

PHYSICS 611      Spring 2020

## MIDTERM EXAM

**Room:** ARC-205

**Time:** March 4 (Wednesday), 3:20-4:40 pm

### GROUND RULES

- There are four problems based on the material listed below
- Closed book and notes
- Two-page formula sheet and calculator are permitted
- Partial credit will be given. Do as many parts of a problem as possible.

### PROGRAM

**Study material:** Mehran Kardar, “Statistical Physics of Particles” (Chapters 2,3). See also posted lecture notes and solutions of the homework assignments 1-6.

- **PROBABILITY**

**Probability:** Definitions. Examples: Buffon’s needle, lucky tickets, random walk in one dimension. Saddle point method. Diffusion equation. Fick’s law. Entropy production in the process of diffusion.

**One random variable:** General definitions: the cumulative probability function, the Probability Density Function (PDF), the mean value, the moments, the characteristic function, cumulant generating function. Examples of probability distributions: normal (Gaussian), binomial, Poisson.

**Many random variables:** General definitions: the joint PDF, the conditional and unconditional PDF, the expectation values. The joint Gaussian distribution. Wick’s theorem. Central limit theorem.

- **ELEMENTS OF THE KINETIC THEORY OF GASES**

**Elements of Classical Mechanics:** Virial theorem, microscopic state, phase space. Liouville’s theorem, Poisson bracket.

**Statistical description of a system at equilibrium:** Mixed state, the equilibrium probability density function, basic assumptions of statistical mechanics.

**Bogoliubov-Born-Green-Kirkwood-Yvon (BBGKY) hierarchy:** Derivation of the BBGKY equations. Collisionless Boltzmann equation. Solution of the collisionless Boltzmann equation by the method of characteristic. Vlasov equations.

**Boltzmann equation:** Length and time scales in the BBGKY hierarchy. Binary collisions. Differential cross section. Mean free path. Dilute gas approximation. Bogoliubov's condition (Boltzmann's hypothesis of molecular chaos). Bogoliubov's form of the collision integral. Boltzmann's collision integral. Heuristic "derivation" of the Boltzmann equation.

**General consequences of the Boltzmann equation:** H - theorem and irreversibility. Equilibrium properties: the equilibrium distribution, the ideal gas entropy. Collision-time approximation for the Boltzmann equation.

**Chapman-Enskog method (self study, Ch.3.7-3.9):** Conservation laws. Zero and first order hydrodynamics.