topic problem sets
- Error-log review
- Method-selection discussions

Semester-Based

- Cumulative written exam
- AP-style free-response section
- University-style challenge section
- Oral explanation assessment
- Lab or modeling portfolio review

Final

- AP Physics 1/2/C readiness review
- Mechanics and E&M synthesis
- Final capstone project or presentation
- Individual learning summary

Lab and Modeling Experience

Students practice physics as an experimental and modeling discipline. Possible labs and demonstrations include motion tracking, projectile motion, friction, circular motion, conservation of energy, collisions, rotational inertia, static equilibrium, springs and SHM, buoyancy, standing waves, sound resonance, calorimetry, ideal gases, electrostatics, RC circuits, magnetic force, electromagnetic induction, lenses, interference, diffraction, and radioactive decay simulation.

Expected Student Outcomes

- Prepare strongly for AP Physics 1, AP Physics 2, AP Physics C Mechanics, and AP Physics C E&M.
- Attempt F=ma-style mechanics problems with meaningful breadth, speed, and confidence.
- Read introductory university physics material independently.
- Derive central physics equations from first principles.
- Translate between diagrams, graphs, equations, and words.
- Choose efficient methods instead of blindly plugging into formulas.
- Explain physical reasoning clearly to another student.
- Continue into advanced mechanics, electromagnetism, engineering physics, or physics competitions.

The Nexus Standard
Students should not merely know which equation to use. They should understand why the equation exists, what assumptions support it, and how to adapt the idea when the problem changes.