

ENERGY AND FUSION RESEARCH

Course PM Spring 2022

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Course home page: <https://canvas.kth.se/courses/31124>
(<https://www.kth.se/kursutveckling/ED2200> for course development)

COURSE SUBJECT

In earlier days, the question "For how long will the fossil fuels last?" was often raised, but the development during the last decades rather imply the question "When can we free ourselves from the dependence on fossil fuels?".

In this course, a background is given to the problems concerning future energy production that we are realizing today and that will become critical towards the mid-century unless new energy sources are developed. We will also discuss the alternative energy sources that are known today. Within fusion research, the goal is to produce a sustainable energy source for large scale generation of electricity. By using the surplus energy that is released in fusion reactions, as light atomic nuclei merge, the final benefit comes from an enduring, affordable and environmentally friendly "Sun on earth".

The Alfvén Laboratory at KTH collaborates internationally in this field. This introductory course will provide the physical and technological basics and give a picture of the state of present day fusion research. Development in fusion has now reached a state where we may say, with some confidence, that fusion power will indeed be realized. In the course, different solutions to this "the greatest technological challenge ever pursued by man" will be presented.

COURSE LITERATURE

- *Fusion Physics – introduction to the physics behind fusion energy*, J. Scheffel and P. Brunsell
- *Exercises with solutions*, J. Scheffel and P. Brunsell

Course book and exercises are freely available as pdf:s. Physical course book costs 200 kr.

ABOUT TEACHING AND LEARNING IN THIS COURSE

Lectures (Le) provide an overview of the energy provision problem and the development of fusion research, as well as an understanding for important problems in fusion research. Some course book material will be taught as home assignments.

Home assignments provide credits for the course examination.

Class exercises (Ex) develop skills to solve formal problems within fusion research and an opportunity to discuss questions encountered during the studies. A few problems are solved on the blackboard during the first hour, whereafter the students solve a given problem in the classroom as a group exercise the second hour. Protocols from each group (typically three students) are handed in at the end of the session, as part of the examination.

EXAMINATION

Continual examination, based on a credit point system, is used. The grades "pass" (P) or "fail" (F) are determined by the total number of credit points accumulated during the course. Maximum 42 credit points are available. A minimum of 30 credit points is required for grade "pass". Students achieving 26-29.5 credit points may be awarded "pass" grade after completing an additional exam within 6 weeks after the course.

HOME ASSIGNMENTS are six in total and provide a total maximum of 30 credit points. They are handed out (and posted on the course web) each week, and should be handed in (or scanned with SwiftScan / uploaded as pdf on Canvas) *before the first lecture the week after*. *The first five assignments* cover the subjects presented in the lectures the same week. Each assignment gives maximally 4 credit points.

The *second and sixth assignments* contain surveys on the Canvas course platform as first questions. These *must* be answered for receiving credit points from assignments two and six. The *first part* of the *sixth assignment* covers last week's lectures and can give 4 credit points while the *second part* of the sixth assignment covers the whole course and can give maximally 6 credit points. NOTE: you are free to cooperate with other students during the solution of the problems, but ***your answers must be formulated from your personal understanding. Measures will be taken in cases of plagiarism!***

GROUP WORK SESSIONS (see above) may provide 12 credit points in total. Handed in protocols for each session are graded "pass" or "fail". Constructive participation is a minimum requirement for the "pass" grade. Protocols graded "pass" in 4-6 sessions give 12 credit points while protocols graded "pass" in 2-3 sessions give 6 credit points. You may do the group work *distantly*, alone or with 1-2 other students – then post your answer sheet at the web page it was announced before the deadline provided (use SwiftScan and upload as pdf).

COURSE PROGRAM

Week	Day	Date	Time	Place	Le/Ex	Topic
12	Mon	21 Mar	10-12	E36	Le 1	Fusion in nature, future energy needs, energy alternatives (Ch 1.1).
	Wed	23 Mar	15-17	E36	Le 2	Energy alternatives (cont'd), fusion reactions, brief fusion history (Ch 1.2).
	Thu	24 Mar	10-12	E52	Ex 1	Le 1, 2
13	Mon	28 Mar	10-12	E36	Le 3	Lawson criterion, quality parameters of the fusion plasma (Ch 1.2, 2).
	Wed	30 Mar	15-18	E53	Le 4	Plasma models; particle, kinetic and fluid models (Ch 2).
	Thu	31 Mar	10-12	Q11	Ex 2	Le 3, 4
14	Mon	4 Apr	10-12	E36	Le 5	Equilibrium, plasma waves (Ch 3, 4).
	Wed	6 Apr	15-18	E53	Le 6	Stability (Ch 4).
	Thu	7 Apr	10-12	E52	Ex 3	Le 5, 6
15	Mon	11 Apr	10-12	E52	Le 7	Transport (Ch 5).
	Wed	13 Apr	15-17	E36	Le 8	Transport cont'd (Ch 5).
	Thu	14 Apr	10-12	E34	Ex 4	Le 7, 8
17	Mon	25 Apr	10-12	E36	Le 9	Radiation, boundary, heating (Ch 6).
	Wed	27 Apr	15-17	E36	Le 10	Diagnostics (Ch 7). Visit to the Alfvén laboratory.
	Thu	28 Apr	10-12	E51	Ex 5	Le 9, 10
19	Mon	9 May	10-12	E52	Le 11	Alternative concepts, inertial confinement fusion (Ch 8).
	Wed	11 May	15-17	E36	Le 12	Reactor, safety, environment (Ch 9).
	Mon	12 May	10-12	E36	Ex 6	Le 11, 12

Disability

If you have a disability, you may receive support from Funka, KTH's coordinator for students with disabilities, see <https://www.kth.se/en/student/studentliv/funktionsnedsattning>. Please inform the course coordinator if you have special needs not related to the written exam, and show your certificate from Funka.

- Support measures under code R (i.e. adjustments related to space, time, and physical circumstances) are generally granted by the examiner.

- Support measures under code P (pedagogical measures) may be granted or rejected by the examiner, after you have applied for this in accordance with KTH rules. Normally, support measures under code P will be granted.