This is a special topic course on kinetics. The content of the course is clear from the list of topics below. I will discuss paradigms of the physical kinetics which can be frequently seen across different areas of theoretical physics. Roughly speaking the first part of the course will correspond to two books of L.D. Landau and E.M. Lifshitz Fluid mechanics, and E.M. Lifshitz L.P. Pitaevskii, Physical kinetics. In the second part of the course I am planning to use reviews on different subjects.

The course is aiming at students with a variety of backgrounds.

Grading: C/NC.

There will be no final exam. Students will be judged by bi-weekly HW.

I will use the following books:
L.D. Landau, E.M. Lifshitz, Physical kinetics,
L.D. Landau, E.M. Lifshitz, Fluid mechanics,
A.A. Abrikosov, Fundamental of the theory of metals,
I.M. Khalatnikov, The introduction to the theory of superfluidity,
and reviews on different subjects.

A TENTATIVE PLAN OF THE COURSE:

I. FLUID MECHANICS.

A. Ideal fluid, 2 lectures.

1. The continuity and Euler’s equations, Energy and momentum fluxes. Sound waves in compressible fluids. Do sound waves transfer mass?

B. Viscous fluids. 1 lecture.

1. The equations of motion of a viscous fluid. Second viscosity.
2. Classical corrections to hydrodynamics and breakdown of classical hydrodynamics in 1d.

C. Turbulence. 2 lectures.

1. Several scenario of transition to strong turbulence: quasi-periodic flow and frequency locking, strange attractors, transition to turbulence by period doubling.
2. Fully developed turbulence, Khomogorov’s spectrum.
3. The relation between the lift and the fluid circulation (Zhukovskii’s theorem.)

D. Magnetic fluid dynamics. 1 lecture.

2. Frozen magnetic field in conducting fluids. Spontaneous magnetic field in turbulent fluid (magnetic dynamo) and origin of cosmic magnetic field.
E. Relativistic fluid hydrodynamics. 1 lecture

F. Superfluid hydrodynamics. 1 lecture.

II. CLASSICAL KINETICS.

A. Weakly interacting particles. (Gases, Fermi liquid.) 2 lectures.
   2. Derivation of Navier-Stokes equations and the diffusion equations.

B. Kinetic theory of plasma. 1 lecture.
   1. Ambipolar diffusion.

C. Theory of weak plasma turbulence, collapse of the weak turbulence. 1 lecture.

D. Phonon transport in dielectrics. 1 lecture.

E. Electron kinetics in metals. 2 lectures.
   1. derivation of kinetic coefficients.
   2. Galvano-magnetic effects.
   3. Normal and anomalous skin effects.
   4. Helical and magneto-plasma waves in metals.

III. ELECTRON TRANSPORT IN SUPERCONDUCTORS. 3 LECTURES.

1. Kinetic coefficients (conductivity, thermal conductivity, thermoelectric effects etc.)
2. Pinning of the flux lattice in superconductors and the flux flow.

IV. QUANTUM KINETICS. 4 LECTURES.

A. How to calculate transport properties if systems are strongly correlated and the Fermi liquid theory is violated? Luttinger method. 1 lecture.

B. Weak localization and mesoscopic effects in metals. 2 lectures.