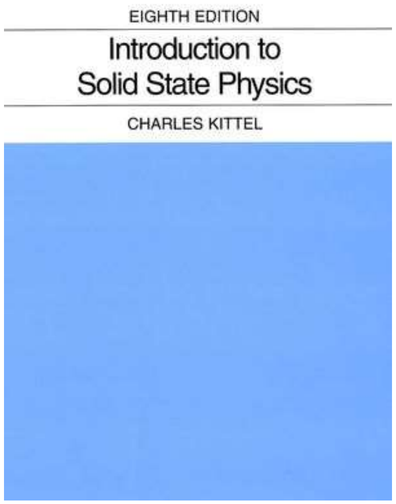
Advanced Solid State Physics

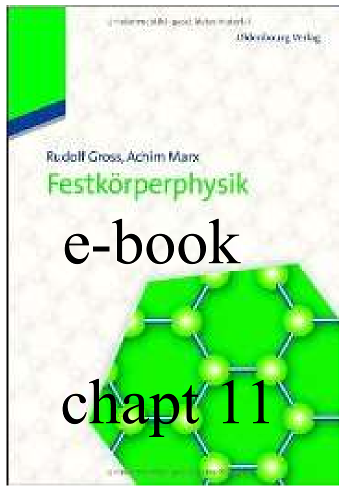
Solid state physics is the study of how atoms arrange themselves into solids and what properties these solids have.

Calculate the macroscopic properties from the microscopic structure.

Advanced Solid State Physics

Quantization
Review: Photons (noninteracting bosons), photonic crystals
Review: Free electrons (noninteracting fermions), electrons in crystals
Electrons in a magnetic field
Fermi surfaces
Quantum Hall effect
Linear response theory
Dielectric function / optical properties
Transport properties
Quasiparticles (phonons, magnons, plasmons, exitons, polaritons)
Mott transition, Fermi Liquid Theory
Ferroelectricity, pyroelectricity, piezoelectricity
Landau theory of phase transitions
Superconductivity


EIGHTH EDITION
Introduction to Solid State Physics
CHARLES KITTEL


Rudolf Gross, Achim Marx
Festkörperphysik
e-book
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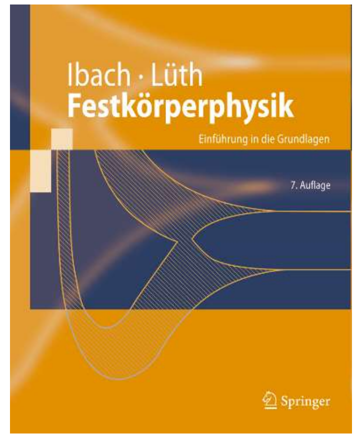
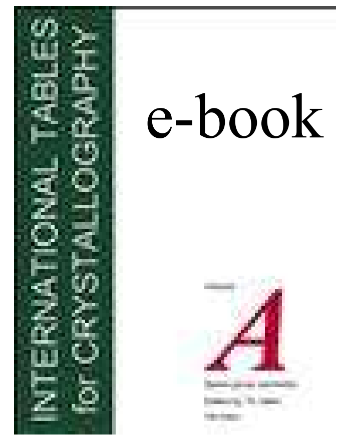
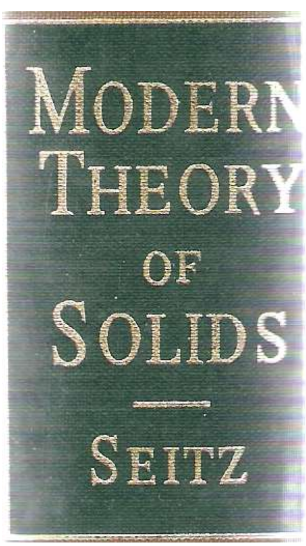
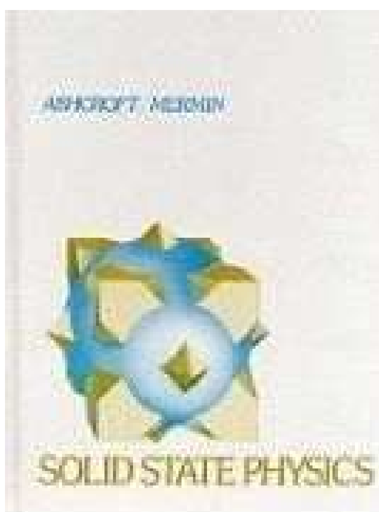
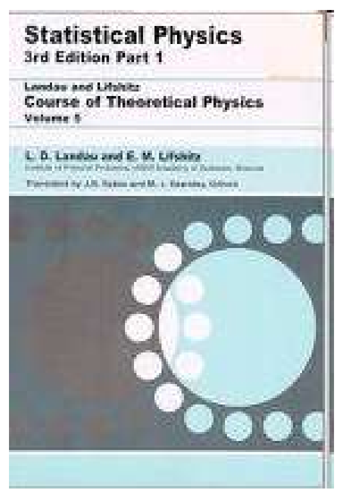
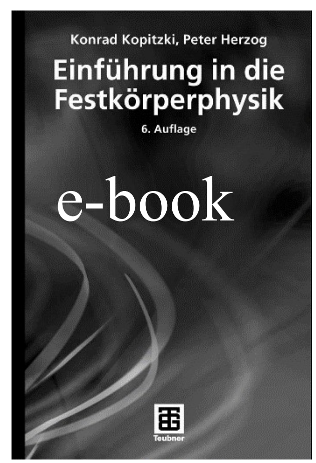

Ibach · Lüth
Festkörperphysik
Einführung in die Grundlagen
7. Auflage
Springer


INTERNATIONAL TABLES for CRYSTALLOGRAPHY
e-book
A


MODERN THEORY OF SOLIDS
SEITZ


ASHCROFT MERMIN
SOLID STATE PHYSICS


Statistical Physics
3rd Edition Part 1
Landau and Lifshitz
Course of Theoretical Physics
Volume 5
L. D. Landau and E. M. Lifshitz


Konrad Kopitzki, Peter Herzog
Einführung in die Festkörperphysik
6. Auflage
e-book
Teubner


Czycholl
Theoretische Festkörperphysik
Von den klassischen Modellen zu modernen Forschungsthemen
Lösungen im web
3. Auflage
e-book
Springer

Advanced Solid State Physics

Solid-state physics, the largest branch of condensed matter physics, is the study of rigid matter, or solids. The bulk of solid-state physics theory and research is focused on crystals, largely because the periodicity of atoms in a crystal, its defining characteristic, facilitates mathematical modeling, and also because crystalline materials often have electrical, magnetic, optical, or mechanical properties that can be exploited for engineering purposes. The framework of most solid-state physics theory is the Schrödinger (wave) formulation of non-relativistic quantum mechanics.

- Solid state physics in Wikipedia

The most remarkable thing is the great variety of *qualitatively different* solutions to Schrödinger's equation that can arise. We have insulators, semiconductors, metals, superconductors—all obeying different macroscopic laws: an electric field causes an electric dipole moment in an insulator, a steady current in a metal or semiconductor and a steadily accelerated current in a superconductor. Solids may be transparent or opaque, hard or soft, brittle or ductile, magnetic or non-magnetic.

From *Solid State Physics* by H. E. Hall

To a large extent, our success in understanding solids is a consequence of nature's kindness in organizing them for us... By the term solid we shall really always mean crystalline solid, and, moreover, infinite perfect crystalline solid at that.

From *States of Matter* by David L. Goodstein

http://lamp.tu-graz.ac.at/~hadley/ss2/

TUG -> Institute of Solid State Physics -> Courses

Student projects

Something that will help other students pass this course

2VO + 1UE

Solutions to exam questions
Example calculations (phonon dispersion relation for GaAs)
Javascript calculations
Lecture videos

No lecture

March 9

Examination

1 hour written exam

half of the questions will be from the website

Oral exam

- Student project
- Mistakes on written exam
- General questions about the course

Quantization

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V(\vec{r})\psi = E\psi$$

Start with the classical equations of motion
Find the normal modes
Construct the Lagrangian
From the Lagrangian determine the conjugate variables
Perform a Legendre transformation to the Hamiltonian
Quantize the Hamiltonian

Harmonic oscillator

Newton's law: $$ma = -Kx$$

Euler - Lagrange equations: $$\frac{d}{dt}\frac{\partial L}{\partial \dot{q}_i} - \frac{\partial L}{\partial q_i} = 0$$

Lagrangian (constructed by inspection) $$L(x, \dot{x}) = \frac{m\dot{x}^2}{2} - \frac{Kx^2}{2}$$

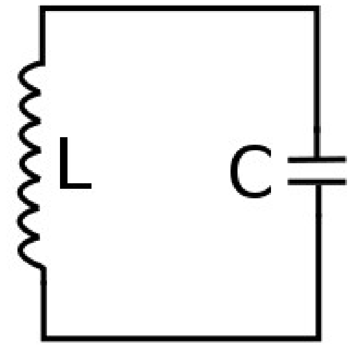
Conjugate variable: $$p = \frac{\partial L}{\partial \dot{x}} = m\dot{x}$$

Legendre transformation: $$H = p\dot{x} - L = \frac{p^2}{2m} + \frac{Kx^2}{2}$$

Quantize: $$p \to -i\hbar\frac{\partial}{\partial x}$$ $$H\psi = \frac{-\hbar^2}{2m}\frac{d^2\psi}{dx^2} + \frac{Kx^2}{2}\psi$$

LC circuit

Classical equations $V = L\frac{dI}{dt}$ $I = -C\frac{dV}{dt}$ $Q = CV$

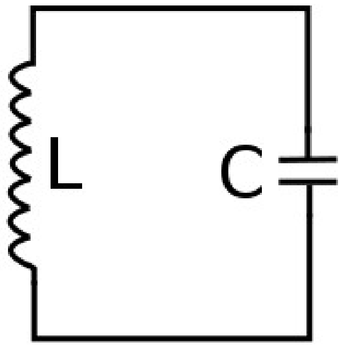


$$\frac{Q}{C} = -L\frac{d^2Q}{dt^2}$$

Euler - Lagrange equation: $$\frac{d}{dt}\frac{\partial \mathcal{L}}{\partial \dot{Q}} - \frac{\partial \mathcal{L}}{\partial Q} = 0$$

Lagrangian (constructed by inspection) $$\mathcal{L}\left(Q,\dot{Q}\right) = \frac{L\dot{Q}^2}{2} - \frac{Q^2}{2C}$$

LC circuit



Conjugate variable: $$p = \frac{\partial \mathcal{L}}{\partial \dot{Q}} = L\dot{Q}$$

Legendre transformation: $$H = L\dot{Q}^2 - \mathcal{L} = \frac{L\dot{Q}^2}{2} + \frac{Q^2}{2C}$$

Quantize: $$p \rightarrow -i\hbar \frac{\partial}{\partial Q}$$

$$H\psi = \frac{-\hbar^2}{2L}\frac{d^2\psi}{dQ^2} + \frac{Q^2}{2C}\psi = E\psi$$