FUSION PLASMA PHYSICS
ALFVÉN LABORATORY
KTH
Jan Scheffel and Per Brunsell

ENERGY AND FUSION RESEARCH

www.alfvenlab.kth.se/edu/courses/ED2200
Spring 2009

COURSE SUBJECT

In earlier days, the question ”For how long will the fossil fuels last?” was often raised, but experiences during the last decade have given us reasons to instead ask 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 provision 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 an energy source for large scale generation of electricity. By using the surplus energy that is released when light atomic nuclei merge (fusion), the final benefit comes from an endurable and environmentally friendly ”Sun on earth”. Since the early 1960’s, the Alfvén Laboratory at KTH has been part of the international collaboration 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. The development 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.

LECTURES AND CLASS EXERCISES

Week	Le	Le	Ex
12	Mon 10.15-12.00 (E52)	Tue 10.15-12.00 (E36)	Fri 10.15-12.00 (E36)
13	Wed 08.15-10.00 (E31)	Thu 08.15-10.00 (E31)	Fri 13.15-15.00 (D41)
14	Mon 10.15-12.00 (E36)	Tue 09.15-12.00 (E36)	Fri 13.15-15.00 (E36)
16	Tue 10.15-12.00 (E36)	Wed 08.15-10.00 (E36)	Fri 13.15-15.00 (E52)
17	Mon 10.15-12.00 (E31)	Tue 10.15-12.00 (E53)	Fri 13.15-15.00 (E36)
18	Mon 13.15-15.00 (E36)	Tue 10.15-12.00 (E36)	Thu 08.15-10.00 (E35)

Teachers are Prof Jan Scheffel (Jan.Scheffel@ee.kth.se, tel. 790 8939) and
Assoc prof Per Brunsell (Per.Brunsell@ee.kth.se, tel. 790 6246)
at the division for Fusion Plasma Physics, Alfvén Laboratory, Teknikringen 31.
The course secretary is Ingeborg Mau, 790 7704 (Ingeborg.Mau@ee.kth.se).

ABOUT TEACHING AND LEARNING IN THIS COURSE

The purpose of the lectures is to 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, being distributed at each lecture. The home assignments provide credits for the course examination.

The purpose of the class exercises is to 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, whereafter the students solve a given problem as a group exercise. Protocols from each group are handed in at the end of the session, as part of the examination.

LECTURE PROGRAM

Date	Ref.	Topic
Mon 16/3	Ch. 1.1	Fusion in Nature. Future energy needs. Energy alternatives.
Tue 17/3	Ch. 1.2	Energy alternatives (cont'd.) Fusion reactions. Brief fusion history.
Wed 25/3	Ch. 1.2, 2	The Lawson criterion. Quality parameters of the fusion plasma.
Thu 26/3	Ch. 2	Plasma models (particle, kinetic and fluid models).
Mon 30/3	Ch. 3, 4	Equilibrium. Plasma waves.
Tue 31/3	Ch. 4	Stability.
Tue 14/4	Ch. 5	Transport.
Wed 15/4	Ch. 5	Transport.
Mon 20/4	Ch. 6	Radiation, boundary layer, heating.
Tue 21/4	Ch. 7	Diagnostics. Visit to the laboratory.
Mon 27/4	Ch. 8	Alternative concepts. Inertial confinement.
Tue 28/4	Ch. 9	The reactor. Safety and environmental issues.

EXAMINATION

The course is examined from home assignments and group exercises. The grades are pass/fail.

- *Home assignments* (being 6 in total) each provides maximally 4 credits. They are handed out each week, and should be handed in at the first lecture the week after.
- *Problem solutions during group work* (at the class exercises) may provide 12 credits in total (if you contribute successfully during at least 4 sessions) or 6 credits (2-3 sessions).
  A maximum of 36 credits are thus available. For the "pass" grade 24 credits are required.

COURSE LITERATURE

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

The cost for the course literature is 250 kr.

The introductory character of the course forces us sometimes to leave out details of the theory. Recommended, supplementary textbooks are

- J. Freidberg, *Plasma Physics and Fusion Energy* (Cambridge Univ. Press 2007)
- W. M. Stacey, *Fusion Plasma Physics* (Wiley 2005)
- G. McCracken and P. Stott, *Fusion – the energy of the universe* (Elsevier 2005)

You will find more information on fusion at our homepage **www.alfvenlab.kth.se/fusion**.