

Condensed Matter Physics 2, 2018-2019

Week	Tuesday (13:15–15.00 & 15.15–17.00)	Friday (8:15–10.00 & 10.15–12.00)
1 (19+20/11) Note lecture dates. Exercise dates are 20+23/11)	Session 01 Atomic physics I <u>Reading:</u> Blundell Ch. 1 (1-15), App. C + E. <u>Topics:</u> Introduction to the course. Magnetic moments. The absence of magnetic materials in classical physics (Bohr-van Leuven theorem), the atomic origin of magnetic moments, reminder of quantum mechanics of spins, atoms in a magnetic field, susceptibility, a bit of Dirac magic. <u>Exercises for Tuesday 20/11:</u> 1.1, 1.2, 1.7, 1.12. We have no exercise class Monday 19/11! But we have a lecture Monday 19 th 10.15-12.00.	Session 02 Atomic physics II <u>Reading:</u> Blundell Ch. 2 (18-36), App. C + E. [As optional supplementary reading you may consult S. Simon Ch. 19).] <u>Topics:</u> The Hamiltonian in a magnetic field, diamagnetism, paramagnetism, Curie law, magnetic susceptibility, Hund's rules. <u>Exercises:</u> Blundell 1.9, 2.1, 2.4, 4.5, 2.7.
2 (27+30/11)	Session 03 Magnetism I <u>Reading:</u> Blundell Ch. 3 (45-71), Ch. 4 (74-81). Pages 52-71 can be read cursorily. <u>Topics:</u> Crystal fields, quenching, Jahn-Teller effect, various experimental techniques, different types of exchange interactions, Ising and Heisenberg models. <u>Exercises:</u> Blundell 4.7 (partly done/discussed in lecture), 4.8. Magnetism problems: 1.1, 1.2, 3.1 (See Absalon) Monday 26/11, 9-12. Help with exercises.	Session 04 Phase transitions <u>Reading:</u> CMP2 notes (1-19, 21-25). [As optional supplementary reading you may consult S. Simon Ch. 22.] <u>Topics:</u> The concept of an order parameter, Landau expansions, mean field theory, first and second order transitions, critical temperature, critical exponents, diverging correlation length. <u>Exercises:</u> Box question on p. 11 in CMP2 notes. Show Eqns. 52 and 57 in the CMP2 notes. Blundell 6.5.
3 (4+7/12)	Session 05 Magnetism II <u>Reading:</u> Blundell Ch. 5 (85-102). [As optional supplementary reading you may consult S. Simon Ch. 20.] <u>Topics:</u> Different kinds of magnetic order, ferromagnetism, antiferromagnetism, spin flop, helical order, spin glasses. <u>Exercises:</u> Blundell 5.1, 5.3, 5.7, 5.4. Monday 3/12, 9-12. Hand-in 1 help. Hand-in 1 is exercise 4.1, Box questions on pp. 12-14 in the CMP2 notes. Due 11/12.	Session 06 Magnetism III <u>Reading:</u> Blundell Ch. 6 (111-134) <u>Topics:</u> Spontaneously broken symmetry, Spin waves. Bloch's $T^{3/2}$ law, general phase transitions, domain walls, hysteresis, break-down of mean-field theory in low dimensions, the Mermin-Wagner theorem. <u>Exercises:</u> Blundell 6.1, 6.2. Mermin-Wagner spin-wave box p. 32-33 in the CMP2 notes.
Now we are done with magnetism of atoms and insulators. For the rest of the course we will study metals.		
4 (11+14/12)	Session 07 Magnetism in metals <u>Reading:</u> Blundell Ch. 7 (140-148, 153-163). [As optional supplementary reading you may consult S. Simon Ch. 23.] <u>Topics:</u> The free electron gas, Pauli paramagnetism, itinerant magnetism, Stoner instability, Spin-density-waves, momentum dependence of the susceptibility, RKKY interaction. <u>Exercises:</u> 6.7, 7.1, 7.2, 7.4 in Blundell. Monday 10/12, 9-12. Hand-in 1 help.	Session 08 Superconductivity I <u>Reading:</u> CMP2 notes 40-44. <u>Topics:</u> Phenomenology of superconductivity, London equations, Meissner effect, introduction to Ginzburg-Landau theory. <u>Exercises:</u> 7.8 in Blundell. Box question on p. 43 in the CMP2 notes. Problem 3.1, 3.2, 4.2 from Annett (Additional problems).
5 (18+21/12)	Session 09 Superconductivity II <u>Reading:</u> CMP2 notes 44-50. <u>Topics:</u> Continuation of Ginzburg-Landau theory, local gauge invariance, characteristic length scales, type I versus type II, flux quantization, vortex lattices. <u>Exercises:</u> Problem 4.2, 3.3 from Annett (Additional problems). Kittel 10.3, 10.7 Monday 17/12, 9-12. Hand-in 2 help. Hand-in 2 is exercise 7.1, Box questions on pp. 25-27 in the CMP2 notes. Due 21/12.	Session 10 Superconductivity III <u>Reading:</u> <u>Topics:</u> Josephson junctions, SQUIDS, hands-on superconductivity, macroscopic quantum coherence, microscopic origin of superconductivity: Cooper instability. <u>Exercises:</u> Box question on p. 50 in the CMP2 notes. Hand-in 2 due. Hand-in 1 return.
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<p>6 (4/1+8/1)</p>	<p>Session 11</p> <p>Friday 4/1 10-12 and Monday 7/1, 9-12. Hand-in 3 help. Box questions on pp. 38-39 in the CMP2 notes. Due 8/1.</p> <p>Hand-in 2 return.</p>	<p>Session 12 Transport I <u>Reading:</u></p> <p><u>Topics:</u> Distribution functions, transport coefficients, the Boltzmann equation, the collision term, the relaxation time approximation, T-dependence of various scattering rates.</p> <p><u>Exercises:</u></p> <p>Hand-in 3 due.</p>
<p>7 (11+15/1)</p>	<p>Session 13 Transport II <u>Reading:</u></p> <p><u>Topics:</u> Distribution functions, transport coefficients, the Boltzmann equation, the collision term, the relaxation time approximation, T-dependence of various scattering rates.</p> <p><u>Exercises:</u></p> <p>Hand-in 3 return.</p>	<p>Session 14 Quantum Hall Effect <u>Reading:</u></p> <p><u>Topics:</u> Hall effect and magneto-resistance, Landau levels, classical Hall effect, Landau diamagnetism, Integer quantum Hall effect, edge states.</p> <p><u>Exercises:</u> 7.3 in Blundell</p>
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	Exam 22, 25 Jan	

Place and Time Sessions (Lectures and Exercises)

Lectures: Tuesday 13:15-15:00 and Friday 8:15-10.00 (BMA).

Exercises: Tuesday 15:15-17:00 and Friday 10.15-12.00 (Hano O. M. Sura). In addition, we will use Mondays 9.15-12.00 for extra help with problems and hand-in assignments.

Room: Lectures take place in Aud. 2 (HCØ) on Tuesdays, and Aud. D (Blegdamsvej) on Fridays.

Room: Exercises take place in Aud. M (Aud. D) on Blegdamsvej on Mondays (Fridays). And in RF062 + RF079 (Rockefeller) on Tuesdays.

Course material

S. Blundell; "Magnetism in Condensed Matter"

B. M. Andersen, "Notes for CMP2"

S. Simon; "The Oxford Solid State Basics".

(free download through the course homepage on Absalon).

Teachers (lectures & exercises)

BMA Brian Møller Andersen (lectures)

HOMS Hano O. M. Sura (exercises)

The course consists of Session 1-14 (lectures and exercises) plus self-study. The students' mastery of the course subjects (equivalent of 7.5 ETCS points) is evaluated at the oral exam (mark given). The course contains three longer written hand-in problems, whose content and solution will be a natural part of the oral examination.

Prerequisites:

Completed courses in basic electromagnetism, quantum mechanics, and statistical physics. CMP1 provides a foundation for this course but it is not a strict prerequisite.

Other good textbooks:

Ashcroft and Mermin; "Solid state physics".

C. Kittel; "Introduction to Solid State Physics".

J. Singleton; "Band theory and electronic properties of solids".

H. Ibach and H. Luth; "Solid-state physics".

C. Kittel; "Quantum theory of solids".

H. Smith and H. H. Jensen, "Transport Phenomena".

M. P. Marder; "Condensed matter physics".