ENERGY AND FUSION RESEARCH

Course PM Spring 2020

NOTE! This is a revised PM – the course is **digitalized** this year due to the Corona virus.
Please pay particular attention to red-marked text below.

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Course home page:	**https://kth.instructure.com/courses/17122**
	(see also **https://www.kth.se/kursutveckling/ED2200?l=en**)

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 endurable, 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 cost is 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.

This year:

- Please be aware that education at KTH presently is changing on short notice; the new digitalized course design as presented here may possibly be modified later on. Any change will, however, be posted as a message on the course home page
- Instead of the standard lecture (Le1) on Monday 16 March at 10:15, there will be a brief introductory meeting where the course design for this year will be presented. Physical copies of the course book will be available for purchase (please bring 200 kr in cash). The course book is also available as a pdf for free on the course home page

- There will not be a physical lecture (Le2) given on Wednesday 18 March.
- Instead of the physical lectures Le1 and Le2, normally given the first course week, please watch the video lectures on fusion, primarily lectures 1-4, at https://www.kth.se/fpp/education/video-lectures-on-fusion-1.648407
  If you have any questions regarding the content of the video lectures, please use the "Discussion" tool on Canvas, where also answers to the questions will be posted
- Remaining lectures are presently planned to be **online video lectures using Zoom**; see https://www.kth.se/student/kth-it-support/work-online/webbmoten-zoom/zoom-1.893273
  You will receive more information about this on the Canvas home page.

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. Normally a few problems are solved on the blackboard during the first hour, whereafter the students solve a given problem as a group exercise the second hour. Protocols from each group are handed in at the end of the session, as part of the examination.

This year no class exercises will be given in the physical class room:

- Solved problems, relating to the first part of the class exercise, will be posted on the course home page early each week
- Group work exercise problems, and answer sheets for these, will be posted on the course home page at the scheduled day for exercises (see Course Program). For solving these, and examination of these, please see below

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.

Course activities required for examination:

HOME ASSIGNMENTS are six in total and provide a total maximum of 30 credit points. They are handed out each week, and should be handed in at the first lecture the week after.

The first five assignments cover the subjects presented in the lectures the same week. Each assignment give 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.

This year:

- Home assignments are made available at the course home page on Canvas
- Solutions should be uploaded to Canvas on the same web page as where the Home assignment was posted. If you scan: do not use poor mobile phone photos
- Note that Home assignments uploaded after the time specified above will not be considered!

- In this course your individual understanding is in focus; 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.

This year:

- The group exercises may, as before, be solved in groups of 2-3 students. In this case, a "secretary" for the group should be appointed, that should fill in the answer sheet
- You also have the possibility to solve the problems individually
- Upload the answer sheets no later than by the end of the day for the exercise (see Course Program below) to Canvas on the same web page as where the exercise was posted. If you scan: do not use poor mobile phone photos
- Please note that plagiarism checks will be carried out

COURSE PROGRAM

Week	Day	Date	Time	Place	Le/Ex	Topic
12	Mon	16 Mar	10-12	E33	Le 1	Fusion in nature, future energy needs, energy alternatives (Ch 1.1).
	Wed	18 Mar	~~15-17~~	~~E32~~	Le 2	Energy alternatives, cont'd., fusion reactions, brief fusion history (Ch 1.2).
	Thu	19 Mar	~~10-12~~	~~E53~~	Ex 1	Le 1, 2
13	Mon	23 Mar	10-12	~~E33~~	Le 3	Lawson criterion, quality parameters of the fusion plasma (Ch 1.2, 2).
	Wed	25 Mar	15-18	~~E36~~	Le 4	Plasma models; particle, kinetic and fluid models (Ch 2).
	Thu	26 Mar	~~10-12~~	~~D42~~	Ex 2	Le 3, 4
14	Mon	30 Mar	10-12	~~Q11~~	Le 5	Equilibrium, plasma waves (Ch 3, 4).
	Wed	1 Apr	15-18	~~E32~~	Le 6	Stability (Ch 4).
	Thu	2 Apr	~~10-12~~	~~D33~~	Ex 3	Le 5, 6
15	Mon	6 Apr	10-12	~~E33~~	Le 7	Transport (Ch 5).
	Wed	8 Apr	15-17	~~E32~~	Le 8	Transport cont'd (Ch 5).
	Thu	9 Apr	~~10-12~~	~~D36~~	Ex 4	Le 7, 8
17	Mon	20 Apr	10-12	~~E36~~	Le 9	Radiation, boundary, heating (Ch 6).
	Tue	21 Apr	13-15	~~E32~~	Le 10	Diagnostics (Ch 7). Visit to the Alfvén laboratory.
	Wed	22 Apr	~~15-15~~	~~E35~~	Ex 5	Le 9, 10
19	Mon	4 May	15-17	~~D35~~	Le 11	Alternative concepts, inertial confinement fusion (Ch 8).
	Wed	6 May	15-17	~~E32~~	Le 12	Reactor, safety, environment (Ch 9).
	Thu	7 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.