16.55/22.64J IONIZED GASES
Fall 2020 (Virtual)

Course material will be updated weekly on https://canvas.mit.edu

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Grading:

Problem sets	60% (6 total. 10% each. Due dates in Lecture outline)
Virtual Lab	10% (Due date in Lecture outline)
Quizzes	24% (weekly 1-2 short questions posted on Canvas)
Participation	6% (plasma of the day!)

– if due to time zone you are unable to attend synchronous lectures, let the instructor know to find alternatives to 6% participation score

Collaboration in problem sets and lab is acceptable but peer contributions and consulted references must be explicitly cited.
Quizzes should be worked on individually – no discussing with others or checking references outside materials posted on Canvas.

Lecture Outline

	DATE	Handout	TOPICS COVERED
1	Sept 1, Tue	1-2	Introduction. Length and time scales. Shielding. **Charged particle dynamics in prescribed electromagnetic fields**: Uniform $\vec{B}$. Cyclotron motion.
2	Sept 3, Thu	2	Diamagnetism, magnetization current. $\vec{E} \times \vec{B}$, Polarization drift.
3	Sept 8, Tue **P.S. 1 OUT**	3	Inhomogeneous $\vec{B}$, orbit averaging. Grad - $\vec{B}$ drift. Curvature drift.
4	Sept 10, Thu	3-4	Parallel drift, magnetic mirroring. Time varying $\vec{B}$, adiabatic invariants.
5	Sept 15, Tue	5	Relationship between drifts and fluid picture.
6	Sept 17, Thu **P.S. 1 DUE** **P.S. 2 OUT**	6	**Classical theory of elastic collisions**. Collision cross sections. Elastic collisions.
7	Sept 22, Tue	6	Hard sphere model. Power-law potentials. Coulomb collisions.

8	Sept 24, Thu	6	Relationship to lab-frame measurements. Inelastic collisions.
9	Sept 29, Tue	7	**Kinetic theory**. Statistical description of plasmas. Distribution functions, averages.
10	Oct 1, Thu **P.S. 2 DUE** **P.S. 3 OUT**	7-8	Vlasov's equation. The Boltzmann equation. Boltzmann's H-theorem.
11	Oct 6, Tue	9	Relationship between H and S (Entropy). The equilibrium distribution and its properties.
12	Oct 8, Thu	10	Equilibrium in force fields. Distribution functions near repelling and attracting walls.
	(Reading)	11*	The Fokker-Plank equation.
13	Oct 15, Thu **P.S. 3 DUE**	12	**Moments of the Boltzmann equation**. Mass conservation. Momentum conservation.
14	Oct 20, Tue **LAB OUT**		**Virtual Lab**
15	Oct 22, Thu	13	Energy conservation. Momentum and energy transfer rates for Maxwellian collisions. Electron momentum equation. Ohm's Law.
16	Oct 27, Tue **Lab DUE** **P.S. 4 OUT**	14	Electron energy equation for Maxwellian collisions.
17	Oct 29, Thu	15	Inclusion of inelastic effects. Thermal non-equilibrium.
	(Reading)	16*	Non-Maxwellian collisions. Momentum and energy transfer between shifted Maxwellian populations.
18	Nov 3, Tue	17	**Plasma-wall interaction**. The Bohm sheath criterion. Particle and energy flux to a wall.
19	Nov 5, Thu **P.S. 4 DUE** **P.S. 5 OUT**	18	Langmuir probe theory. Double probes, other probes.
	(Reading)	19*	Probe theory. The Orbital Motion Limit (OML).
20	Nov 10, Tue	20	**Introduction to Statistical Mechanics**. Equilibrium. Quantum statistics. Fermi-Dirac and Bose-Einstein. Boltzmann limit.
21	Nov 12, Thu	20	The partition functions. Connection to Thermodynamics.

22	Nov 17, Tue **P.S. 5 DUE** **P.S. 6 OUT**	21	Multi-component systems. Reaction equilibrium.
23	Nov 19, Thu	22	Translational partition function. Electronic partition function.
24	Dec 1, Tue	22	Vibrational partition function. Rotational partition function.
25	Dec 3, Thu **P.S. 6 DUE**	23	Applications of Equilibrium Statistical Mechanics. Ionization Equilibrium and Saha equation. Free electrons in metals. Thermionic emission. Field-enhanced emission.
26	Dec 8, Tue		Applications – open discussion.