Calculus 1

Lecturer: Prof. Dr. Michael Wolf

Formal logic, integral- and differential calculus, real and complex numbers, sequences, series, topological concepts, continuity, convergence, Taylor- and Fourier series, ODEs

Calculus 2

Lecturer: Prof. Dr. Michael Wolf

Topological spaces, Banach spaces, fixed-points, multi-dimensional calculus (Frechet derivative, Taylor Series, Lagrange multiplier), vector analysis with integral theorems, manifolds, Euler-Lagrange equation and Noether theorem, Legendre transformation

Linear Algebra 1

Lecturer: Dr. Michael Kaplan

Linear systems of equations, set theory, relations, groups, functions, rings, fields, vector spaces, linear maps, tensor- and dyadic product, determinant, trace, eigenvalues, Jordan canonical form, Euclidian vector spaces, bilinear maps

Linear Algebra 2

Lecturer: Prof. Dr. Georg Kemper

Euclidian vector spaces, analytical geometry, symmetric bilinear maps, matrix groups (GL, SL, O, SO, U, SU), normal forms (Jordan, Schur, Principal component analysis, SVD)

Introduction to Differential Geometry

Lecturer: Prof. Dr. Tim Hoffmann

Introduction to curves, reparameterisation, evolvent, evolute, Darboux transformation, arc length, tangent, normal, curvature, Four-vertex theorem, frames (Frenet, parallel), tangent space and bundle, Gauss curvature, theorema egregium, normal curvature, 1st and 2nd fundamental form, Weingarten operator, minimal surfaces, elements of complex analysis

Theory of Functions

Lecturer: Prof. Dr. Tom Ilmanen

Complex functions, Cauchy-Riemann equations, Cauchy integral theorem, singularities, residue theorem, winding number, analytic continuation, conformal maps, Riemann mapping theorem

Methods of Mathematical Physics I

Lecturer: Prof. Dr. Eugene Trubowitz

Fourier series, Fourier transformations (FT, DFT, FFT), orthogonal function spaces, Hilbert spaces, eigenvalue problems, distributions, Dirichlet problem, harmonic functions, differential equations, Green's functions, elements of quantum information theory (gates, algorithms, ...)

Methods of Mathematical Physics II

Lecturer: Prof. Dr. Eugene Trubowitz

Groups, represenation of groups, representation theory of finite groups, symmetric eigenvalue problems, rotation and Lorentz group, Lie algebra, representation of Lie groups, representation theory of SU(N), Fourier transformations and Schwartz space

Methods of Numerical Mathematics

Lecturer: Dr. Vasile Gradinaru

Zeros finding, Fixed point, bisection, Newton iteration, Damped Newton method, QR-decomposition, SVD, least squares, Gauss-Newton method, direct eigensolvers, PINVIT, Krylov subspace methods, polynomial interpolation, Newton, Lagrange and Chebychev polynomials, trigonometric interpolation (DFT, FFT), numerical quadrature, Euler methods, Störmer-Verlet, splitting methods, Runge-Kutta methods, Stiff integrators

Physics I

Lecturer: Prof. Dr. Friedrich Simmel

Kinematics, dynamics, work, energy, rotations, many-particle systems, theory of gravitation, rigid body dynamics, thermodynamics, differential equations, oscillations

Physics II

Lecturer: Prof. Dr. Friedrich Simmel

Waves, electro statics, electrical conductors, electrical current, introduction into SRT, field of moving particles, magnetic fields, electromagnetic induction, alternating current, Maxwell equations, electromagnetic fields in matter

Physics III

Lecturer: Prof. Dr. Jonathan Home

Introduction into quantum mechanics, hydrogen atom, spin, multi-electron systems, physics of the nucleus, molecules, optics, statistical physics

Astrophysics I

Lecturer: Prof. Dr. Alexandre Refregier

Coordinate systems, magnitude scale, different bands, interaction of radiation with matter, basic equations of stellar structure, HR-diagram, nucleosyntheses, galactic shape and size, properties of our galaxy, ISM phases, stellar dynamics, plasma astrophysics, Jeans instability, extra-galactic astrophysics, unification scheme, space-time dynamics, Friedman equation, radiation and matter dominated universe, thermal history of the universe, gravitational lensing

Introduction to Nuclear and Particle physics

Lecturer: Prof. Dr. Günther Dissertori

Detector systems and accelerators, basic constituents of matter (quarks, leptons) and their interactions (QED, QCD, weak interaction), symmetries and symmetry violations, electroweak interaction, Standard Model and fundamental open questions, nuclei structure and stability, fusion and fission, neutrino physics

Introduction to Solid State Physics

Lecturer: Prof. Dr. Klaus Ensslin

Lattice structures, interatomic bindings, lattice dynamics, thermal properties of insulators, metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals), semiconductors (band structure and n/p-type doping), magnetism, superconductivity

General Mechanics

Lecturer: Prof. Dr. Renato Renner

Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, spinning top, relativistic space-time structure, particles in an electromagnetic field, Hamiltonian mechanics, canonical transformations, integrable systems, Hamilton-Jacobi equation

Electrodynamics

Lecturer: Prof. Dr. Thomas K. Gehrmann

Electrostatics, boundary value problem, magnetostatics, Maxwell equations, electromagnetic waves, SRT, electrodynamics in matter, conservation laws, reflection, refraction, dispersion, wave guide, field point charge, radiation relativistic particles

Theory of Heat

Lecturer: Prof. Dr. Renato Renner

Ideal gas, laws of thermodynamics, thermodynamic potentials, phase transitions, compositions and chemical reactions, Boltzmann equation, H-theorem, classical statistical physics, spin phase transitions (Ising, Heisenberg, XY), Maxwell daemon

Quantum Mechanics I

Lecturer: Prof. Dr. Gian Michele Graf

Historical concepts (Planck), Schrödinger-equation, basic formalism (quantum states, operator, commutator, process of measuring), symmetries (translation, rotation and angular momentum), central forces, scattering processes, Schrödinger-, Heisenberg-, Dirac-picture, time reversal, perturbation theory, variational methods, theory of angular momentum

Quantum Mechanics II

Lecturer: Prof. Dr. Gian Michele Graf

SO(3), SU(2) and their corresponding Lie algebras in quantum mechanics, Zeeman effect and spin, density operators (Stern-Gerlach measurement, pure and mixed states, Bloch sphere), time-dependent perturbation theory, Fermi's golden rule, emission- and absorption rates (Einstein coefficients), quantization of the electromagnetic field, identical particles (fermions, bosons), Pauli exclusion principle, braid group statistics and anyons, Thomas-Fermi atom, Hartree-Fock method, periodic table, second quantization, EPR paradox, hidden variables, Kochen-Specker theorem, Bell's inequality, quantum teleportation, Grover's algorithm

Quantum Information and Cryptography

Lecturer: Prof. Dr. Stefan Wolf

Topics related to quantum information science, the 2nd Law of Thermodynamics, information theory and cryptography, presentation on superdeterministic interpretation of quantum mechanics (cellular automaton interpretation by Gerard 't Hooft)

General Relativity

Lecturer: Prof. Dr. Gian Michele Graf

Differential geometry, manifold, Riemannian metric, connection, torsion and curvature, Special Relativity, Lorentzian metric, Equivalence principle, Tidal force and space-time curvature, Energy-momentum tensor, field equations, Newtonian limit, Post-Newtonian approximation, Schwarzschild solution, Mercury's perihelion precession, light deflection, Kerr metric, Hawking radiation, Gravitational waves

Statistical Physics

Lecturer: Prof. Dr. Manfred Sigrist

Kinetic gas theory, Master equation, H-theorem, Classical statistical physics, micro-canonical ensembles, canonical ensembles and grand-canonical ensembles, Quantum statistical physics, single particle, ideal quantum gases, fermions and bosons, Second quantization, Correlation functions, Bose-Einstein condensation, Bogolyubov theory, superfluidity, Mean field and Landau theory, Ising and Heisenberg model, Landau theory of phase transitions, fluctuations

Introduction to Computational Physics

Lecturer: Prof. Dr. Hans J. Herrmann

Random number generators, phase transitions, percolation, Metropolis algorithm, Monte-Carlo integration, Ising model, random walks, Gauss-Seidel and Jacobi methods, gradient methods, finite element methods, finite volume methods, spectral methods, classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equation, Navier-Stokes equation), Euler methods, Runge-Kutta methods, Predictor-Corrector methods, multigrid methods

Computational Statistical Physics

Lecturer: Prof. Dr. Hans J. Herrmann

Classical Monte-Carlo-simulations: finite-size scaling, cluster algorithms, histogram-methods, molecular dynamics simulations: long range interactions, Ewald summation, particle mesh methods, discrete elements, parallelization, canonical molecular dynamics, event-driven approach and contact dynamics

Computer Science

Lecturer: Prof. Dr. Bernd Gärtner

Introduction to computer science (C++), algorithms, data types, operators, loops, pointers, dynamic memory allocation, multi-dimensional arrays, functions, iteration, recursion, structs, classes, random numbers, binary search trees

High Performance Computing 1a: Using Resources

Lecturer: Prof. Dr. Romain Teyssier, Doug Potter

Introduction to high performance computing and available resources, available supercomputers (ETHZ, UZH, CSCS, PRACE), proposal structure, cloud computing and storage, data storage and management, running jobs, storing data at specific available platforms, characterising work, estimating requirements, choosing platforms

High Performance Computing 1b: Parallel Computing

Lecturer: Prof. Dr. Romain Teyssier

Architecture of parallel computers, parallel compilers and libraries, code design, parallelization: load balancing, message passing and synchronization, libraries for message passing (MPI, OpenMP), data movement, parallelization of a grid code using MPI (Godunov hydro solver)

Introduction to Data Science

Lecturer: Prof. Dr. George Lake, Riccardo Murri

Definition of data science, hypothesis testing and discovery science, fraud and outliers, relational databases, relational algebra, MapReduce, NoSQL (PIG, Spark), graph analytics, topics in machine learning (bootstrap, K-means, SVM), visualization

Beginners Lab I & II

Lecturer: Dr. Martin Saß, Prof. Bernd Schönfeld

Experiments on mechanic (chaotic), thermodynamic, electromagnetic, optical and radioactive systems, error analysis

Advanced Lab

Lecturer: Prof. Dr. Christoph Grab, Prof. Dr. Thomas Ihn

Advanced experiments covering topics of Solid-state physics, Astrophysics, Quantum physics and Particle physics.

International humanitarian law

Lecturer: Dr. Jakob Kellenberger (ICRC)

Basic principles of international law and law of war, Geneva Conventions and additional protocols, Hague Conventions, international and non-international armed conflicts, humanitarian aid

Economy
Lecturer: Prof. Dr. Renate Schubert
Behavior of companies and individuals on free markets, market equilibrium and taxation, social product economy indicators, unemployment, economic growth, economic policy

Venture Challenge
Lecturer: Philipp Winteler (Venturelab, St. Gallen)
Business Opportunity, Business Strategy, New Product Development, Industrialization, Marketing, Communications, Sales, Negotiation, Accounting, Finance, Business Plan, Intellectual Property, Financing

Modelling Social Systems with MATLAB
Lecturer: Stefano Balietti, Karsten Donnay
Project with MATLAB (Swiss Railway Formation) and theoretical background on operations with matrices and vectors, differential equations, statistical tools, graphical representation of data, agent-based models, e.g. models of interactive decision making, group dynamics, human crowds, or game-theoretical models

Introduction to Dynamical Systems and Chaos
Lecturer: Prof. Dr. David Feldman (Santa Fe Institute)
Iterated functions and differential equations, chaos and the Butterfly Effect, bifurcations, universality, phase space, strange attractors, pattern formation

Auditor
Data Mining: Learning from Large Data Sets (Prof. Dr. Andreas Krause), Programming Techniques for Scientific Simulations (Prof. Dr. Matthias Troyer), Computational Quantum Physics (Prof. Dr. Matthias Troyer), Complex Systems (Prof. Dr. Ruedi Stoop)