Table of Contents [ntc]

- 1. Introduction: Contents and Maps
 - Table of contents [ntc]
 - Equilibrium thermodynamics overview [nln6]
 - Thermal equilibrium and nonequilibrium [nln1]
 - Levels of description in statistical physics [nln2]
 - Contraction memory time scales [nln15]
 - Markov process: map of specifications [nln16]
 - Brownian motion: panoramic view [nln23]
 - Linear response and equilibrium dynamics [nln24]
- 2. Probability: Intuition Ambiguity Absurdity Puzzles
 - Two bus companies: regular versus random schedules
 - Pick the winning die [nex2]
 - Educated guess [nex4]
 - Coincident birthdays [nex82]
 - Win the new car or take the goat! [nex11]
 - Three-cornered duel [nex13]
 - Bad luck: waiting for the worst [nex74]
 - Bertrand's paradox
 - Random quadratic equations [nex12]
 - Crossing a river [nex84]
 - Combinatorics of poker hands [nex124]
 - Know your odds [nex125]
- 3. Elements of Probability Theory with Applications
 - Elements of set theory [nln4]
 - Set identities [nex88]

- Sample space and events
- Probability axioms and simple theorems [nex94]
- Joint probability and conditional probability [nex90]
- Symmetry and elementary events
- Bayes' theorem
- Statistical independence
- Statistical uncertainty and information [nln5], [tex47]
- Event or complement? That is the question [nex9]
- Successive random picks [nex91]
- Heads or tails [nex93]
- Quantity and quality [nex76]
- Diagnosis of a rare disease [nex77]
- Subtlety of statistical independence [nex1]
- Random train connections [nex92]
- Random inkjet printer [nex10]
- Information and the reduction of ignorance [tex48]
- Information of sequenced messages [tex61]
- 4. Random Variables: Concepts
 - Probability distributions
 - Moments, variance, standard deviation
 - Moment expansion and characteristic function
 - Cumulant expansion
 - Factorial moments and cumulants, generating function
 - Multivariate distributions [nln7]
 - Transformation of random variables
 - Propagation of statistical uncertainty [nex24]
 - Chebyshev's inequality [nex6]
 - Law of large numbers [nex7]

- Binomial, Poisson, and Gaussian distribution [nln8]
- Binomial to Poisson distribution [nex15]
- De Moivre Laplace limit theorem [nex21]
- Central limit theorem [nln9]
- Multivariate Gaussian distribution
- Robust probability distributions [nex19]
- Stable probability distributions [nex81]
- Exponential distribution [nln10]
- Waiting time problem [nln11]
- Pascal distribution [nex22]
- 5. Random Variables: Applications
 - Reconstructing probability distributions [nex14]
 - Probability distribution with no mean value [nex95]
 - Variances and covariances [nex20]
 - Statistically independent or merely uncorrelated? [nex23]
 - Sum and product of uniform distribution [nex96]
 - Exponential integral distribution [nex79]
 - Generating exponential and Lorentzian random numbers [nex80]
 - Random chords (Bertrand's paradox) [nex5]
 - From Gaussian to exponential distribution [nex8]
 - Transforming a pair of random variables [nex78]
 - Gaussian shootist versus Lorentzian shootist [nex3]
 - Moments and cumulants of the Poisson distribution [nex16]
 - Maxwell velocity distribution [nex17]
 - Random bus schedules [nex18]
 - Life expectancy of the young and the old [nex106]
 - Life expectancy of the ever young [nex38]
 - Random frequency oscillator [nex35]

- 6. Stochastic Processes: Concepts
 - Time-dependent probability distributions
 - Correlation functions and characteristic functions
 - Equilibrium nonequilibrium stationarity
 - Classification of processes (factorizing/Markov/non-Markov)
 - Deterministic versus stochastic time evolution
 - Contraction memory time scales [nln15]
 - General specification of Markov process
 - Chapman-Kolmogorov equation
 - Diffusion process and Cauchy process
 - Stationarity, normalization, consistency, Markovian nature [nex26]
 - Computer generated sample paths [nsl1]
 - Continuous versus discontinuous processes (Lindeberg condition) [nex97]
 - Differential Chapman-Kolmogorov equation
 - Fokker-Planck equation (drift and diffusion processes)
 - Drift equation (deterministic processes) [nex29]
 - Master equation (jump processes) [nex28]
 - Non-differentiability of sample paths [nex99]
 - Master equation with finite jump moments [nex32]
 - Equations of motion for mean and variance [nex30]
 - Markov process: map of specifications [nln16]
 - Approach to a stationary state (detailed balance) [nex85]
 - Markov chains (discrete variables, discrete time)
 - Transition matrix, left and right eigenvectors, stationary states
 - Regularity, ergodicity, detailed balance, absorbing states
 - Master equation with detailed balance (discrete variables, continuous time) [nln12]

- Regression theorem for autocorrelation functions [nex39]
- Birth death processes (specifications, models, levels of description) [nln18]
- Birth and death of single species [nln19]
- Birth-death master equation: stationary state [nln17]
- Nonlinear birth-death process
- 7. Stochastic Processes: Applications
 - Diffusion process [nex27]
 - Cauchy process [nex98]
 - Random walk in one dimension: unit steps at unit times [nex34]
 - Random walk in one dimension: unit steps at random times [nex33]
 - Random walk in one dimension: tiny steps at frequent times [nex100]
 - Random walk in Las Vegas: chance and necessity [nex40]
 - Poisson process [nex25]
 - Free particle with uncertain position and velocity [nex36]
 - Fokker-Planck equation with constant coefficients [nex101]
 - House of the mouse: two-way doors only [nex102]
 - House of the mouse: some one-way doors [nex103]
 - House of the mouse: one-way doors only [nex104]
 - House of the mouse: mouse with inertia [nex105]
 - House of the mouse: mouse with memory [nex43]
 - Mixing marbles red and white [nex42]
 - Random traffic around city block [nex86]
 - Modeling a Markov chain [nex87]
 - Ornstein-Uhlenbeck process [nex31] [nex41]
 - Predator-prey system: deterministic, stochastic, observational [nsl3]
 - Populations with linear birth and death rates I [nex44]

- Populations with linear birth and death rates II [nex112]
- Catalyst-driven chemical reaction: stationary state [nex46]
- Catalyst driven chemical reaction: dynamics [nex107]
- Catalyst driven chemical reaction: total rate of reactions [nex108]
- Air in leaky tank I: generating function [nex48]
- Air in leaky tank II: probability distribution [nex109]
- Air in leaky tank III: detailed balance [nex49]
- Air in leaky tank IV: evolution of mean and variance [nex110]
- Pascal distribution and Planck radiation law [nex50]
- Effects of nonlinear death rate I: Malthus-Verhulst equation [nex111]
- Effects of nonlinear death rate II: stationarity and fluctuations [nex51]
- Modified linear birth rate I: stationarity [nex113]
- Modified linear birth rate II: evolution of mean and variance [nex114]
- Modified linear birth rate III: generating function [nex115]
- Modified linear birth rate IV: probability distribution [nex116]
- Bistable chemical system [nex52]
- Ultracold neutrons in an ideal Steyerl bottle [nex47]
- Random light switch [nex45]
- 8. Brownian Motion
 - Relevant time scales (collisions, relaxation, observations)
 - Einstein's theory
 - Smoluchovski equation with link to Fokker-Planck equation
 - Einstein relation (example of fluctuation-dissipation relation)
 - Fick's law for particle current
 - Fourier's law for heat current
 - Thermal diffusivity [nex117]
 - Shot noise (e.g. electric current in vacuum tube)

- Campbell's theorem [nex37]
- Critically damped ballistic galvanometer [nex70]
- Langevin's theory (on most contracted level of description)
- White noise
- Brownian motion and Gaussian white noise [nln20]
- Wiener process [nsl4]
- Autocorrelation function of Wiener process [nex54]
- Ballistic and diffusive regimes of Langevin solution
- Langevin's equation: attenuation without memory [nln21]
- Formal solution of Langevin equation [nex53]
- Velocity correlation function of Brownian particle I [nex55]
- Mean-square displacement of Brownian particle [nex56], [nex57], [nex118]
- Ergodicity [nln13]
- Intensity spectrum and spectral density (Wiener-Khintchine theorem) [nln14]
- Fourier analysis of Langevin equation
- Velocity correlation function of Bownian particle II [nex119]
- Generalized Langevin equation: attenuation with memory [nln22]
- Fluctuation-dissipation theorem
- Velocity correlation function of Brownian particle III [nex120]
- Brownian harmonic oscillator I: Fourier analysis [nex121]
- Brownian harmonic oscillator II: position correlation function [nex122]
- Brownian harmonic oscillator III: contour integrals [nex123]
- Brownian harmonic oscillator IV: velocity correlations [nex58]
- Brownian harmonic oscillator V: formal solution for velocity [nex59]
- Brownian harmonic oscillator VI: nonequilibrium correlations [nex60]
- Generalized Langevin equation inferred from microscopic dynamics

- Brownian motion: levels of contraction and modes of description [nln23]
- 9. Linear Response and Equilibrium Dynamics
 - Overview [nln24]
 - Many-body system perturbed by radiation field [nln25]
 - Response function and generalized susceptibility [nln26]
 - Kubo formula for response function [nln27]
 - Symmetry properties [nln30]
 - Kramers-Kronig dispersion relations [nln37]
 - Causality property of response function [nex63]
 - Energy transfer between system and radiation field [nln38]
 - Reactive and absorptive part of response function [nex64]
 - Fluctuation-dissipation theorem (quantum and classical) [nln39]
 - Spectral representations [nex65]
 - Linear response of classical realxator [nex66]
 - Linear response of classical oscillator [nex67]
- 10. Zwanzig-Mori Formalism
 - Introduction [nln28]
 - Time-dependence of expectation values (quantum and classical)
 - Zwanzig's kinetic equation: generalized master equation [nln29] [nex68]
 - Projection operator method (Mori formalism) [nln31]
 - Kubo inner product [nln32]
 - Projection operators [nln33]
 - First and second projections [nln34] [nln35]
 - Continued-fraction representation of relaxation function [nln36]
 - Recursion method (algorithmic implementation of Mori formal-ism)

- Relaxation function with uniform continued-fraction coefficients [nex69]
- Continued-fraction expansion and moment expansion
- Generalized Langevin equation
- n-pole approximation
- Green's function formalism
- Structure function of harmonic oscillator [nex71], [nex72], [nex73]
- Scattering process and dynamic structure factor
- Electron scattering, neutron scattering, light scattering
- Scattering from a free atom
- Scattering from an atom bound in a harmonic potential
- Scattering from a harmonic crystal