LINKÖPINGS UNIVERSITET

ITN

Course information TNE041 Modern Physics 2025

Prerequisites: TNA006 Multivariable calculus, TNE043 Mechanics and Wave Physics, or similar courses.

Examiner, lecturer: Michael Hörnquist, office TP6168, email michael.hornquist@liu.se

Course contents, intended learning outcomes and assessment criteria:
See syllabus and "Additional documents" at https://studieinfo.liu.se/en/.

Webpage: Lisam, http://lisam.liu.se. You get full access after you have registered.

Language: English if non-Swedish speaking students have signed up for the course and are present, otherwise Swedish. Course material such as lecture notes, lab instructions and exams will be available in English only.

Course literature:
Textbook: R Harris: Modern Physics, Second Edition (Pearson Addison-Wesley)

There are several versions of the same book: Try to find one which is "Compiled by Mats Eriksson Linköping University", ISBN: 978-1-783-76953-7 or 978-1-784-47415-7. It sometimes contains an access code, not used in this course, and which you do not need to worry about if you buy a used copy.

The following sections in Harris are included:

- Chapter 1: All
- Chapter 2: Sections 2.1 and 2.7
- Chapter 3: All
- Chapter 4: All
- Chapter 5: All
- Chapter 6: All except alpha decay in 6.3
- Chapter 7: All except degeneracy (p 258) and 7.10
- Chapter 8: Sections 8.1-8.4
- Chapter 9: Sections 9.1, 9.2(except the discussion of temperature), 9.3-9.5, 9.6 (Bose-Einstein condensation is optional), 9.7 (the derivation in Appendix C that is referred to is optional), 9.8
- Chapter 10: Sections 10.1, 10.4-10.8

In addition to the textbook Harris, you also need C Nordling, J Österman: Physics Handbook for Science and Engineering (Studentlitteratur). The latest edition has number 9, but previous editions can be used as well.

Additional material will be available in Lisam.

Examination:

A written examination (tentamen, TEN1, 4,5 hp) that consists of 6 problems worth 4 points each. To pass the examination, a minimum of 10 points is required (15 points for grade 4, 19 points for grade 5), with at least 2 points for the first problem (reflecting the learning outcome concerning the need of "new physics"). The problems will be given in English, but the solutions may be given in either English or Swedish. **You are allowed to bring the following to the written examination (tentamen):** Calculator (with no information stored and no possibility of wireless connection), Physics Handbook, one handwritten page (A4, not copied) with notes of your own choice. Notes ***must*** be confined to the handwritten page, no notes allowed in Physics Handbook. Two pages with formulae will be available in Lisam. Don't bring these to the examination yourself; they will be attached to the examination problems.

Two sets of homework problems (UPG1) will be distributed. These problems are ***not*** compulsory but may give up to two (2) bonus points at the written examination, details are provided through Lisam, where you also hand in the solutions. As part of the second set there will be a short oral presentation and discussion (scheduled as seminar) at the end of the course. Details and dates can be found in Lisam. Any use of generative AI is strongly discouraged since the answers one gets there too often is simply wrong.

There are four computer lab sessions (LAB1, 1.5 hp) during the course. A short-written report must be submitted after each session, and all reports must be approved to obtain grade pass (G) on the lab assignments. Attending the scheduled lab sessions is ***not*** compulsory. You may work with the assignments at other times, but the reports must be submitted through Lisam before the deadlines that will be ***one week after*** each scheduled lab session. Any corrected versions of reports must be submitted not later than ***6 April***. If reports have not been given the grade pass (G) by this date, one last opportunity will be given in August 2025. Detailed instructions will be provided to those for which this is relevant. Any use of generative AI is strongly discouraged since the answers one gets there too often is simply wrong.

Teaching plan (referring to Harris).

Underlined problems will be discussed during the tutorials.

Lecture 1	Introduction. Relativity theory (2.1, 2.7). Waves as particles (3.1 – 3)
Lecture 2	Waves as particles (3.4 – 6). Introductory quantum mechanics (4.1 – 3)
Tutorial 1	2: 70, 73, 75, 79, 83, 84, 87, 97, 117 3: 17, 19, 25, 29, 30, 32, 36, 41, 48, 52 4: 11, 15, 17, 20, 33, 37
Lecture 3	The uncertainty principle, the Bohr model (4.4 - 7). The one-dimensional Schrödinger equation, bound states (5.5 - 7)
Lecture 4	Expectation values, operators, nonstationary states, eigenvalues (5.8 – 11)
Tutorial 2	4: 41, 46, 50, 54, 61, 65 5: 28, 30, 35, 47, 49a, 60, 61, 64, 66, 69, 80, 81
Lab session 1	The photoelectric effect. Quantum bound states.
Lecture 5	Unbound states, potential step, barrier, tunnelling (6.1 – 2). Phase and group velocity, dispersion (6.3 – 4).
Tutorial 3	6: 13, 15, 18, 21, 26, 33, 41, 42, 49, 53
Lab session 2	Quantum tunnelling, plane waves and wave packets.
Lecture 6	The 3D Schrödinger equation, infinite well (7.1 – 2). The hydrogen atom and hydrogenlike atoms (7.3 – 9).
Tutorial 4	7: 18, 20, 21, 23, 25, 30, 33, 35, 37, 45, 49, 56, 58, 67, 70, 71.
Lecture 7	Spin, identical particles, many-electron systems, the periodic table (8.1 – 4)
Tutorial 5	8: 25, 28, 30, 33, 36, 38, 41, 49, 54, 84.
Lab session 3	Two-dimensional infinite well. The Stern-Gerlach experiment.
Lecture 8	Thermodynamic systems, entropy, statistical mechanics, Maxwell-Boltzmann distributions (9.1 – 4)
Lecture 9	Fermi-Dirac and Bose-Einstein distributions, laser (9.5 – 8)
Tutorial 6	9: 19, 22, 27, 37, 41, 43, 61, 62, 66. Add probl Lisam: 1, 2, 3, 4.
Lecture 10	Solid state physics, multiatom systems, crystalline solids, energy bands (10.1, 10.4 – 5). Conductor, semiconductor, insulator (10.5 – 6). Semiconductor theory, devices (10.7 – 8)
Tutorial 7	10: 51, 52, 57, 58, 63, 64, 66. Add probl Lisam: 5, 6, 7.
Lab session 4	Monte Carlo simulations of an ideal quantum gas
Lecture 11	Repetition
Tutorial 8	Questions and answers
Seminar	Students presenting homework 2